OESTERREICHISCHE NATIONALBANK
EUROSYSTEM

WORKING PAPER 168

Stock Market Volatility, Consumption and Investment; An Evaluation of the Uncertainty Hypothesis Using Post-War U.S. Data

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Imprint: Responsibility according to Austrian media law: Günther Thonabauer,
Communications Division, Oesterreichische Nationalbank.
Published and printed by Oesterreichische Nationalbank, Wien.
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Editorial

The authors estimate the effects of stock market volatility on the growth rates of durable consumption, non-durable consumption and investment using post-war US data. The authors' results indicate that high levels of stock market volatility exert large adverse effects on the growth rates of investment and durable consumption, whereas the influence on non-durable consumption growth is rather limited. The ordering of the magnitudes of the effects of stock market volatility across the three components of aggregate demand supports the idea that stock market volatility is closely related to uncertainty about future economic developments.

May 11, 2011

Stock Market Volatility, Consumption and Investment; An Evaluation of the Uncertainty Hypothesis Using Post-War U.S. Data*

Burkhard Raunig[†] Johann Scharler[‡]

May 4, 2011

Abstract

We estimate the effects of stock market volatility on the growth rates of durable consumption, non-durable consumption and investment using post-war US data. Our results indicate that high levels of stock market volatility exert large adverse effects on the growth rates of investment and durable consumption, whereas the influence on non-durable consumption growth is rather limited. The ordering of the magnitudes of the effects of stock market volatility across the three components of aggregate demand supports the idea that stock market volatility is closely related to uncertainty about future economic developments.

Keywords: uncertainty hypothesis, stock market volatility, consumption,

investment

JEL codes: E44, E20, E30

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* We would like to thank Nick Bloom and Skander Van den Heuvel for helpful comments and discussions.

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1 Introduction

The role of uncertainty in explaining business cycle fluctuations has recently received renewed interest. For instance, Bloom (2009) and Bloom et al. (2009) introduce models where the source of fluctuations in economic activity is not primarely stochastic productivity, as it is in standard real business cycle models, but shocks to the variance of the distribution describing productivity. Huge stock market fluctuations may constitute (or at least reflect) another important source of economic uncertainty which may in turn influence the business cycle. Indeed, Romer (1990) argues that the stock market crash in 1929 and the subsequent increase in the volatility of stock prices was interpreted by consumers as an indication that the future development of incomes had become less certain. The higher uncertainty about future income had an adverse effect on consumption spending and the resulting shortfall in aggregate demand ultimately lead to the Great Depression. This view has been labeled the 'uncertainty hypothesis'.

Uncertainty plays an important role when decisions are (at least partly) irreversible (Bernanke, 1983; Romer, 1990). Intuitively, higher uncertainty makes the commitment associated with irreversible decisions more costly. Stated in the language of option pricing theory, delaying an irreversible decision has a high option value when uncertainty is high. Thus, if stock market volatility is indeed associated with uncertainty, then its influence should depend on the extent to which decisions are irreversible. Given that investment decisions are presumably the least reversible, one should observe the largest effect of stock market volatility on investment, followed by durable consumption and non-durable consumption. Thus, comparing the magnitudes of the effects across the different categories of aggregate demand should help in assessing the hypothesis that stock market volatility is closely related to uncertainty.[1]

In this study we examine empirically the uncertainty hypothesis using post-war U.S. macroeconomic and financial data. In particular, we estimate how the growth rates of durable consumption, non-durable consumption and investment respond to measures of stock market volatility using system estimation methods. We extend the original uncertainty hypothesis in two directions. Firstly, by using post-war U.S. data we examine the business cycle implications of stock market volatility more generally and not specifically in the context of the Great Depression. Secondly, we analyze durable and non-durable consumption along with private investment. As argued above, uncertainty should depress investment even more than durable and non-durable consumption.

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[1] Romer (1990) finds that it was primarily durable consumption which declined substantially during the early 1930s.

We find that stock market volatility exerts statistically and economically significant negative effects on consumption and investment growth. Quantitatively, we obtain the largest adverse effect for investment growth, followed by durable and non-durable consumption growth. This ordering of the magnitudes of the effects is consistent with the prediction that stock market volatility exerts particularly pronounced effects when the degree of the irreversibility of decisions is high. Thus, stock market volatility appears indeed to be closely related to economic uncertainty. Furthermore, we find that stock market volatility has contributed substantially to lower consumption and investment growth during the last three recessions. Taken together, our empirical results provide some support for the uncertainty hypothesis.

Our paper is related to earlier contributions on the uncertainty hypothesis: Greasley et al. (2001) study the role of income uncertainty during the Great Depression using various indicators for uncertainty in the light of different theories of consumption. Ejarque (2009) evaluates the role of uncertainty in the context of the Great Depression in a calibrated business cycle model. To our knowledge, the uncertainty hypothesis has not been evaluated using post war data. Although Choudhry (2003) analyzes the effects of stock market volatility on consumption and investment, by treating stock market volatility as a non-stationary variable in an error-correction framework, his analysis does not deal with the uncertainty hypothesis per se.

