Uncertainty Shocks and the U.S. Great Depression

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Abstract

The United States of the 1930s experienced unprecedented uncertainty including a severe banking crisis, major policy changes, and the breakdown of the gold standard. Uncertainty, as measured by three uncertainty measures I construct, was extremely high during recession periods but declined during the recovery from the Great Depression. I outline several uncertainty shock events that coincide with recession periods. A New Keynesian model is calibrated to the conditions of the 1930s by modeling the passive monetary policies of the Federal Reserve and incorporating wage stickiness. Simulations of the model show that uncertainty shocks generate declines in output, consumption, investment, and hours worked. I estimate several structural vector autoregressions to produce econometric estimates of the impact of uncertainty on the broader U.S. economy during this period. Based on these multifaceted sources of evidence, I find support for the hypothesis that uncertainty shocks were a significant factor in the U.S. Great Depression.

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1 Introduction

While the literature on the determinants and causes of the Great Depression is extensive, economists' understanding of this event remains incomplete. A series of papers by Cole and Ohanian and the *Monetary History* of Friedman and Schwartz (1971) represent two common viewpoints regarding the U.S. Great Depression. Cole et al. (2005) find that productivity fell sharply during the recession of 1929-1933, and Ohanian (2009) argues that Hoover's high wage policy drove the output decline of 1929-1931. But explaining such a large drop in productivity is difficult to justify either with a decline in technology or some other inefficiency. Inklaar et al. (2011) show that factor hoarding stemming from the output declines of the 1930s can completely explain the fall in productivity. Nominal wages fell rapidly from 1931-1933 as output collapsed so Hoover's support for high wages could only have mattered for two years of the Depression decade. Cole and Ohanian (2004) also argue that New Deal policies can explain the weak recovery of 1933-1941 and the recession of 1937-1938. But recoveries from financial crises are generally weak as shown by Reinhart and Rogoff (2011), and New Deal policies, if anything, were more moderate after 1936. Eggertsson (2012) shows that negative supply shocks like those discussed by Cole and Ohanian would be stimulative for an economy suffering from deflation and stuck at the zero lower bound on interest rates, as the American economy was during the 1930s.

Friedman and Schwartz argue for monetary tightness as the main cause of the Depression, with the recessions of 1929-1933 and 1937-1938 being driven by banking failures and increases in reserve requirements respectively. However, in the early 30s,, the base money supply was rising while broader monetary aggregates fell which points to a non-monetary factor driving money demand higher.[1] In the late 1930s, banks had large quantities of excess reserves and so could easily satisfy higher reserve requirements without reducing lending as shown by Telser (2001). Temin (1976) shows that an autonomous decline in expenditure can explain the Great Depression better than the monetary hypothesis, but does not provide an explanation for this sudden decline in demand. Other demand-based contributions come from the debt-deflation of Fisher (1933) and related balance-sheet based theories of Mishkin (1978) and Olney (1999). A significant flaw in previous Keynesian

[1] This argument is originally made in Temin (1976)

thinking about the Great Depression was the lack of an exogeneous shock on a scale relevant to the most severe economic crisis in world history. Uncertainty shocks, which act like aggregate demand shocks, provide an explanation for the sharp drop in aggregate expenditure that characterized the Great Depression in the USA.

Romer (1990) examined the impact of the Great Crash of October 1929 as an uncertainty shock. Following Bernanke (1983), she connected the large increase in uncertainty stemming from this massive collapse in equity prices to the decline in expenditure and output. While Romer's analysis provided a starting point for my paper, her analysis is limited to one uncertainty shock event and uses a simple partial equilibrium model without price or general equilibrium effects. My DSGE model is used to simulate a model economy for the 1930s under uncertainty shocks. I introduce a passive monetary policy through a constant money supply rule to simulate the Fed policy of the 1930s. I also add wage stickiness which is relevant to the 1930s as wages stayed high despite a large and persistent output gap.[2] I find that both passive monetary policy and wage stickiness interact with uncertainty shocks to generate a sharp fall in output. As these features are salient in the Great Depression, I conclude that not only do uncertainty shocks generate a plausible business cycle, but that the negative effect of uncertainty shocks would have been larger in the Great Depression than in the postwar period. I also study the entire period, as uncertainty was a significant factor throughout the 1930s. The result of Romer's model that non-durable consumption increases on impact of an uncertainty shock is not present in the data nor in my model however, as consumption falls due to general equilibrium effects. Romer's result remains in general equilibrium under flexible prices, as precautionary savings increases consumption (and hours worked), but with the inclusion of price and wage stickiness, consumption, labor hours, and investment and output all fall on impact of an uncertainty shock, which looks like a recession.

