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The Changing Macroeconomic Response to Stock Market Volatility Shocks

Abstract

There is substantial consensus in the literature that positive uncertainty shocks predict a slowdown of economic activity. However, using U.S. data since 1950 we show that the macroeconomic response pattern to stock market volatility shocks has changed substantially over time. The negative response of GDP growth to such shocks has become smaller over time. Further, while during earlier parts of our sample both a slowdown in consumption and investment growth contribute to a reduction of GDP growth, during later parts, only the investment reaction contributes to the GDP slowdown. A variance decomposition for consumption growth shows that the contribution of stock market volatility becomes negligible as we go from earlier to later parts of the sample, while the corresponding decomposition for investment growth reveals an increase in the role of stock market volatility.

JEL-Code: E200, E310, E400.

Keywords: Dow Jones index, stock market volatility shocks, economic growth, consumption, investment, sample splits.

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1. Introduction

The recent global economic and financial crisis has stimulated research on the relationship between financial markets and the macro-economy. There is by now substantial evidence in the literature that positive uncertainty shocks predict a slowdown of economic activity. However, the literature does not document whether this relationship is stable over time. In this article, using U.S. data since 1950 until now, we demonstrate that the macroeconomic response pattern to stock market volatility changes rather markedly over our sample period both in qualitative and quantitative terms. It is important to explore such changes in the macroeconomic response pattern, because this might provide policymakers with additional insights on the (relative importance of the) channels through which uncertainty shocks affect the macro-economy and on the role that policy plays in the transmission. Moreover, to the extent that uncertainty is attributable to policymaking, it provides them with information on changes in the costs of policy uncertainty.

There are several potential channels through which an unexpected increase in uncertainty in the economy may affect macroeconomic variables. It may lead to an increase in precautionary savings (e.g. Carroll and Samwick, 1998), thereby depressing consumption spending. It may raise the required compensation for bearing systematic risk in financial markets, thereby pushing up the cost of capital and, hence, depressing investment. Higher uncertainty also raises the value of the option-to-wait in making irreversible investment decisions, thereby slowing down investment expenditures (e.g., Bernanke, 1983, Dixit and Pindyck, 1994, and Bloom *et al.*, 2007). The same is true for durable consumption goods. Finally, it is sometimes argued that higher (stock) market volatility reflects enhanced uncertainty about future cash flows and discount rates that result from expected resource-consuming structural changes that depress GDP growth (see Campbell *et al.*, 2001). Hence, in a regression of GDP growth on lagged stock market volatility, the latter variable is expected to enter with a negative coefficient.

This paper draws on different strands in the literature. There is an earlier strand in the finance literature that explores the link between output growth and stock market volatility, see, in particular, the work by Campbell *et al*. (2001) and Guo (2002).[1] In contrast to these works, we employ a multivariate vector auto-regression (VAR) methodology that also controls for monetary policy and inflation. This paper is closely related to the more recent contributions that explore the relationship between uncertainty and economic activity. These include Bloom (2009), Alexopoulos and Cohen (2009) and Knotek II and Khan (2011). While Bloom (2009) measures volatility on the

[1] The current paper is also sideways related to the literature that investigates the effects of macroeconomic volatility on growth (for example, Ramey and Ramey, 1995).

basis of shocks to the stock market, the latter two articles use also a second measure based on the number of articles in the New York Times that contain simultaneous references to uncertainty and the economy. In our analysis we use stock market volatility as a measure of uncertainty as it is readily available over a long period of time.[2] In addition, this measure of volatility leaves us with sufficient observations for our sub-sample analyses. The latter two articles also delve deeper into the transmission channel from volatility to growth by exploring the response of investment and different components of consumption to a change in volatility.

In contrast to the aforementioned works, we thus explore how the transmission changes over time. To this end we use a longer sample period than recent articles studying this transmission. Our estimates over the entire sample period confirm that an increase in U.S. stock market volatility is followed by a slowdown of U.S. real GDP growth. The main channel responsible for this finding is a slowdown of investment growth, although also consumption growth deteriorates after a volatility shock. Further, we find that both inflation and the federal funds rate tend to fall after the shock. Finally, the stock market return reacts negatively to the volatility shock, which suggests that this may be the main channel through which stock market volatility affects output growth. However, a counterfactual experiment in which we shut off the feedback from volatility onto the return confirms that the volatility measure has an independent, although reduced, effect on output growth. These findings are robust to using alternative measures of the stock market index (e.g. dropping or using only the most extreme volatility observations) and altering the VAR ordering and specifications.

If we split our sample, we find remarkably different results for the two sub-samples. Based on the literature we select as the breakpoint the first quarter of 1984. The negative response of GDP growth is substantially smaller during the second sub-period. Further, while during the first sub-period both a slowdown in consumption and investment growth contribute to a slowdown of GDP growth, during the second sub-period, only the investment reaction contributes to the GDP slowdown. These findings are also confirmed by rolling regressions. A variance decomposition shows that, going from the first to the second sub-period, the contribution of stock market volatility becomes negligible for consumption growth, while its contribution in the case of investment growth increases substantially. The role of the federal funds rate shrinks substantially for both variables.

The remainder of this paper is structured as follows. In the next section, we present our empirical specification, discuss the impulse responses that it produces, and test the robustness of the volatility – growth relationship when estimated over the full sample period. Section 3 explores the stability of the estimated relationships over time. Section 4 delves deeper into the potential

[2] Other authors using stock market volatility as a measure of uncertainty are Romer (1990) and Hassler (2001).

transmission channels of stock market volatility and how they change over time. Finally, Section 5 concludes this paper.

2. Full sample results and robustness

2.1. Baseline estimation for the full sample

Following other recent contributions we explore the relation between U.S. GDP growth and stock market volatility in a VAR system in order to allow for feedback effects among the variables and to control for monetary policy, which may be more or less accommodative to developments in the stock market. Therefore, our baseline quarterly VAR-specification is given by

$$Bx_t = \alpha d_t + A(L)x_{t-1} + \varepsilon_t, \qquad (1)$$

where $x_t = \left[x_t^{macro}\text{'}, x_t^{stockmarket}\text{'}\right]'$, $x_t^{macro} = \left[YGROWTH_t, INFL_t, FFR_t\right]'$ is a block of macro-economic variables and $x_t^{stockmarket} = \left[VOLDJ_t, RDJ_t\right]'$ is a block of stock market variables. All variables (and data) refer to the U.S., where $YGROWTH_t$ is real per capita GDP growth, $INFL_t$ is the CPI inflation rate, FFR_t is the federal funds rate, $VOLDJ_t$ is the volatility of the Dow Jones index and RDJ_t is the return on the Dow Jones index. Variables $YGROWTH_t$, $INFL_t$, FFR_t and RDJ_t are all annualised, while $VOLDJ_t$ is the sample standard deviation of the daily returns over the quarter. We have also calculated our volatility measure on the basis of the daily stock market return in excess of the risk-free interest rate, that is, in excess for federal funds rate. However, it turns out that this latter measure has a correlation of over 0.99 with $VOLDJ_t$ and, hence, we adhere to the use of $VOLDJ_t$ as our measure of volatility. Specification (1) also includes a vector d_t of seasonal dummies. Finally, α is a vector of parameters and B and $A(L)$ are matrices of parameters, where L is the lag operator. Under our baseline we include four lags of the vector of dependent variables. Below, we will show that the results are robust to the inclusion of additional lags.[3]

Our identifying assumption is based on matrix B being triangular, i.e. it is based on a Choleski decomposition. Hence, we assume that within a given period each variable does not react

[3] All macro variables were collected from the Bureau of Economic Analysis (real output growth, its components and the total population figure), the Bureau of Labor Statistics (CPI inflation) and the Federal Reserve (federal funds rate). The federal funds rate was available since July 1954, and was extended backwards using the Treasury Bills rate available from the Federal Reserve. The stock market variables were downloaded from Datastream.