In the literature on investment under uncertainty, stock market volatility is also frequently used to proxy the uncertainty associated with future cash flows (see for example Schwert, 1989; Leahy and Whited, 1996; Bloom et al., 2007; Carruth et al., 2000, and the references therein). However, most contributions in this literature analyze firm level data and focus more on firm or industry speciffic uncertainty, whereas we are interested in the effects of general macroeconomic uncertainty on economic aggregates.

The remainder of the paper proceeds as follows: Section 2 describes our methodology and the data set. Section 3 presents the main results and additional robustness checks, while Section 4 discusses to what an extend stock market volatility contributed to the decline in consumption and investment during the last three recessions. Section 5 summarizes and concludes the paper.

2 Empirical Methodology

To empirically assess the impact of stock market volatility on consumption and investment growth, we estimate the following equations:

$$con_t^d = \sum_{i=0}^{N} \gamma_i^d v_{t-i} + \delta_d' x_t^d + \epsilon_t^d, \tag{1}$$

$$con_t^{nd} = \sum_{i=0}^{N} \gamma_i^{nd} v_{t-i} + \delta_n' x_t^{nd} + \epsilon_t^{nd}, \tag{2}$$

$$inv_t = \sum_{i=0}^{N} \gamma_i^{inv} v_{t-i} + \delta_i' x_t^{inv} + \epsilon_t^{inv}, \tag{3}$$

where con_t^d, con_t^{nd} and inv_t are quarterly growth rates of real durable consumption, real non-durable consumption and real private investment, v_t is a measure of stock market volatility, x_t^d, x_t^{nd} and x_t^{inv} are vectors of control variables (including a constant), and $\epsilon_t^d, \epsilon_t^{nd}$ and ϵ_t^{inv} are error terms.

According to the uncertainty hypothesis, increased stock market volatility raises uncertainty about the future course of the economy and hence about the level of future income. The increased uncertainty puts in turn downward pressure on consumption. Consequently, we should observe a negative relationship between stock market volatility and consumption. The negative effect of stock market volatility on durable consumption should be particularly pronounced, due to the increased irreversibility of durable consumption. High stock market volatility may also reduce non-durable consumption, but this need not be case, since consumers may substitute non-durable consumption for durable consumption because the irreversibility is not as pronounced as for durable consumption. Thus, the uncertainty hypothesis does not yield an unambiguous prediction about the sign of the effect of volatility on non-durable consumption. In theory the effect of uncertainty on durable consumption could also be positive if agents reduce irreversible investment but substitute into the relatively less irreversible durable consumption (Ejarque, 2009). Whether these possible substitution effects are of practical relevance is an empirical question.

In analogy to consumption, increased stock market volatility may also raise uncertainty about future cash flows from planned investments and lead firms to postpone investment projects.In an influential book, Dixit and Pindyck (1994) use option pricing theory to analyze investment behavior. They show that delaying an investment project is a valuable option when investment decisions are irreversible (see also McDonald and Siegel, 1986; Bertola and Caballero, 1994; Caballero and Engel, 1999; Abel and Eberly, 1996). Consequently, to make an investment, the expected future cash flow associated with the project has to cover the value of the option of delaying the investment in addition to the costs arising from the project. The interesting result for our purposes is that an increase in uncertainty increases the option value of waiting. To the extent that investment is even less reversible than durable consumption we expect the effect of stock market volatility on investment to be especially pronounced.[2]

Consumption- and investment decisions may be influenced by similar shocks. Therefore, it is plausible that the errors across equations (1), (2) and (3) are correlated. This potential correlation can be exploited to obtain

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[2] Again, theoretically, the sign of the relationship between volatility and investment growth is ambiguous. For instance, in Bloom et al. (2009) uncertainty exerts a positive effect on investment in the absence of adjustment costs.

more efficient coefficient estimates. Therefore, we estimate equations (1) - (3) as a system. In particular, we estimate the system using Generalized Method of Moments (GMM) with the full set of explanatory variables in the system serving as instruments in each individual equation. Thus, like in a seemingly unrelated regression (SUR) framework, we assume that the explanatory variables are not only predetermined in their own equation but also in all the other equations of the system. These 'cross orthogonalities' impose a priori exclusion restrictions which are exploited in the estimation of the system. Under conditional homoskedasticity SUR estimation of the system would be appropriate, but the usual SUR standard errors are not robust against autocorrelation and conditional heteroskedasticity. By using efficient multiple-equation GMM instead of SUR we need not assume conditional homoskedasticity and are able to obtain heteroskedasticity and autocorrelation (HAC) robust standard errors.