I construct three uncertainty measures for the interwar period: the traditional measure of equity return volatility, a newspaper index of sentiment regarding economic uncertainty, and bond spreads as a measure of financial uncertainty. I examine the history of the United States in the 1930s and show that uncertainty shock events line up with spikes in volatility, which themselves are

[2]See Bernanke and Carey (1996a)

concentrated during the recession phases of the Great Depression. All three uncertainty measures are high during the recession of 1929-1933, when industrial output fell about 75% peak to trough, and the recession of 1937-1938, when industrial output fell almost 40%.[3] This shows the close temporal relationship between uncertainty shocks and changes in output during the 1930s. Reverse causality is also ruled out by showing that recessions do not drive uncertainty. The empirical section uses structural vector auto-regressions to estimate the impact of uncertainty shocks on the broader macroeconomy at a monthly frequency. All three uncertainty measures generate significant declines in output, employment and hours in the interwar economy. I find that a one standard deviation shock to stock volatility (my preferred measure of uncertainty) generates a 2% peak decline in output and that uncertainty was a significant factor determining the course of the Great Depression in the USA.

Section 1 introduces the topics under consideration. Section 2 will review the literature on uncertainty, outline the three uncertainty measures, and show that major uncertainty shocks are prevalent during the Great Depression. Section 3 outlines the major uncertainty shock events that made the Great Depression so uncertain. Section 4 focuses on VAR evidence regarding uncertainty's impact on employment, output, and hours worked during the interwar period. Section 5 will simulate a New Keynesian DSGE model calibrated to conditions of the 1930s. Section 6 concludes.

2 Uncertainty

I define an uncertainty shock to be a significant rise in the dispersion of future expected income. Dixit and Pindyck and their coauthors have written much of the literature on investment under uncertainty.[4] In general in these models, firms face uncertainty over revenue and costs when making an irreversible investment. As some future states of the world can be characterized by low profits, firms delay investment (McDonald and Siegel, 1986).

[3] By comparison, industrial output fell less than 19% from December 2007 to June 2009

[4] See Pindyck (1991, 1993); Abel et al. (1996); Caballero and Pindyck (1996); Pindyck (1988); Majd and Pindyck (1987); Dixit and Goldman (1970); Dixit (1992, 1993); Dixit and Pindyck (1994).

2.1 Uncertainty and Business Cycles

Bernanke (1983) connects this microeconomic uncertainty literature with macroeconomics. With higher uncertainty firms delay investment and this decline in expenditure decreases aggregate demand and a recession results. Romer (1990) applies Bernanke's thesis to October 1929, arguing households faced unprecedented income uncertainty, which can be seen in the gyrations of stock prices as well as in a heightened dispersion of economic forecasts. Consumers, facing this uncertainty, cut back sharply on their durable goods purchases, as they were uncertain about their future income. Romer's model predicts that uncertainty would induce consumers to switch from durable to nondurable purchases due to a precautionary motive.[5] However, declines in durable purchases should reduce consumer nondurable purchases as income and wealth decline, which is consistent with the data. All categories of consumption, including nondurable consumption, fall after 1930 as Olney shows. Flacco and Parker (1992), Ferderer and Zalewski (1994), Greasley et al. (2001), and Ferderer and Zalewski (1999) all find support for a negative effect for uncertainty in the Great Depression.