to the ensuing ones in the ordering in x_t, while a given variable is allowed to react to those that precede it. Because stock market variables can react instantaneously to developments in the "real" economy, we order the stock market block after the macro-economic block.[4] Specifically, we also order FFR_t before the stock market block, because during a substantial part of the sample policymakers try to exert control over this variable by setting a target for it. On the one hand, they set the target in response to the preceding variables in the macro-economic block, while on the other hand they try to smooth its value (for example, see Clarida *et al.*, 1998) to avoid bringing financial markets in disarray by erratically moving their instrument. More generally, the monetary authority tries to maintain leadership position over the financial markets. Notice that the ordering within the macro-economic block is immaterial since all these variables are ordered before the stock market volatility, which is the variable whose impulse responses we want to study (see Christiano *et al.*, 1999). Within the stock market block we position $VOLDJ_t$ directly before RDJ_t, because theory suggests that stock market volatility has a contemporaneous (negative) effect on the returns, but not the other way round.[5]

The sample period for this benchmark specification is 1950Q2 – 2011Q2. Figure 1 depicts our stock market volatility measure $VOLDJ_t$. Volatility is found to be particularly high in 1987Q4, the period in which Black Monday occurred, and in 2008Q4, the period after the collapse of Lehman Brothers. In contrast to Campbell *et al.* (2001), our baseline keeps these extreme observations in our sample without adjusting them. The reason is there is no convincing economic argument that these observations should be treated as outliers. If anything, these observations are the "most exogenous" ones in the sample, which means that it is of particular interest to keep them in our sample. This is exactly why Bloom (2009) selects the most extreme stock market volatility observations to identify his uncertainty shocks. However, we will show below that our results are robust to dropping these extreme observations.

Figure 2 depicts the impulse responses to a shock in $VOLDJ_t$. Here, and in the sequel, we will *always* assume that the size of the shock is one standard deviation of the full sample series for $VOLDJ_t$ (see Table 2 below). This normalisation will allow us to directly compare the responses of output growth (and its components) across different specifications and sample periods. We will always use a 90% confidence interval and the responses of the other variables will always be expressed in percentage points on an annual basis.

[4] Bloom (2009), instead, positions the stock market index first, followed by the stock market volatility, the federal funds rate and, finally, macro-economic variables. Later, we will show that changes in the ordering of our VAR leave our results essentially unchanged.

[5] For example, see also Guo (2002). In his empirical analysis he runs regressions of stock market returns on the contemporaneous volatility.

Owing to the ordering in the VAR the contemporaneous responses of GDP growth, inflation and the federal funds rate are zero. One quarter after the shock, GDP growth drops below trend. This drop not only is statistically significant, it also is economically significant because GDP growth falls by roughly 1%-point on an annual basis. This slowdown in growth remains significant until two quarters after the shock. Over the subsequent periods growth gradually converges to its trend level. Inflation falls by roughly 0.3% point in the period after the shock. The fall in inflation is only significant one quarter after the shock. Further, in line with the slowdown of growth and the drop in inflation monetary policy is relaxed. The fall in the federal funds rate is marginally significant during the first five quarters after the shock and reaches a maximum of approximately 30 basis points one year after the shock.[6] Finally, we observe that the increase in stock market volatility produces a highly negative market return of roughly minus 18% points on an annual basis. The fall in the stock market index makes room for the higher future return demanded by investors that is the result of an increase in systematic stock market risk.

2.2. Investigation into the transmission channel

Earlier work by Schwert (1989) and Campbell *et al.* (2001) suggests that stock market volatility has significant predictive power for real GDP growth. However, Guo (2002) shows that the relationship between stock market volatility and economic activity is not fully robust to alternative model specifications. In particular, regressing GDP growth on contemporaneous stock market volatility, he finds a highly significant negative effect on GDP growth. However, once he controls for the current stock market return or for the current and past return jointly, the effect of volatility tends to weaken or it even becomes insignificant. Hence, the conclusion from his work is that stock market returns drive out stock market volatility in forecasting output and, therefore, that beyond stock market returns the volatility of the stock market provides no additional information about future output.[7]

As in Bloom (2009) and Alexopoulos and Cohen (2009), our model differs in two fundamental ways from the models of the aforementioned contributions. First, we allow for more lags in our model. Second, through the use of a VAR we also allow for feedbacks among the endogenous variables. The role of the feedback effect of stock market volatility via the stock market return can be explored by taking the stock market return RDJ_t out of the vector of endogenous variables x_t and entering it as an exogenous variable in equation (1). Hence, the stock market return

[6] Notice that if the monetary authorities had chosen not to lower their policy target, the negative impact of stock market volatility on growth might have been even larger.

[7] For the U.S. a positive correlation between economic activity and lagged returns has been documented in a number of studies quite long ago, see e.g. Fischer and Merton (1984) and Barro (1990).

is no longer allowed to react to the stock market volatility. This is equivalent to an experiment in which in response to a volatility shock the impulse response of the stock market return is counterfactually held fixed at its baseline value.[8] Figure 3 shows that under this counterfactual, one quarter after the shock output growth remains close to the baseline in which the stock market return is allowed to respond. The responses differ more substantially after two and three quarters, although the response under the counterfactual remains well within the original confidence band.

To investigate the transmission channel further, Table 1 reports the variance decomposition of output growth. During the entire response period we consider, more than three-quarters of the variance in output growth is explained by output itself, while relatively small portions are explained by the other variables. The share explained by the other variables is slowly increasing with the amount of time after the impulse and after 10 quarters around 7% of the variance is explained by volatility in the stock market and slightly less by the return on the stock market. These figures are of the same order of magnitude as the share explained by the federal funds rate. It is interesting to notice that at a quarterly frequency the volatility shock seems to play a similar role for variation in the GDP growth rate to what is found by the previous literature using monthly data for industrial production. In particular, Alexopoulos and Cohen (2009) show that at a 36 month horizon, stock market volatility shocks explain roughly 6 percent of the variation of industrial production.

Table 1: Variance decomposition of output growth (in percent)

After:	**1Q**	**2Q**	**5Q**	**10Q**
Output growth	93.68	83.48	79.50	79.13
Inflation	0.34	0.61	2.26	2.49
Federal funds rate	0.23	5.38	5.65	5.73
Stock price volatility	5.30	6.54	6.57	6.61
Stock price return	0.45	4.00	6.01	6.04

2.3. Robustness of full sample results

In this subsection we do a number of robustness checks on our baseline results for the full sample. The motivation for these robustness checks is that we want to make sure that our baseline results are unaffected by changes in the specification, the ordering in the VAR and the precise volatility

[8] Such counterfactual experiments are always potentially vulnerable to the "Lucas critique". Therefore, the evidence from this exercise should not be over-interpreted. Similar counterfactual experiments, though in a different context, are found in e.g. Ramey (1993) and Lozej (2011).

measure employed, so as to have a proper basis for the use of our baseline model in the comparison of the sub-sample periods.

Figure 4 graphs the responses of GDP growth to a stock market volatility shock for the various cases. We do not show the responses of the other variables, because they are rather similar to the baseline responses. The first robustness check involves the replacement of the Dow Jones index with the S&P 500 index. The disadvantage of using the S&P 500 index is that it starts only in 1965, thereby shortening our sample period by 15 years. However, the response of output growth is very similar to the baseline response, both qualitatively and quantitatively. In our second check, we add to our baseline VAR system the volatility of the oil price $VOLOP_t$, measured as the standard deviation of monthly logarithmic oil price changes calculated over the past year including the current month.[9] Oil price volatility can reasonably be considered the "most exogenous" variable. Hence, we place it first in our VAR ordering so that, now, $x_t = [VOLOP_t, YGROWTH_t, INFL_t, FFR_t, VOLDJ_t, RDJ_t]'$. The negative response of output growth after one quarter is somewhat weaker than before, but remains highly significant. Next, following Gilchrist *et al.* (2010) we add to our baseline VAR system the Baa/AAA corporate bond spread taken from the Federal Reserve. The output response is neither qualitatively, nor quantitatively affected. Our fourth check extends the number of lags in our VAR to six, which again yields an output growth response very similar to the baseline. The same is the case when we control for the two most extreme observations of $VOLDJ_t$, those of 1987Q4 and 2008Q4, by including as an exogenous variable a dummy that takes a value of one in these periods and a value of zero otherwise.[10] In our sixth check, we replace $VOLDJ_t$ with "Bloom's excessive volatility variable", which takes on the actual value of $VOLDJ_t$, whenever $VOLDJ_t$ exceeds its average by 1.65 standard deviations and a value of zero otherwise. This differs from Bloom (2009) who uses a dummy that takes on a value of one when stock market volatility exceeds its average by 1.65 standard deviations and a value of zero otherwise. However, in our view it is more appropriate to use the actual value to avoid imposing that smaller and larger shocks have the same effects.[11] The number of quarters selected in this way is rather small, but nevertheless output growth exhibits a (marginally) significant negative response one quarter after the shock, although quantitatively the output growth response is less than half that under the baseline. The next graph is based on a less conservative selection of high-volatility periods. Namely we assign our new "excessive volatility variable" the value of $VOLDJ_t$, whenever $VOLDJ_t$ exceeds its average by one standard deviation and a value of zero otherwise. The larger number of shocks

[9] Oil prices were taken from the Bureau of Labor Statistics.