We include lagged dependent variables, lagged aggregate consumption growth, con_{t-1}, as well as the lagged, quarterly return on the S&P 500 stock index ($return_{t-1}$), and the growth rate of industrial production, ip_{t-1} as contol variables in our baseline specification. Later we also estimate versions of (1), (2) and (3) including lagged inflation (inf_{t-1}), the term spread ($spread_t$) as well as measures of the conditional standard deviations, $\sigma(inf_t)$ and $\sigma(spread_t)$, of inflation and the term spread, respectively. We also estimate specifications were we control for possible uncertainty arising from real economic activity as opposed to stock market uncertainty. To proxy this type of uncertainty, we use the conditional standard deviation of industrial production growth, $\sigma(ip_t)$.

In our analysis, we use quarterly macroeconomic data about the US economy ranging from 1959q3 to 2008q4. We calculate quarterly percentage growth rates of real durable and non-durable consumption as well as investment using data on durable consumption, non-durable consumption and private investment in real terms provided by the economic data base FRED of the Federal Reserve Bank of St. Louis. The quarterly data on industrial production and the consumer price index (CPI) from which we obtain quarterly percentage changes in industrial production and inflation come also from the FRED data base. The term spread $spread_t$ is calculated as the difference between the 10 year government bond yield and the three month money market rate provided by the data base of the Board of the Governors of the Federal Reserve System. Daily closing values of the S&P 500 stock index, retrieved from Yahoo!Finance, are used for calculating quarterly returns on the S&P 500 and in estimating quarterly US stock market volatility.

We consider four different measures of stock market volatility. Our reference measure comes from an asymmetric GARCH (generalized autoregressive conditional heteroskedasticity) model proposed in Glosten et al. (1993), henceforth GJR. The GJR model allows for the possibility that stock market volatility responds differently to 'bad news' (i.e. negative shocks) and 'good news' (i.e. positive shocks). We apply the model to monthly S&P 500 stock index returns, r_{mt}, calculated from daily S&P 500 data. We specify the conditional mean of the returns as a first order autoregressive process

$$r_{mt} = \alpha_0 + \alpha_1 r_{mt-1} + \sqrt{h_t}\varepsilon_t \tag{4}$$

where ε_t is an independently and identically distributed error with zero mean and unit variance. The conditional variance of the returns is given by

$$h_t = \beta_0 + \beta_1 \varepsilon_{t-1}^2 + \beta_2 \Pi_{t-1}^- \varepsilon_{t-1}^2 + \beta_3 h_{t-1} \tag{5}$$

with Π_t^- equal to 1 if $\varepsilon_t < 0$ and zero otherwise. We take the square root of the sum of the estimated monthly conditional variances from the model over a given quarter as a measure of quarterly stock market volatility, which we denote by σ_t.

To explore the sensitivity of our results with respect to different measures of stock market volatility, we also estimate specifications for consumption and investment where v_t is either the quarterly standard deviation of the S&P 500 returns, implied volatility or an indicator for increased stock market volatility constructed by Bloom (2009). We calculate the quarterly standard deviation of S&P 500 stock index returns from daily log returns r_i as

$$s_t = Q\sqrt{\frac{1}{N-1}\sum_{i=1}^{N}(r_i - \overline{r})^2}, \tag{6}$$

where $\overline{r}$ is the average daily return over a given quarter, N denotes the number of trading days within this quarter and $Q = \sqrt{365/4}$ is a scaling factor that converts daily volatility into quarterly volatility.

Our measure of implied US stock market volatility is the the Chicago Board Options Exchange (CBOE) implied volatility index VIX introduced in Whaley (1993) which is based on the implied volatility backed out from prices of traded S&P 500 (SPX) index options. Originally the index was calculated from S&P100 index (OEX) options which were more liquid at that time. The older index is now named VXO. In 2003 the CBOE changed the calculation of the index to account, among other things, for the fact that the market for S&P 500 index options became much deeper than the market for S&P 100 options.[3] The CBOE provides the VIX using the new calculation methodology back until 1990. Our sample starts in 1959, however. Therefore we develop a VIX_t history back until 1959. To this end we first exploit daily VXO data which are available back until the beginning of 1986. To construct a history of the VIX over the period 1986 - 1989, we regress the daily VIX over the period 2008-1990 on the corresponding daily VXO (suppressing the

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[3] See Whaley (2009) for further details on the history and the construction of the VIX.

intercept). The coefficient from this regression yields the adjustment factor 0.949. We multiply the daily VXO over the period 1989-1986 with this adjustment factor to get the corresponding daily VIX history. Since our other volatility measures are on a quarterly basis we calculate a quarterly VIX series, VIX_{it}, as the average of the daily VIX within a quarter and divide this average by $\sqrt{4}$ since the daily VIX is quoted on an annualized basis. To construct the VIX history from 1959q3-1985q4, we regress VIX_{it} over the period 2008q4-1986q1 on the corresponding quarterly S&P 500 standard deviation s_t as obtained with equation (6). This regression (again without a constant) yields an adjustment factor of 0.929 which we then use to scale s_t over the period 1959q3-1985q4 to construct a VIX history for that period.