2.2 Stock Volatility and Uncertainty

I follow Schwert's characterization of stock market volatility as directly reflecting economic uncertainty:"[T]he volatility of stock returns reflects uncertainty about future cash flows and discount rates, or uncertainty about the process generating future cash flows and discount rates" (Schwert, 1990, 85). Veronesi (1999) develops a financial model with a regime shift between high and low economic uncertainty which produces significant variation in stock volatility over time which provides a theoretical justification for the connection between uncertainty and stock volatility.[6]

Traditionally, financial economics has modeled equity returns using a geometric Brownian motion with constant mean and variance (Black and Scholes, 1973). A more recent literature has examined stochastic volatility models of time-varying volatility.[7] I follow this latter method by

[5]Olney (1999) finds that the increase in nondurable purchases in 1930 comes from consumers switching from independent to chain grocery stores and driving up measured grocery purchases with little change in actual purchases.

[6]This also helps explain the excess volatility puzzle of Shiller (1981) where dividend volatility is not sufficient to explain equity price volatility, as Shiller did not consider such regime shifts.

[7]Hull and White (1987) and Wiggins (1987) are early papers in this literature

assuming that volatility is generally fairly stable, but occasionally is hit by an uncertainty shock that increases dispersion. Stock volatility is calculated as the monthly standard deviation of log equity return of the Standard and Poor's 500 Index and the Dow Jones Industrial Average.[8]

2.3 Other Uncertainty Measures

I construct two other uncertainty measures to ensure that stock volatility is robust as an uncertainty measure. The newspaper index I use is constructed in the same way as the "Main Street" index of Alexopoulos and Cohen (2009). This index measures the number of times "uncertain" or "uncertainty" and "economic" or "economy" appeared in articles in the New York Times from 1923-1942. The other uncertainty measure is the spread between BAA and AAA rated corporate bonds rated by Moody's. The close correlation between credit spreads and the other uncertainty measures shows why financial crisis appear as uncertain periods with elevated stock volatility. These three uncertainty measures are plotted against each other in Figure 1 of the appendix. The link between the three series in very close, which both confirms their robustness as uncertainty measures as well as the intuition that uncertainty was very high in the 1929-1933 and 1937-1938 recession phases of the Great Depression.

3 Uncertainty Shocks: 1929-1941

Bloom (2009) points to major uncertainty shock events in the post-war era such as the Cuban missile crisis, the Asian Financial Crisis, 9/11, and the 2008 financial crisis. I construct a similar timeline of Depression uncertainty shock events with a corresponding chart in Figure 19. The initial impulse for the Great Depression of 1929-1941 was from a monetary tightening.[9] Friedman and Schwartz (1971) argue that the Federal Reserve could and should have acted as a lender of last resort to prevent the massive waves of banking failures of 1930-1933. It is fairly intuitive how large scale bank failures would reduce confidence about the future. When the United Kingdom left the Gold

[8] As the the Standard and Poor's 500 index did not exist for the 1930s, it is constructed in the same manner as the current S&P 500 index; either the 500 largest stocks by market capitalization are used or the entire market is used if there are fewer than 500 listings on the New York Stock Exchange.

[9] See Hamilton (1987), Eichengreen (1996), Friedman and Schwartz (1971), and Romer (1993)

Standard in September 1931, it was uncertain what the future held for the international monetary and trading system. The Smoot-Hawley could have increased uncertainty and thus declines in investment, as argued by Archibald and Feldman (1998). The crisis of the Great Depression marked a nadir of support for existing political and economic structures. With widespread unemployment and poverty, it is perhaps unsurprising that support for radical policies and actions rose, which drove a general sense of uncertainty. [10]

New Deal policies have long been criticized as generating substantial uncertainty. Business did not want to invest the uncertain political environment of the New Deal (Schumpeter, 2010). Events in Europe and Asia in the run-up to World War Two also appear as major uncertainty shocks. In 1937, FDR was convinced by his advisors that inflation was rising and that the economy was near complete recovery, so the FDR's administration abandoned its commitment to its previous expansionary policy. I interpret this an an increase in uncertainty over monetary policy which became vague and unclear, and indeed, all three uncertainty measures rise significantly around this time. By 1938, the administration recommitted itself to its previous policy of reflation and price-level targeting at the 1926 price-level. With a clear policy environment restored, uncertainty receded and the economy resumed its recovery path.