[10] This is in line with Campbell *et al.* (2001) and Guo (2002), who replace (in their shorter sample) the volatility of 1987Q4 by the next-highest value in the sample.

[11] This is also in line with Alexopoulos and Cohen (2009), who use the actual values of the volatility to enhance the comparability with their New York Times based measure of uncertainty.

included allows us to estimate more precisely the effect of volatility shocks on output. Now the output growth response is indeed quantitatively closer that under the baseline.

In our next-to-last check we change the ordering of the VAR and place the "macro-economic block" at the end, so that we have $x_t = \left[x_t^{stockmarket}{}', x_t^{macro}{}' \right]'$. This ordering may be harder to justify theoretically, because it denies the fact that the volatility and the return on the stock market can be affected by contemporaneous economic conditions. Hence, this new ordering leaves the impact reactions of output growth, inflation and the federal funds rate to a volatility shock unrestricted. The impact response of output growth is negative and very close to significance. Output growth falls further one quarter after the shock, when the response becomes significant and is about the same size as that under the baseline. Finally, when we replace $VOLDJ_t$ with our excessive volatility variable in this ordering with the macro-economic block at the end, we observe a rather similar output growth response, which is quantitatively a bit smaller though after one quarter.

3. Sample split and rolling regressions

This section splits the sample into the two sub-periods 1950Q2 – 1983Q4 and 1984Q1 – 2011Q2. The selected sample split is based on the rather generally accepted view that the first quarter of 1984 is a breakpoint in the behaviour of U.S. GDP. McConnell and Perez-Quiros (2000) and Kahn *et al.* (2002) find that in this quarter there is a permanent shift of GDP from always having been in a state of high variance to a state of low variance. In particular, Kahn *et al.* (2002) find that technological factors are mainly responsible on the output side, while the more aggressive anti-inflation monetary policy regime gets the credit for more stable inflation. In order to check whether the period after 1984Q1 remains less volatile if we include the recent crisis, Table 2 reports the annual means and standard deviations of real output growth, real consumption growth, real investment growth and CPI inflation for the full sample and the two sub-periods. Consistent with the previous literature, we find that the volatility of all these variables is substantially lower during the second sub-period. Table 2 also displays the mean and standard deviation of the stock market volatility and the annual stock market return. It is of interest to notice that the average stock market volatility has been quite a bit larger during the second sub-period, though part of this difference can be attributed to the extreme stock market movements in 1987Q4 and 2008Q4.

Table 2: Mean and standard deviations of selected variables

	Full Period	1950Q2 - 1983Q4	1984Q1 - 2011Q2
Output growth	2.04 (3.92)	2.33 (4.73)	1.70 (2.60)
Consumption growth	2.17 (3.45)	2.37 (4.18)	1.92 (2.26)
Investment growth	3.72 (19.49)	4.67 (22.80)	2.54 (14.45)
Inflation	3.77 (3.28)	4.44 (3.90)	2.95 (2.03)
Stock market volatility	0.0084 (0.0043)	0.0073 (0.0027)	0.0099 (0.0054)
Stock price return	11.60 (31.74)	9.66 (30.51)	13.97 (33.18)

Notes: for all variables, except for the stock market volatility, the average annual value is reported in percent, while the corresponding standard deviation is reported in brackets. In the case of the stock market volatility we report the average (over the quarters) of the standard deviation of the daily returns over each quarter, with the standard deviation over these quarterly volatility observations reported in brackets below.

Figures 5a and 5b show the impulse responses for the respective sub-periods. The responses differ substantially between the two sub-periods. While for both sub-periods the response of GDP growth is significantly negative after one quarter, the response in the first sub-period is about five times larger than that in the second sub-period. In fact, if we were to exclude the turbulent years 2009 – 2011 from the data (a period also neither included by Bloom, 2009, nor by Alexopoulos and Cohen, 2009) then the response of output growth to the volatility shock would be even smaller in the second sub-period. It is important to emphasise that the sharp difference in the output growth responses between the two sub-periods cannot be attributed to a lack of variation in stock market volatility during the second sub-period, because the variability of $VOLDJ_t$ is substantially larger during the second sub-period (see Table 2).

The response of inflation is insignificant in the first sub-period, while it is significantly negative after one quarter in the second sub-period. Also, the federal funds rate behaves rather differently between the two sub-periods. In the first sub-period it becomes only significantly negative after two quarters, while in the second sub-period its response is significant (although marginally so) after one quarter. More important is the difference in the sizes of the responses, with that in the first sub-period around eight-fold larger at its peak than the maximum response in the second sub-period. The one-quarter responses of the stock market return are rather similar for the two sub-periods, but differ substantially two and three quarters after the shock when in the first sub-period the return response is substantial and significantly positive, while in the second sub-period it is close to zero, suggesting a permanent drop in the stock market index.

Figure 6 (Panel A) shows the impulse responses together with their significance bands one, two and four quarters after a volatility shock when we estimate a rolling VAR for the baseline model with a window of twenty-five years each time. The year indicated on the horizontal axis is the final year of the window. In line with the above results for the sample split, we see that the absolute sizes of the negative response coefficients after one and two quarters tend to shrink and lose significance as we go from earlier to later windows. To check the robustness of these results, in panel B we replace the extreme observations for 1987Q4 and 2008Q4 by the next-largest realised variance in the rest of the sample (up to the end of the relevant window). We see that the development of response patterns over time remains qualitatively the same, although for the two-quarter responses the pattern seems to become slightly "smoother". Shortening the window to twenty years (panel C) again yields similar patterns.

Table 3 shows the variance decomposition of output growth during the two sub-periods. Splitting the overall sample into the two sub-periods, we see that the role of output itself in explaining the output variance shrinks in the medium run when compared with the full sample decomposition. Comparing the two sub-periods, in the second sub-period the roles of the federal funds rate and the stock market volatility have shrunk substantially, while the role of the stock market return has become slightly more important and that of inflation has become substantially more important, rising to about 17% after ten quarters.

Table 3: Variance decomposition of output growth for sub-periods (in percent)

	1950Q2 – 1983Q4				**1984Q1 – 2011Q2**			
After:	**1Q**	**2Q**	**5Q**	**10Q**	**1Q**	**2Q**	**5Q**	**10Q**
Output growth	92.57	79.45	74.48	74.04	94.66	86.55	67.65	66.08
Inflation	0.65	1.29	2.85	2.89	0.58	4.88	16.31	16.76
Fed. funds rate	0.02	9.53	9.66	9.49	0.54	2.89	5.54	5.72
Stock price volatility	6.75	7.80	9.85	9.99	4.21	4.19	5.23	5.70
Stock price return	0.01	1.94	3.15	3.59	0.01	1.50	5.28	5.74

4. The responses of the components of GDP growth

This section explores how real private consumption and investment growth as major components of GDP growth are affected by a volatility shock. In each variant we take the baseline VAR in (1) and replace GDP growth by the per capita growth rate in one of these main components. Figure 7 depicts the impulse responses. We only show the responses of consumption or investment growth, but not those of the other variables in our VAR, because the responses of those variables are very similar to the corresponding responses when GDP growth is included.