Finally, we use a stock market volatility indicator, SVI_t, constructed in Bloom (2009) as an alternative qualitative measure of US stock market volatility. This measure differs from the former ones in the sense that it is not a direct measure of stock market volatility but a dummy variable that takes on the value of one in times of jumps in stock market volatility and zero otherwise. Table 2, adopted from Bloom (2009), lists the periods when $SVI_t = 1$ for easy reference.

Tables 3 and 4 report summary statistics and correlations between our alternative measures of US stock market volatility. According to Table 3, all quantitative volatility measures indicate a similar level of about 8 percent volatility on average, albeit the minima and maxima of the volatility measures differ considerably. Table 4 shows that the VIX_t and s_t are highly correlated ($\rho = 0.93$) partly because the earlier part of the history of the VIX is a scaled version of s_t. The the correlation of the GJR-based volatility σ_t with s_t and the VIX_t is 0.76 and 0.68, respectively. As to be expected, the correlation of the indicator variable of stock market volatility SVI_t with the other volatility measures is somewhat lower and in a range from 0.45 to 0.60.

3 Estimation Results

We begin our empirical investigation of the uncertainty hypothesis by estimating the system of equations (1), (2) and (3) using the GJR based conditional volatility, σ_t, as a measure of US stock market volatility. Starting with contemporaneous volatility and a maximum number of $N = 4$ lags we then exclude statistically insignificant lags. In the equations for consumption growth (1) and (2) only contemporenous volatility is significant. We keep only lagged volatility, σ_{t-1}, in the equation for investment growth (3) since higher lags as well as contemporenous volatility are insignificant, which is consistent with the idea that investment decisions are likely to be subject to implementation lags. To capture the dynamics in the consumption and investment series we include in each equation the first lag of the dependent variable and also lagged aggregate consumption growth, con_{t-1}, in (1) and (2) and the lagged growth rate of industrial production, ip_{t-1} in (3), respectively. Table 5 shows the results for this specification of our system of equations.

In the consumption equations the estimated coefficients on σ_t are negative and statistically significant at the 1 percent level, implying negative effects of contemporaneous stock market volatility on durable and non-durable consumption growth. In the investment equation the coefficient on lagged stock market volatility, σ_{t-1}, is also negative and highly significant. Quantitatively, we obtain the largest effect for investment growth, which is consistent with the interpretation that investment decisions are the least reversible. Furthermore, the dampening effect of stock market volatility on durable consumption growth is about twice as large as for non-durable consumption growth. This ordering of the magnitudes of the effects is in line with the uncertainty hypothesis. The magnitudes of the effects are also of economic significance. For instance, an increase in σ_t by one standard deviation reduces quarterly durable consumption growth by roughly 0.7 percentage points. Since according to Table 1 the standard deviation of durable consumption growth is about 3 percent, fluctuations in stock market volatility account for a non-negligible fraction of the variability of of this series. Similar conclusions also emerge for non-durable consumption and investment growth.

Table 5 also shows that the lagged, quarterly return on the S&P500

stock index, $return_{t-1}$, exerts positive effects on consumption and investment growth. However, the coefficient is statistically significant at conventional levels only for non-durable consumption. Hence, the evidence is weaker than in the case of volatility, which is consistent with Lettau and Ludvigson (2004) who argue that transitory innovations in asset prices account for the bulk of fluctuations in asset wealth and have a negligible influence on consumption.

Turning to the remaining control variables, we find that the lagged endogenous variables are statistically significant and negatively signed in all three specifications. Lagged aggregate consumption growth, con_{t-1}, is positive and statistically significant in the consumption equations and investment growth depends significantly and positively on lagged industrial production growth.[4]

Durable and nondurable consumption may be cointegrated with aggregate consumption. In this case (1) and (2) would be mis-specified since the error-correction mechanism is ignored. Analogously, (3) would be mis-specified if investment and industrial production are cointegrated. Using the Engle and Granger (1987) as well as the Johansen (1991) methodologies, we find only limited evidence in favor of cointegration for the entire sample period.

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[4] In our baseline specifications for consumption growth we follow Romer (1990) and control for aggregate consumption growth, con_{t-1}. We also estimated specifications where we replaced con_{t-1} by the lagged growth rate of real GDP. The results are almost identical and available upon request.

Despite this limited evidence, we re-estimated equations (1), (2) and (3) including error-correction terms. The results for the short-run dynamics, and thus for the effect of stock market volatility on the dependent variables, are essentially identical to what we report in Table 5. Therefore, we do not include the error-correction terms in the remainder on our analysis.[5]

According to the uncertainty hypothesis, high stock market volatility leads to an economic downturn via adverse effects on aggregate demand. However, recessions are frequently accompanied by increased stock market volatility. The results presented so far could therefore simply mirror that consumption and investment growth tend to be relatively subdued during recessions. To guard against this possibility, we now explicitly control for recessions by augmenting our baseline specifications with a recesion dummy variable, rec_t, which takes on the value of one if a quarter is classified as a recession quarter according to the National Bureau for Economic Research (NBER) Business Cycle Dating Committee and is zero otherwise. In addition to recessions, we also control for potential effects of the volatility of real economic activity by augmenting (1) - (3) with the conditional standard deviation of industrial production growth: $\sigma(ip)$, estimated with an AR(4)-GARCH(1,1) model for quarterly changes in industrial production.[6] The

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[5] Detailed estimation results are available upon request.