4 VAR

I use a structural vector autoregression to see the relationship between uncertainty and the broader macroeconomy in the 1930s. I produce a similar SVAR as Bloom (2009)'s study of June 1962- June 2008 using similar or identical monthly time-series data which are available for the interwar period.[12] I also add additional uncertainty measures to ensure that the volatility measure of uncertainty is robust. My endogeneous variables of interest are industrial output, manufacturing employment,

[10](Merton, 1985, 1185) argues that there was significant uncertainty about the future of capitalism: "With the benefit of hindsight, we know that the U.S. and world economies came out of the Depression quite well. At the time, however, investors could not have had such confident expectations."[11]

[12]Modern studies often use manufacturing data due to its availability at a monthly frequency, while investment and other NIPA categories are only available at a quarterly frequency. These manufacturing data were published for the interwar period as well beginning in 1923.

and hours worked in manufacturing.[13]

A vector autoregression is a regression of a variable on itself, its own lags, as well as a regression on other variables and their lags. This allows for interactions between the variables over time that are not visible in a cross-sectional regression Sims (1980). Without restrictions, the system is underdetermined, so structural assumptions informed by economic theory must be used for identification. The Cholesky decomposition assumes that anterior variables can affect posterior variables contemporaneously, but posterior variables cannot affect anterior variables contemporaneously. This framework assumes that uncertainty cannot be measured directly, but that the uncertainty shock measures should rise on impact of an uncertainty shock. The uncertainty shock would then first affect prices (wage, consumer price index, and the interest rate), and then quantities (hours, employment, output). The Cholesky ordering of the variables in the baseline SVAR is: stock return level, stock return volatility, discount rate, hourly earnings, consumer price index, hours worked, employment, and industrial production.

The ordering of the variables is meant to ensure that first the effect of the level of stock prices on other variables is removed before the effect of volatility is considered. Take the case of some other non-uncertainty shock, for example a monetary or a productivity shock, that is expected to decrease industrial output in the future. This type of shock, if only stock volatility is included, may appear to increase stock volatility. A change in the stock level will increase the standard deviation of stock returns and thus increase stock volatility. Placing the stock return level first in the ordering also controls for any impact on future economic variables, through expectations of changes in profitability, on current values of equity returns. This allows one to see the impact of stock volatility on output, employment, and hours separately from the impact of average stock prices on these variables. The VAR is run over a period of 24 months for the three main uncertainty measures, as well as a stock volatility indicator variable. The net impact of a one-standard deviation shock to the uncertainty shock measures on macroeconomic quantities (manufacturing employment, hours, and industrial output) are plotted in the appendix.

[13] As the federal funds rate did not yet exist, the discount rate of the New York City branch of the Federal Reserve is used as the representative interest rate for monetary policy.

4.1 Baseline VAR

The baseline results in Figure 9 show that an impulse to stock volatility generates statistically significant declines in output, employment, and hours. Relative to the results from the modern period, the negative effect in the interwar periods take more time to become statistically significant. The interwar period also has less of a "rebound" effect (where industrial production rises above its initial value) as industrial production returns to trend slowly. Overall, I suspect this difference are driven by the persistence of the uncertainty shocks in the 1930s, which is not the case during the modern period where uncertainty shocks are discrete and short-lived. This persistence makes it difficult econometrically to identify the impact of an uncertainty shock versus lagged or leading uncertainty. The effect of an uncertainty shock on manufacturing employment and hours is similar to the effect for industrial production. I find a a peak impact of stock volatility occurring after about 10 months, with a peak magnitude of approximately -3% for hours worked, of approximately -1.5% for employment, and approximately -2% for industrial production.

4.2 Baseline VAR without Stock Return Level

In Figure 10 I eliminate the stock return level, so that stock volatility is the first variable in the Cholesky ordering, and all the other variables remain as before. While it is important to control for the equity return level, this does tend to dominate other causes as the stock market is forward looking. We can see that the effect of an uncertainty shock is clearer without the inclusion of the stock level, but the general pattern remains of a negative impact of uncertainty. While the face that a significant effect results from uncertainty even when controlling for the level of stock returns, the results without the stock market level are more reflective of the true effect of uncertainty on hours, employment, and output.