In the case of the full sample period both consumption and investment growth fall significantly one quarter after the volatility shock.[12] However, the fall in investment growth is about ten times larger than the fall in consumption growth. Consumption growth falls by around 0.6% points, investment growth by around 6% points. The fall in investment growth is also more protracted. Consumption growth loses its significance after two quarters, while investment growth loses its significance after three quarters.

Splitting the full sample period into our two sub-periods yields useful insights. While consumption growth responds after one quarter with a statistically and economically significant fall in the first sub-period, in the second sub-period consumption growth does not react. The response of investment growth is significant and substantially larger than that of consumption growth in both sub-periods, although also for investment growth the magnitude of the short-run response shrinks as we go from the first to the second sub-period. In Figure 8 we also repeat the rolling regressions for consumption and investment growth and see that for consumption the responses at one, two and four quarters all shrink as the window shifts forward in time. While initially the one-quarter consumption growth responses are significant, the significance vanishes after a number of years. The magnitude of the one-quarter investment responses fall only slowly over time, while the reduction in the (absolute) size of the two-quarter responses is more rapidly and larger. It loses significance within less than a decade.

To gain further insight into the changing behaviour of consumption growth, we split consumption into durable goods, non-durable goods and services. We would expect durables consumption to behave similarly to investment. Figure 9 shows that this is to some extent indeed the case. For the full sample period, durables consumption growth reacts negatively after one period. This is also the case for the first sub-sample. However, there is no reaction in the second sub-period. As a result, quantitatively, the response in the first sub-period after one quarter is found to be more than two times larger than the reaction for the full sample, while even for the full sample it is estimated to be substantial. By contrast, while the response of non-durables after one quarter is significant for both the full sample and the first sub-sample, quantitatively these responses are smaller. When estimated for the full sample, services become significantly negative after two quarters, although also now the response is much smaller than for durables. For both sub-sample estimations, services do not react significantly.

[12] Also Knotek II and Khan (2011) find that stock market uncertainty has some role in driving household spending decisions.

Finally, we turn to the variance decompositions of consumption and investment growth. The results are reported in Table 4. In all instances, by far the largest part of the variance in consumption growth or investment growth is explained by the variance of the component itself. The role of stock market volatility is always (substantially) larger for the variance of investment growth than for the variance of consumption growth. Comparing the first and second sub-period, we see some interesting changes. In the second sub-period, stock market volatility loses almost any of its relevance for the variance of consumption growth, while the federal funds rate loses much of its relevance, both in favour of an increased role for the stock market return, which after 10 quarters explains 15% of the variance. In the case of investment, the federal funds rate becomes even less relevant, while the role of stock market volatility increases even further when compared with the first sub-period and explains about 18% of the variance after 10 quarters. This is in line with the substantially higher stock market volatility during the second sub-sample.

Table 4: Variance decomposition of GDP components (in percent)

	Consumption growth				**Investment growth**			
After:	**1Q**	**2Q**	**5Q**	**10Q**	**1Q**	**2Q**	**5Q**	**10Q**
	Full sample				**Full sample**			
Comp. growth	87.46	79.87	74.10	73.82	86.49	75.50	70.28	69.62
Inflation	6.92	5.99	9.44	9.62	3.30	3.81	5.89	6.00
Federal funds rate	1.27	6.18	6.70	6.68	1.47	5.37	6.33	6.31
Volatility DJ	2.92	2.96	3.70	3.79	8.57	11.94	11.47	12.01
Return DJ	1.43	5.00	6.06	6.09	0.18	3.38	6.02	6.05
	Period 1950 – 1983				**Period 1950 – 1983**			
Comp. growth	84.87	74.27	65.86	65.99	90.74	76.47	69.06	68.14
Inflation	6.75	6.03	11.02	10.90	2.47	6.27	7.56	7.49
Federal funds rate	2.50	14.10	13.59	13.52	1.05	5.40	6.89	6.91
Volatility DJ	5.87	5.21	8.49	8.55	5.05	7.22	10.27	10.69
Return DJ	0.01	0.38	1.05	1.05	0.69	4.64	6.22	6.78
	Period 1984 – 2011Q2				**Period 1984 – 2011Q2**			
Comp. growth	85.16	75.98	68.40	65.29	80.09	77.35	59.11	57.17
Inflation	9.95	9.78	13.92	15.23	2.76	3.08	17.13	17.60
Federal funds rate	0.81	1.63	3.77	3.52	0.03	0.06	0.94	2.21
Volatility DJ	0.23	0.36	0.56	0.76	16.65	19.02	17.52	17.84
Return DJ	3.86	12.25	13.35	15.20	0.48	0.49	5.30	5.17

Notes: "Comp. growth" is growth in the component (consumption or investment) of GDP.

7. Concluding remarks

In this paper we have explored the changing role of stock market volatility for U.S. GDP growth and its main components over the period since the beginning of the 1950s until now. Our baseline model is a VAR that includes a macro block with GDP growth, inflation and the federal funds rate and a stock market block with the stock market return and its volatility. For our full sample we confirm the rather common finding that an increase in U.S. stock market volatility leads to a slowdown of U.S. real GDP growth. We also find such a slowdown for each of our sub-sample periods. However, the slowdown in the first sub-period is much larger than during the second sub-period. During the first sub-period both a slowdown in consumption and investment growth contribute to the GDP slowdown, although the investment slowdown is much larger. During the second sub-period, only an investment slowdown contributes to the GDP slowdown. Regressions with a rolling window over the entire sample period confirm this pattern. A variance decomposition for consumption growth shows that, going from the first to the second sub-period, the contribution of stock market volatility becomes negligible, while the corresponding decomposition for investment growth reveals an increase in the role of stock market volatility.

Several directions for further research present themselves rather naturally. An obvious direction is to extend the empirical analysis of this paper to more countries to see whether the consequences of an increase in stock market volatility found for the U.S. are also found in other countries and, in particular, whether the changing response pattern for the U.S. is confirmed for other countries as well. Eventually one would want to build a theory that can account for the most salient empirical findings.

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Figure 1: Quarterly variance of daily returns on the Dow-Jones index