[6] The estimation results are available upon request.

idea behind putting a measure of the volatility of real economic activity into the equations is to guard against the possibility that stock market volatility mainly reflects uncertainty about short term real economic activity. Table 6 displays the results for this extended specification.

As to be expected, the recession dummy variable rec_t is negative and highly significant for durable and non-durable consumption growth as well as for investment growth. That is, recessions are of course associated with lower consumption and investment growth. However, stock market volatility still exerts negative and statistically significant effects on consumption and investment growth. Although the estimated coefficients are somewhat smaller in the extended specification, the magnitudes of the coefficients are again in line with the hypothesis that stock market volatility exerts larger effects when decisions are potentially harder to reverse.

In the extended system non-durable consumption growth tends to be lower in periods when the volatility of real activity is high as indicated by the negative coefficient on $\sigma(ip)$ in Table 6. The coefficient on $\sigma(ip)$ in the equation for durable consumption growth is also negative but insignificant at standard significance levels. Interestingly, $\sigma(ip)$ has a positive effect on investment growth. This finding is consistent with the idea that production volatility increases the funds available for investment by putting downward pressure on consumption (see Sandmo, 1970; Fountas and Karanasos, 2007).

However, opposing effects of uncertainty on consumption and investment are confined to production volatility as we find that stock market volatility reduces consumption as well as investment.

In short, controlling for recessions and the volatility of real economic activity does not affect our qualitative results concerning the effects of stock market volatility. Thus, stock market volatility does not appear to simply reflect uncertainty about current underlying fundamentals. Stock market volatility therefore seems to reflect uncertainty about future economic developments at least, and it may even be an independent source of uncertainty.

We now conduct some additional robustness checks: First, we re-estimate the baseline system of equations using alternative measures for stock market volatility. Second, we augment the baseline system (1) to (3) with additional control variables, and finally, we estimate the equations of the system individually as single equations.

To see whether the results are sensitive to the way time varying stock market volatility is measured, we re-estimate (1), (2) and (3) with either the quarterly standard deviation of of the S&P 500 returns, s_t, the implied volatility index, VIX_t, or the stock market volatility indicator, SVI_t, instead of σ_t. To preserve space, we just report the estimated coefficients for the alternative measures of stock market volatility in Table 7. Volatility exerts a negative and highly significant effect on our dependent variables, regardless of how we measure volatility. The ordering of the magnitudes of the effects is again in line with the interpretation that the degree irreversibility of decisions matters. For instance, according to the the last two lines of Table 7 we find that periods of increased volatility are associated with a decline of durable consumption growth of approximately 0.8 percentage points. The effect is weaker for non-durable consumption growth and amounts to a reduction of about 0.2 percentage points, and investment growth declines by about 2.7 percentage points. We conclude that our results are robust with respect to different proxies for stock market volatility.

Next, we add the lagged inflation rate, inf_{t-1}, the term spread, $spread_t$, as well as their conditional standard deviations $\sigma(inf_t)$ and $\sigma(spread_t)$ as additional control variables to each equation in the system. We include inf_{t-1} and $\sigma(inf_t)$ since recent experience of inflation and increasing uncertainty about inflation may give rise to distortions resulting in adverse effects on consumption and investment (see Fountas and Karanasos, 2007, and the references therein).[7] According to the uncertainty hypothesis, stock market volatility leads to uncertainty about future incomes, in the case of consumption, and earning opportunities, in the case of investment. Since the term spread ind its volatility captures expectations and uncertainty about future

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[7] Edelstein and Kilian (2009) finds that consumption responds significantly to energy price inflation.

interest rates, we add $spread_{t-1}$ and $\sigma(spread_t)$ to see whether stock market volatility has an influence in addition to what is allready captured by the term structure of interest rates. Table 8 shows that the interest rate spread plays a role for non-durable consumption growth, but neither for durable consumption nor investment growth. The volatility of the inflation rate has a strongly negative and highly significant impact on durable and non-durable consumption. Investment growth, however, is not influenced by the volatility of the inflation rate. Nevertheless, the effects of stock market volatility remain broadly unchanged.

System estimation methods typically yield more efficient estimates than single equation methods when the errors across equations are related. However, mis-specification of one equation can have effects on the estimated coefficients of the remaining equations in the system. To check for this possibility we estimate our most extensive versions of equations (1) to (3) separately as single equations. Table 9 reports the coefficient estimates and their HAC standard errors. As can be seen, the results still hold.