4.3 Volatility Indicator

Again following Bloom's method, I compute a volatility indicator that is coded as 1 when Dow stock volatility was over 1.65 standard deviations above median volatility for the 1886-1962 period and 0 otherwise. This measure is based on the significance level for a one-sided t-test with a 95%

significance, so that the ones would reject at this significance level, while the zeros would not reject. These uncertainty shock dates are listed in Table 1 of the appendix. As shown in Figure 11 the volatility indicator again yields predictions in accordance with theory, with all employment, hours, and output all falling in response to an increase in the stock volatility indicator. The magnitude is slightly lower than for stock volatility itself, which probably reflects the high persistence of this indicator, which is a value of 1 in almost every month of 1931 for example. The results without the stock return level included, shown in 12, are again stronger than those the level included.

4.4 Newspaper Index

Figure 13 shows the same VAR as above using the newspaper index in lieu of stock volatility as my uncertainty indicator. The similarity of the results for the newspaper index show that these results are not purely driven by some factor specific to the stock market. The results for the same VAR as above without the stock return level included are shown in Figure 14 and are broadly similar to the specifications with the return level.

4.5 BAA-AAA spread

The effect of uncertainty, as measured by the BAA-AAA spread, is shown in Figure 15. The impact of uncertainty as measured by credit spreads is similar to that of stock volatility, though generally weaker. I do not include the stock level, as this removes the significant effect from the BAA-AAA spread, which is less strongly correlated with uncertainty as the other measures. Industrial production falls after several months, and the effect is statistically significantly different from zero. All three uncertainty indicators generate significant declines in macroeconomic quantities in the Great Depression.

4.6 Alternative orderings

Figures 16-18 are several robustness checks to ensure that the results are not driven by the ordering of the VARs or the choice of variables. Continuing to follow Bloom's method for comparison, I also report the results of the standard specification using only a "trivariate VAR" (volatility, employment, industrial production), "quadvariate VAR" (volatility indicator, stock-market level, employment, industrial production) and the "quadvariate VAR in reverse" (industrial production, employment, stock market levels, and volatility shocks. The first two specifications are to ensure that the results are not driven by intermediate variables, and the final specification is to show that the results are not driven by reverse causality. The trivariate and quadvariate simulations show that the baseline results are not driven by a specific ordering and that uncertainty robustly drives declines in employment, output, and hours. The reverse quadvariate specification shows that industrial output and manufacturing employment do not have any predictive power for future values of stock volatility, which is consistent with causality running from volatility to macroeconomic quantities, and not the reverse.

4.7 Granger Causality Test

I also perform a Granger causality test to rule out reverse causality. The Granger causality test is a two-variable VAR which regresses each variable on its own lags, as well as the other variable and its lags (Granger, 1969). If variable A is uncorrelated with lags of variables B, then we can rule out that variable B could have a causal relationship with variable A. If variable A is correlated with lags of variables B, then then it is possible that variable B could have a causal relationship with variable A. The results of this test are shown in Table 4 for a six month lag. This shows that causality does not run from industrial output to uncertainty, which rules out reverse causality, but that causality from industrial output to uncertainty is potentially causal.

5 New Keynesian Uncertainty Shocks Model

The model of Basu and Bundick (2012) is a New Keynesian DSGE that examines the impact of uncertainty shocks on the American economy during the 2007-2009 recession.[14] Their model will form the backbone of my model, with some important additions such as wage stickiness and passive monetary policy rules that are more consistent with the economic conditions of the 1930s.