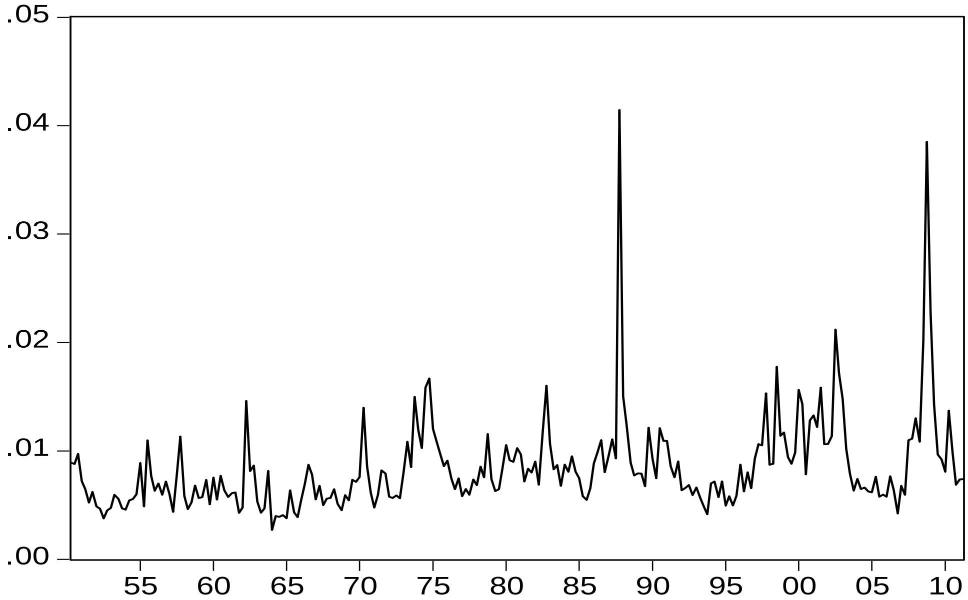
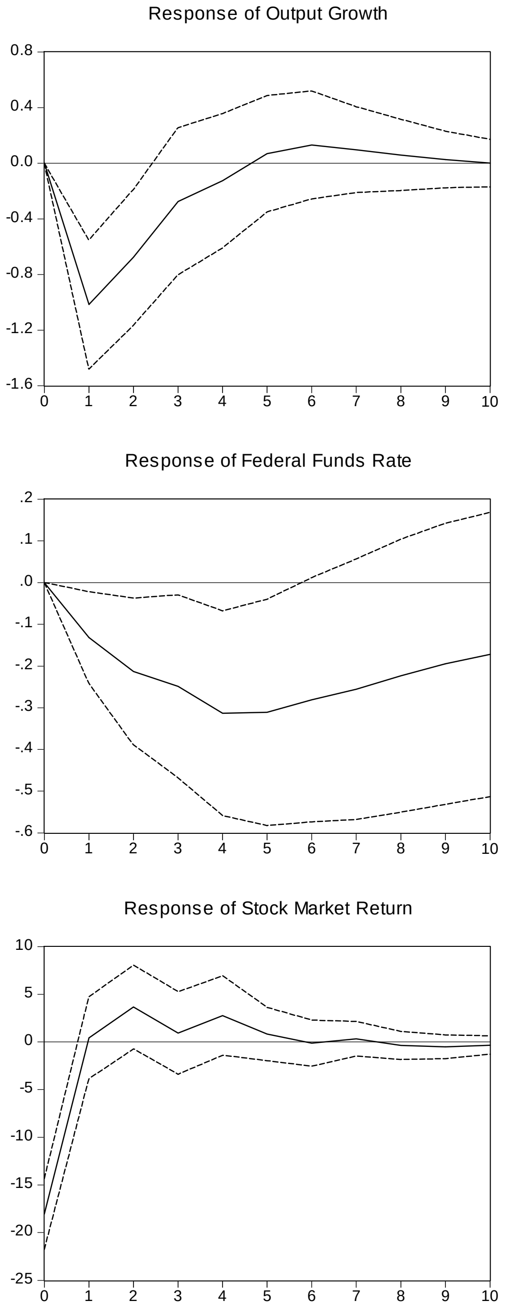
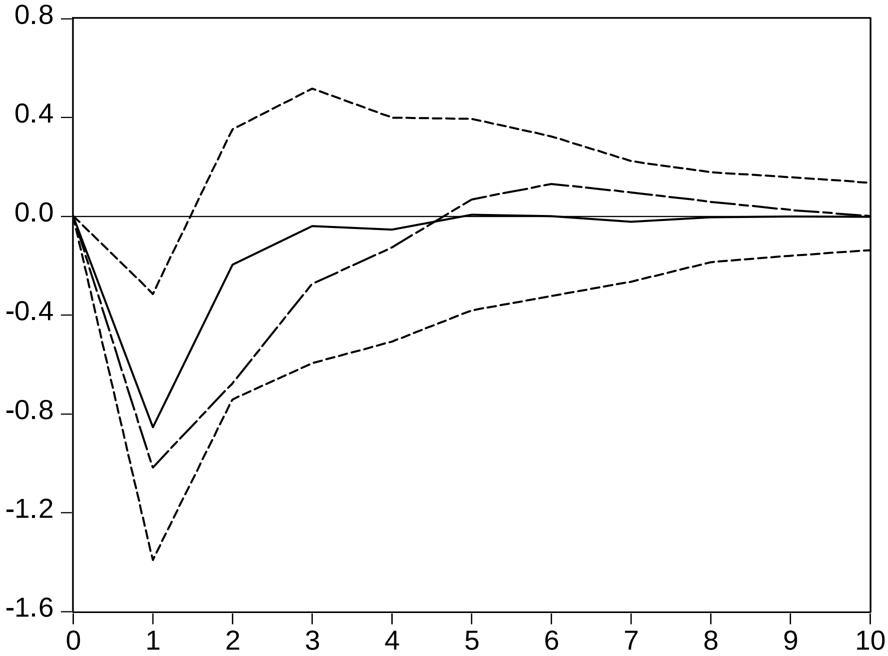


Figure 2: Baseline impulse responses full sample period



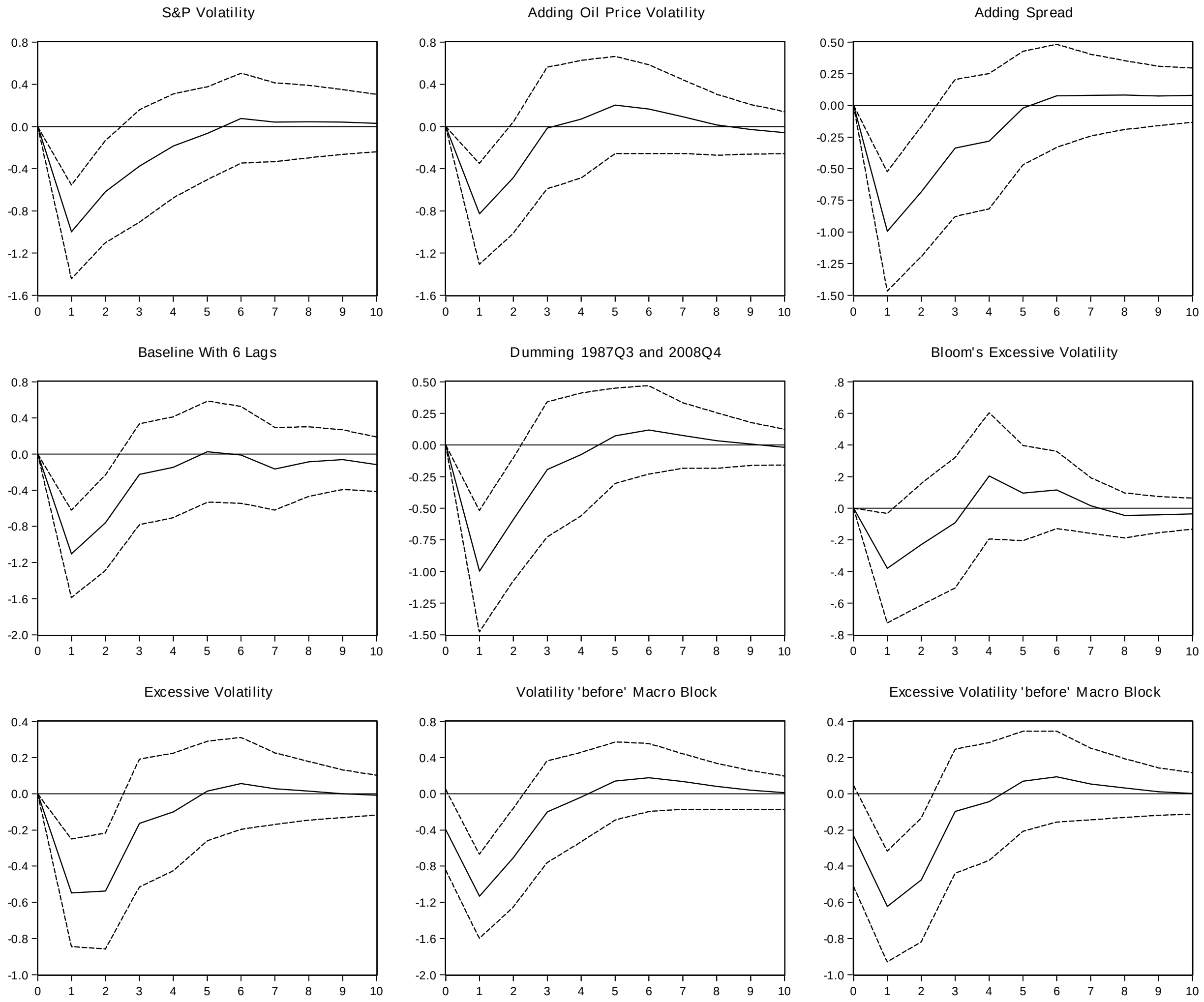
Notes: response of the endogenous variable to a stock market volatility shock. Size of the shock is one standard deviation of the full sample series for $VOLDJ_t$. Confidence bands are based on a 90% significance level and constructed from Monte Carlo simulations based on 1,000 replications.