4 Does Stock Market Volatility Matter for Recessions?

The uncertainty hypothesis was originally proposed as a theory linking the Great Crash in 1929 to the Great Depression. Therefore, a natural issue to consider is if and how stock market volatility contributes to recessions more generally. To get some impression of the extent to which the dynamics of consumption and investment can be attributed to stock market volatility we compare the fitted values obtained from our richest econometric specification presented in Table 8 and historical data for the dependent variables to the fitted values we get when stock market volatility is set to its average level during the last four quarters preceding a recession. These two sets of fitted values should provide some quantitative impression of the influence of stock market volatility during recessions. We calculate and compare fitted values for three recession periods: 1990Q1 to 1991Q1, 2001Q3 to 2002Q1, and 2007Q1 to 2008Q4, where our sample ends. Table 10 shows the averages of the historical and fitted values for these periods. The last column of the table shows the difference between the fitted values with the actual the average σ.

Let us first consider the recession in the early 1990s. From the top panel of Table 10 we see that durable consumption growth declined on average by 2.2 percent, the fitted values of our richest specification suggest an average growth rate of 0.046 percent. Thus, the equation does not fully capture the decline in the consumption of durable goods. However, if we keep volatility constant at the average level during the four quarters preceding the recession, our regression suggests a substantially higher growth rate of 1.85 percent. Thus, the increase of volatility from the average level reduces durable consumption growth by around 1.8 percentage points. The effect of volatility on non-durable consumption is also substantial, albeit somewhat smaller. Our specification with actual volatility captures the decline in investment better than the decline in consumption. If we set volatility to the average level, we obtain even a slightly positive average investment growth.

The next recession in 2001-2002 is somewhat unusual in the sense that consumption, and in particular durable consumption, was rather resilient during this period.[8] Therefore, it is not surprising that our specification underestimates consumption growth rates and also investment growth during this period. But again, setting volatility to its average level results in substantially higher consumption and investment growth. Finally, the bottom panel of the table shows a similar picture for the latest recession which started in 2007. Setting volatility to the average level results in substantially higher consumption and investment growth rates.

5 Concluding Remarks

We investigate the uncertainty hypothesis by estimating the influence of stock market volatility on the growth rates of durable consumption, non-durable consumption and private investment using post-war US data. Our empirical results suggest that stock market volatility adversely affects consumption

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[8] Excluding the unusually large durable consumption growth rate in 2001q4 gives an average growth rate of durable consumption of 0.94 percent.

and investment growth. Consistent with the uncertainty hypothesis, we find the largest effects on investment and durable consumption growth, whereas the influence on non-durable consumption growth is less pronounced. Our empirical results do not support possible substitution effects from durable into non-durable consumption and from investment into durable consumption that would lead to an increase in durable consumption and non-durable consumption in times of increased stock market volatility.

We also present counter factual examples concerning the latest three recessions. These results have to be interpreted with some caution, but they suggest that higher stock market volatility is to a non-neligible extent responsible for the decline in consumption and investment growth during recessions. Thus, we conclude that the uncertainty hypothesis does not only provide a reasonable explanation for how the Great Crash has contributed to the Great Depression, but also helps to explain the negative relationship between stock market volatility, investment and consumption that we find in the US post war data.

Our empirical findings support the idea that stock market volatility is closely related to uncertainty about future economic developments, but the direction of causality remains debatable. Romer (1990) argues that the period of increased stock market volatility following the Great Crash of 1929 was not just a consequence of high overall uncertainty, but partly generated uncertainty which ultimately lead to a shortfall of aggregate demand. It is of course also conceivable that stock market volatility simply mirrors underlying macroeconomic uncertainty. Starting with Shiller (1981), a large literature finds that stock prices are too volatile to mirror fluctuations in fundamentals only. Although we have made some attempts in this paper to disentangle the relationship between stock market volatility and uncertainty, we remain agnostic with respect to the question whether stock market volatility is ultimately an independent source of uncertainty or an indicator for uncertainty. A more detailed investigation of this issue remains an interesting topic for future research.

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Table 1: Summary Statistics for the Dependent Variables.

	con^d	con^{nd}	inv
Mean	1.26	0.63	0.90
Median	1.50	0.62	1.02
Maximum	10.16	3.65	12.21
Minimum	-11.43	-1.82	-19.32
Std. Dev.	3.09	0.74	4.48
Observations	196	196	196

Table 2: Periods of High Stock Market Volatility according to Bloom (2009)

1962q4	1962q4	Cuban missile crisis
1963q4	1963q4	Assassination of JFK
1966q3	1966q3	Vietnam buildup
1970q2	1970q2	Cambodia and Kent State
1973q4	1973q4	OPEC I, Arab-Israeli War
1974q3	1974q4	Franklin National
1978q4	1978q4	OPEC II
1980q1	1980q1	Afghanistan, Iran hostages
1982q3	1982q4	Monetary cycle turning point
1987q4	1987q4	Black Monday
1990q3	1990q4	Gulf War I
1997q4	1997q4	Asian crisis
1998q3	1998q3	Russian, LTCM default
2001q3	2001q3	9/11 terrorist attack
2002q3	2002q3	Worldcom and Enron
2003q1	2003q1	Gulf War II
2007q3	2008q4	Credit crunch