Figure 3: Stock market return included as exogenous variable – full sample period



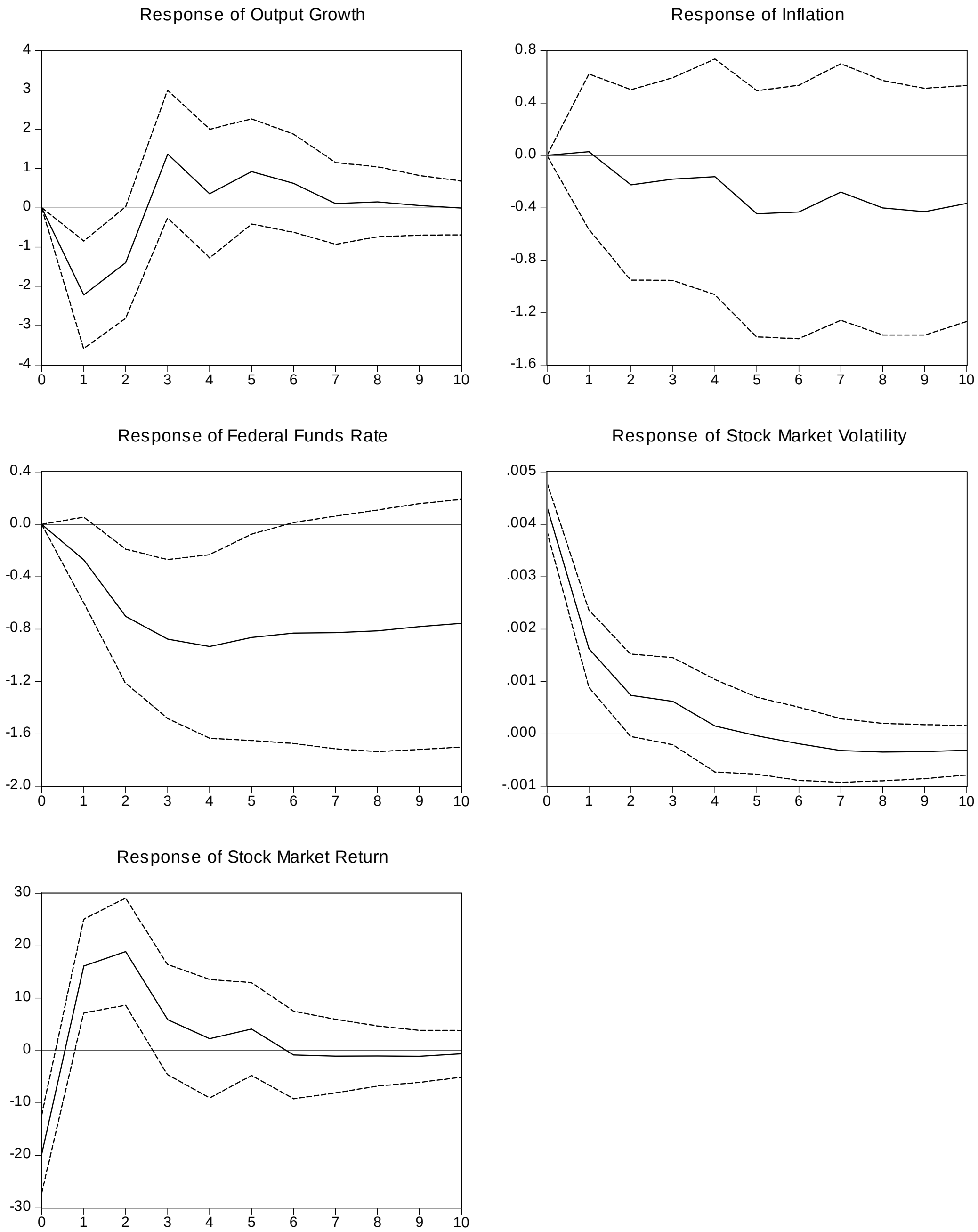
Notes: the unequally-dashed line within the confidence bands shows the response of output growth in the baseline model when the stock-market return is not allowed to react to the volatility shock. Further, see *Notes* to Figure 2.

Figure 4: Robustness for full sample period



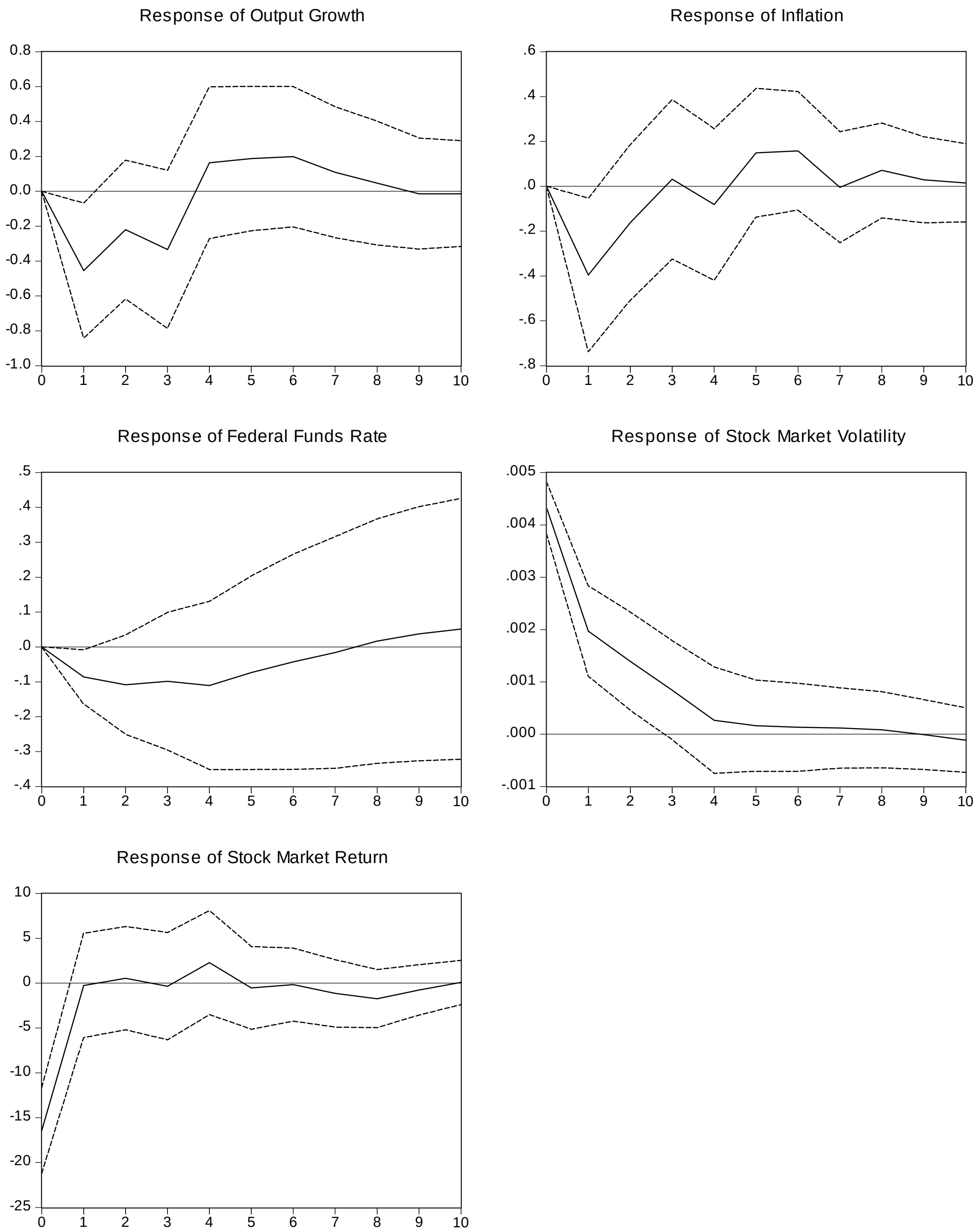
Notes: Each graph shows the response of output growth to a stock market volatility shock under different variations to the baseline VAR model. Further, see *Notes* to Figure 2.