Table 3: Summary Statistics for Stock Market Volatility Measures

	s_t	σ_t	VIX_t	SVI_t
Mean	8.28	7.22	8.18	0.13
Median	7.28	6.77	7.40	0.00
Maximum	40.51	16.93	29.30	1.00
Minimum	2.21	5.20	2.05	0.00
Std. Dev.	4.54	1.48	3.58	0.33
Observations	196	196	196	196

Table 4: Correlation of Stock Market Volatility Measures

	s_t	σ_t	VIX_t	SVI_t
s_t	1.00	0.76	0.93	0.59
σ_t		1.00	0.68	0.45
VIX_t			1.00	0.53
SVI_t				1.00

Table 5: S&P500 Volatility, Consumption and Investment Growth

	con^d		con^{nd}		inv	
σ_t	-0.467	***	-0.104	***		
	(0.102)		(0.026)			
σ_{t-1}					-0.828	***
					(0.170)	
$return_{t-1}$	0.021		0.018	**	0.034	
	(0.028)		(0.006)		(0.034)	
con^d_{t-1}	-0.520	***				
	(0.091)					
con^{nd}_{t-1}			-0.143	**		
			(0.074)			
con_{t-1}	1.960	***	0.312	***		
	(0.424)		(0.080)			
inv_{t-1}					-0.320	***
					(0.077)	
ip_{t-1}					1.628	***
					(0.254)	
constant	3.756	***	1.204	***	6.079	***
	(0.853)		(0.172)		(1.324)	
Obs	196		196		196	
R^2	0.170		0.200		0.264	
$adjR^2$	0.153		0.181		0.249	

Notes: System estimated by GMM with con^d, con^{nd} and inv as dependent variables. Heteroskedasticity and autocorrelation robust standard errors in parenthesis. * denotes significance at the 10%, ** at the 5% and *** at the 1% level.

Table 6: Controlling for Recessions and the Volatility of Industrial Production

	con^d		con^{nd}		inv	
σ_t	-0.267	**	-0.064	***		
	(0.106)		(0.023)			
σ_{t-1}					-0.557	***
					(0.161)	
$return_{t-1}$	0.018		0.016	**	-0.010	
	(0.027)		(0.007)		(0.034)	
con^d_{t-1}	-0.504	***				
	(0.091)					
con^{nd}_{t-1}			-0.153	**		
			(0.075)			
con_{t-1}	1.390	***	0.178	**		
	(0.444)		(0.081)			
inv_{t-1}					-0.421	***
					(0.073)	
ip_{t-1}					1.290	***
					(0.261)	
rec_t	-2.127	***	-0.513	***	-5.041	***
	(0.563)		(0.116)		(0.748)	
$\sigma(ip)$	-0.519		-0.146	**	1.093	**
	(0.370)		(0.062)		(0.487)	
constant	3.745	***	1.280	***	3.787	**
	(0.929)		(0.169)		(1.434)	
Obs	196		196		196	
R^2	0.242		0.260		0.393	
$adjR^2$	0.218		0.236		0.373	

Notes: System estimated by GMM with con^d, con^{nd} and inv as dependent variables. Heteroskedasticity and autocorrelation robust standard errors in parenthesis. * denotes significance at the 10%, ** at the 5% and *** at the 1% level.

Table 7: Alternative Proxies for Stock Market Volatility

	con^d		con^{nd}		inv	
s_t	-0.156	***	-0.054	***	-0.028	
	(0.044)		(0.012)		(0.057)	
s_{t-1}	0.064		0.027	**	-0.279	***
	(0.074)		(0.012)		(0.079)	
s_{t-2}	-0.114	**	0.018	*	-0.017	
	(0.059)		(0.010)		(0.061)	
s_{t-3}	0.102		0.004		0.145	*
	(0.100)		(0.012)		(0.080)	
s_{t-4}	0.049		-0.026	*	0.192	*
	(0.041)		(0.014)		(0.078)	
vix_t	-0.162	*	-0.058	***	-0.092	
	(0.081)		(0.014)		(0.098)	
vix_{t-1}	0.021		0.023		-0.379	**
	(0.129)		(0.025)		(0.152)	
vix_{t-2}	-0.114		0.026		-0.059	
	(0.114)		(0.020)		(0.138)	
vix_{t-3}	0.220		0.014		0.264	**
	(0.136)		(0.020)		(0.134)	
vix_{t-4}	-0.035		-0.035		0.286	
	(0.079)		(0.019)		(0.099)	
SVI_t	-1.315	***	-0.397	***	-1.441	**
	(0.472)		(0.102)		(0.611)	
SVI_{t-1}	0.170		-0.046		-1.907	**
	(0.751)		(0.145)		(0.718)	
SVI_{t-2}	-2.297		-0.096		-1.024	
	(0.684)		(0.144)		(0.856)	
SVI_{t-3}	1.076	*	0.125		1.343	
	(0.552)		(0.119)		(0.943)	
SVI_{t-4}	-0.566		-0.481	***	1.810	***
	(0.667)		(0.165)		(0.588)	

Notes: System estimated by GMM with con^d, con^{nd} and inv as dependent variables. Heteroskedasticity and autocorrelation robust standard errors in parenthesis. In addition to the variables shown in the table each system contains the variables shown in Table 5. * denotes significance at the 10%, ** at the 5% and *** at the 1% level.