Figure 5a: First subsample (1950Q2 - 1983Q4)



Note: See *Notes* to Figure 2.

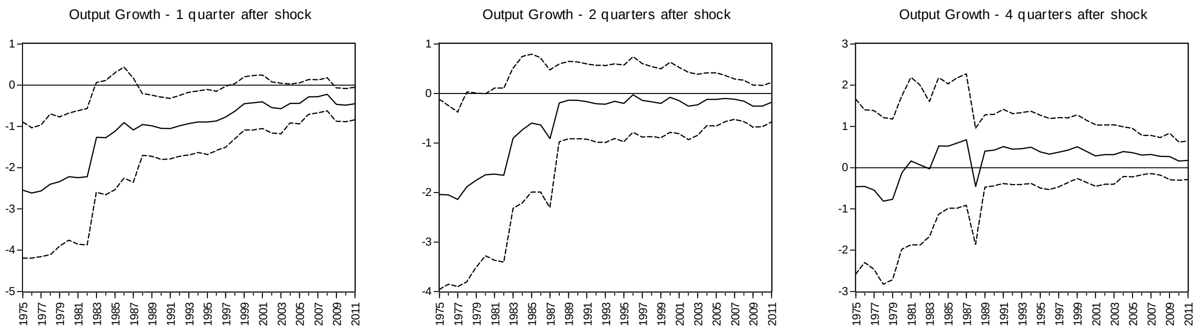
Figure 5b: Second subsample (1984Q1 - 2011Q2)



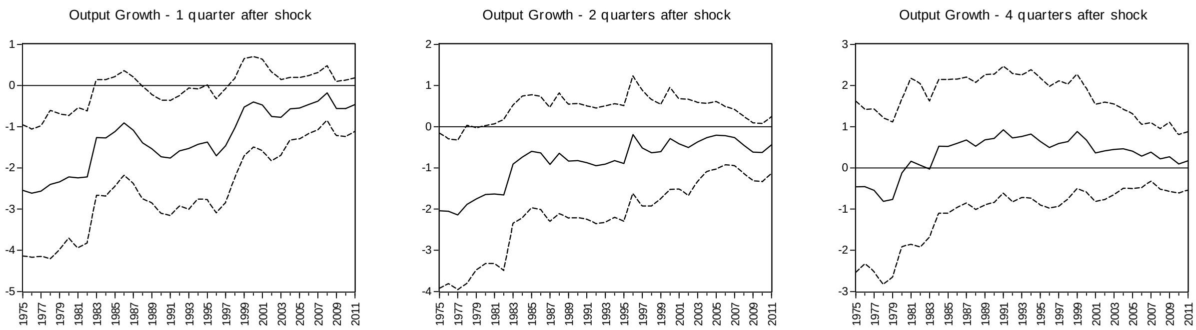
Note: See *Notes* to Figure 2.

Figure 6: Responses of output growth to volatility shocks in rolling VARs

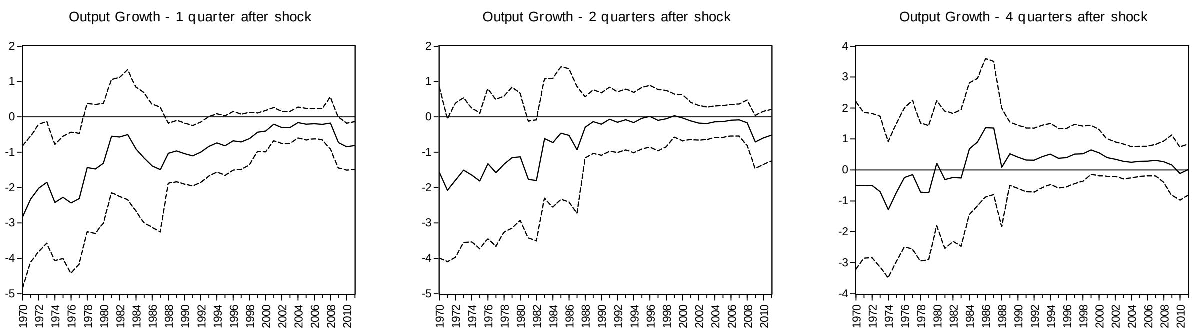
Panel A: 25-year window



Panel B: 25-year window controlling for 1987Q4 and 2004Q4

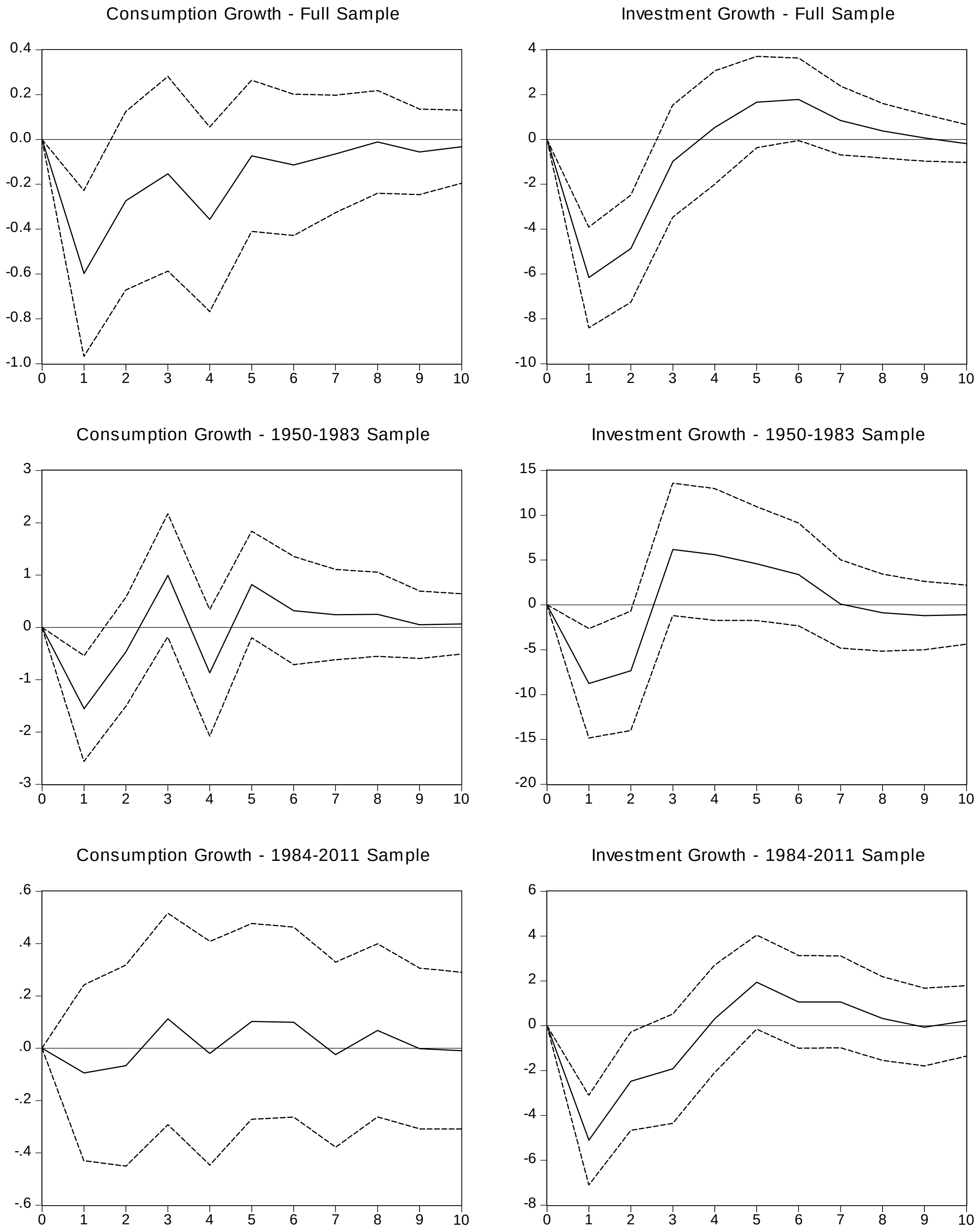


Panel C: 20-year window



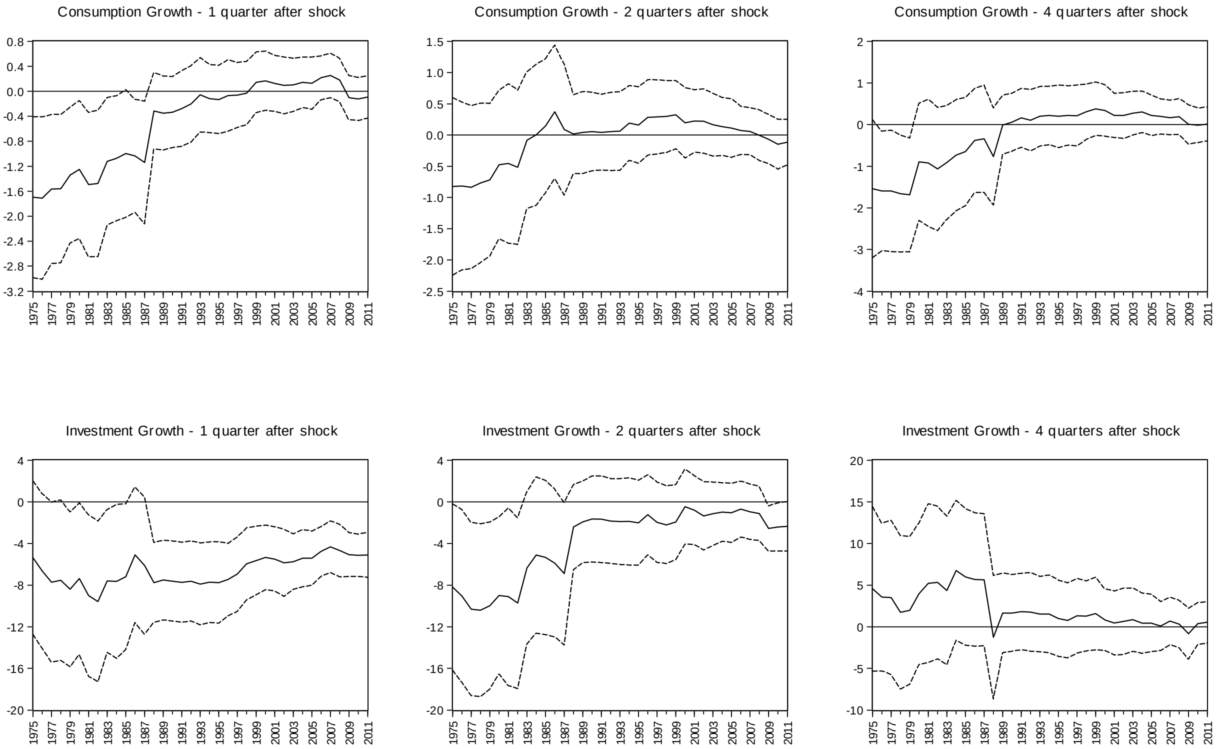
Notes: Following Campbell *et al.* (2001), in Panel B we replace the variances of 1987:Q4 and 2008:Q4 by the next-largest realised variance in the rest-of-the-sample (thus excluding these two dates) up to the end of the window. Further, see *Notes* to Figure 2.

Figure 7: Responses of consumption and investment growth to volatility shocks



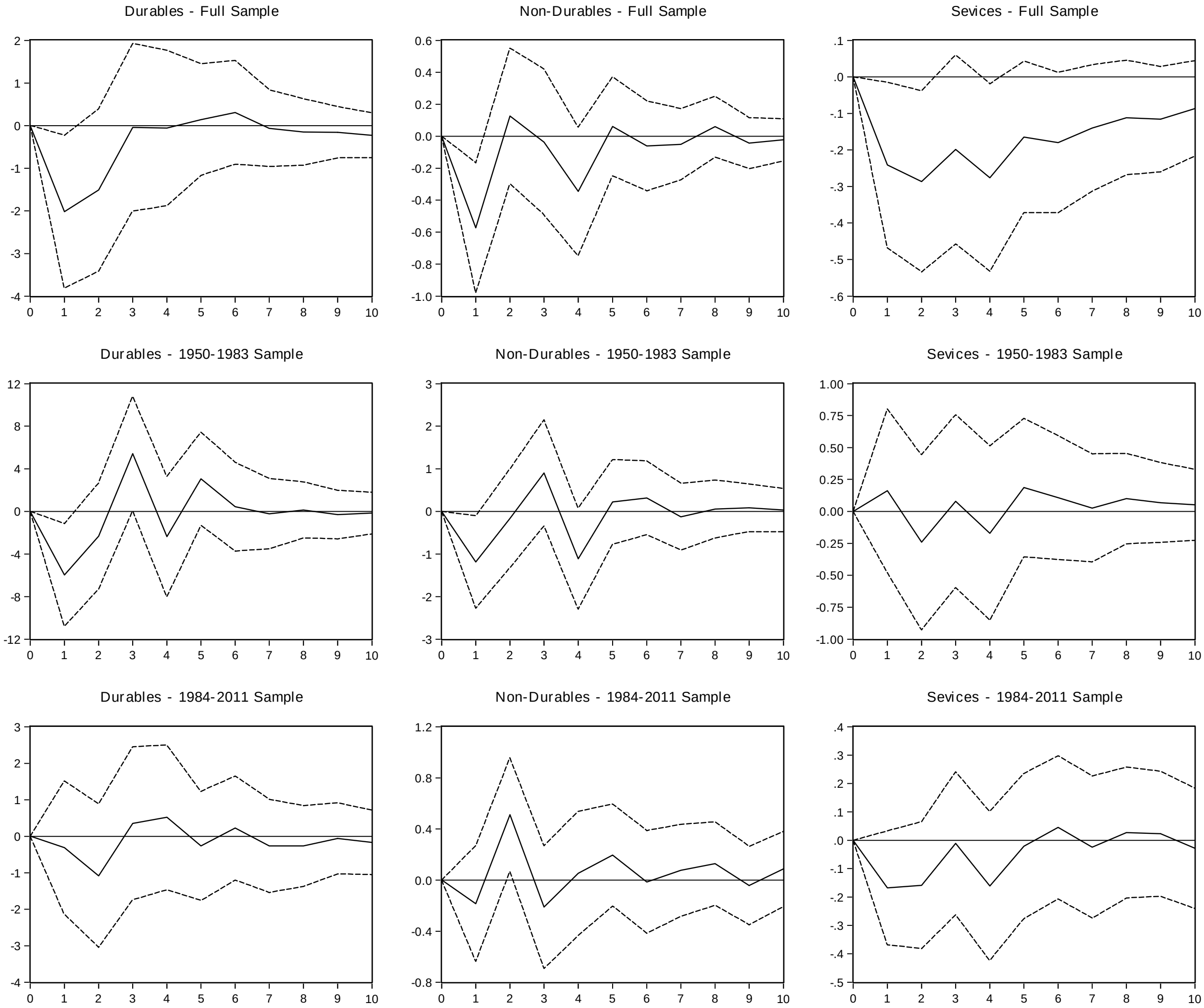
Note: see *Notes* to Figure 2.

Figure 8: Responses of consumption and investment growth to volatility shocks in rolling VARs with 25-year windows



Note: see *Notes* to Figure 2.

Figure 9: Responses of durables, non-durables and services growth to a volatility shock



Note: see *Notes* to Figure 2.