Table 8: Additional Control Variables

	con^d		con^{nd}		inv	
σ_t	-0.471	***	-0.096	***		
	(0.107)		(0.020)			
σ_{t-1}					-0.759	***
					(0.151)	
$return_{t-1}$	0.002		0.014	**	0.006	
	(0.028)		(0.006)		(0.029)	
con^d_{t-1}	-0.497	***				
	(0.102)					
con^{nd}_{t-1}			-0.197	**		
			(0.073)			
con_{t-1}	1.163	**	0.199	**		
	(0.513)		(0.081)			
inv_{t-1}					-0.394	***
					(0.063)	
ip_{t-1}					1.742	***
					(0.217)	
inf_{t-1}	-0.716	***	-0.118	**	0.497	
	(0.217)		(0.052)		(0.281)	
$spread_{t-1}$	0.003	**	0.000		0.008	***
	(0.001)		(0.000)		(0.002)	
$\sigma(inf)$	-2.399	**	-0.974	***	-1.150	
	(1.221)		(0.341)		(1.472)	
$\sigma(spread)$	-0.021	**	-0.005	***	-0.043	***
	(0.012)		(0.002)		(0.018)	
constant	6.338	***	1.995	***	5.313	***
	(1.098)		(0.255)		(1.333)	
Obs	188		188		188	
R^2	0.270		0.290		0.370	
$adjR^2$	0.240		0.260		0.340	

Notes: System estimated by GMM with con^d, con^{nd} and inv as dependent variables. Heteroskedasticity and autocorrelation robust standard errors in parenthesis. * denotes significance at the 10%, ** at the 5% and *** at the 1% level.

Table 9: Single Equation Estimation

	con_t^d		con_t^{nd}		inv_t	
σ_t	-0.382	***	-0.071	***		
	(0.138)		(0.027)			
σ_{t-1}					-0.849	***
					(0.226)	
$return_{t-1}$	0.014		0.016	**	0.000	
	(0.033)		(0.008)		(0.035)	
con_{t-1}^d	-0.615	***				
	(0.119)					
con_{t-1}^{nd}			-0.203	**		
			(0.095)			
con_{t-1}	2.021	***	0.250	***		
	(0.587)		(0.099)			
inv_{t-1}					-0.449	***
					(0.089)	
ip_{t-1}					2.136	***
					(0.338)	
inf_{t-1}	-0.755	***	-0.125	**	0.323	
	(0.250)		(0.063)		(0.400)	
$spread_{t-1}$	0.003	*	0.000		0.007	***
	(0.002)		(0.000)		(0.003)	
$\sigma(inf_{t-1})$	-0.700		-0.946	***	-0.880	
	(1.403)		(0.362)		(1.641)	
$\sigma(spread_{t-1})$	-0.005		-0.003		-0.027	
	(0.014)		(0.002)		(0.022)	
$\sigma(ip_{t-1})$	-1.005	*	-0.222	**	2.825	***
	(0.554)		(0.098)		(0.863)	
$constant$	5.230	***	2.001	***	2.151	
	(1.323)		(0.268)		(1.928)	
Obs	188		188		188	
R^2	0.294		0.306		0.427	
$adjR^2$	0.259		0.271		0.398	

Notes: Equations estimated by OLS with con^d, con^{nd} and inv as dependent variables. Heteroskedasticity and autocorrelation robust standard errors in parenthesis. * denotes significance at the 10%, ** at the 5% and *** at the 1% level.

Table 10: Actual and Fitted Average Growth Rates During Recessions

	Actual Growth Rate	Fitted Values Actual σ	 Average σ	Δ
		1990Q1 - 1991Q1		
con^d	-2.203	0.046	1.856	-1.809
con^{nd}	-0.268	0.107	0.550	-0.443
inv_t	-4.357	-3.42	0.965	-4.385
		2001Q3 - 2002Q1		
con^d	2.727	-1.24	1.192	-2.432
con^{nd}	0.308	-0.059	0.474	-0.533
inv_t	-3.456	-5.611	-2.479	-3.131
		2007Q1 2008Q4		
con^d	-2.25	-1.483	0.666	-2.149
con^{nd}	-0.494	-0.145	0.22	-0.365
inv_t	-3.076	-3.508	-0.439	-3.068

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