[14] I also base some of my model on the earlier working paper of Basu and Bundick (2010)

5.1 Model Intuition

The main aspects of this model are nominal friction, such as price and wage stickiness, as well as monopolistic competition, which generates endogeneous markups. Uncertainty works through an adjustment cost to investment, which is a reduced-form way to model the partial irreversibility of investment or a durable good purchase. Price stickiness and monopolistic competition also improve the predictions of the model significantly compared to a flexible-price, perfect competition model. As BB show, price stickiness and monopolistic competition are necessary to obtain the correct comovements between consumption, investment, labor hours, and output. All these variables should be pro-cyclical and fall on impact of an uncertainty shock. A flexible price, perfectly competitive model does not generate the correct comovement however, as households respond to the uncertainty shock by increasing their labor input. This can be thought of as a "precautionary labor" effect. There is also a "precautionary savings" effect which reduces consumption and increases savings. This tends to increase investment, output and hours worked. Countercyclical markups combined with price stickiness resolves this issue. On impact of an uncertainty shock, marginal costs fall faster than price as prices adjust slowly. This increase in the markup reduces demand for investment and consumption, which then causes output and employment to fall. This generates a comovement in the relevant variables that can generate a plausible business cycle.

BB show heuristically that wage stickiness should generate a similar business cycle as price stickiness does. Price stickiness generates a markup of price over marginal cost which implies that output prices will rise faster than the marginal product of labor, and thus faster than wages. Wages themselves are marked up over the relevant marginal cost, which in this case is the marginal disutility of labor. This generates a further decline in the marginal disutility of labor, which works in the same direction as the price markup in discouraging the precautionary labor effect. I introduce wage stickiness and wage markups to see exactly how wage stickiness affects endogenous variables both alone and in conjunction with price stickiness.

5.2 Households

Households are indexed by j∈[0,1]. The household utility function will include money as in Sidrauski (1967) or Walsh (2003). Households maximize lifetime utility by choosing consumption $C_{t+s}(j)$, labor $L_{t+s(j)}$, bonds $B_{t+s+1}(j)$, equity shares $S_{t+s+1}(j)$,and real balances m_{t+s} for all time periods s=0,1,2,... by solving the following problem:

$$\max \mathrm{E}_t \left\{ \sum_{s=0}^{\infty} \beta^{t+s} a_{t+s} \left(\frac{C_{t+s}(j)^{1-\sigma}(1-L_{t+s}(j))^{\eta(1-\sigma)}}{1-\sigma} + \frac{m_{t+s}(j)^{\eta_m(1-\sigma)}}{1-\sigma} \right) \right\} \tag{1}$$

The preference parameter, a_t, acts multiplicatively with the discount rate β and enters into the marginal utility of consumption and wealth. When a_t is higher(lower), consumption increases(decreases) and labor supply increases(decreases). I follow BB in interpreting the preference parameter as demand. The intertemporal elasticity of substitution is given by σ. Households own equity shares S_t as well as bonds B_t issued by the intermediate goods firms. Equity shares pay a dividend D_t^E per share, while the risk-free bond yields a gross one-period riskless interest rate R_t^R. The household uses its income to purchase consumption C_t, its purchases of financial assets for the next period S_{t+1} and bonds B_{t+1} to carry into the next period. Here $m_t = \frac{M_t}{P_t}$ is real money balances. The government grows the money supply at rate $\tau = \frac{m_t}{M_{t-1}/P_t}$ every period. Households are subject to the following intertemporal household budget constraint:

$$\frac{M_t(j)}{P_t} + C_t(j) + \frac{P_t^E}{P_t} S_{t+1}(j) + \frac{1}{R_t^R} B_{t+1}(j) \leq \frac{W_t(j)}{P_t} L_t(j) + \left(\frac{D_t^E}{P_t} + \frac{P_t^E}{P_t} \right) S_t(j) + B_t(j) + \frac{M_{t-1}(j)}{P_t} + \tau$$

This yields the following first-order conditions:

$$a_t C_t(j)^{-\sigma}(1-L_t(j))^{\eta(1-\sigma)} = \lambda_t(j) \tag{2}$$

$$\eta \frac{C_t(j)}{(1-L_t(j))} = \frac{W_t(j)}{P_t} \tag{3}$$

$$\frac{P_t^E}{P_t} = E_t \left\{ \frac{\beta \lambda_{t+1}(j)}{\lambda_t(j)} \left(\frac{D_t(j)^E}{P_t} + \frac{P_{t+1}^E}{P_t} \right) \right\} \tag{4}$$

$$1 = R_t^R E_t \left\{ \frac{\beta \lambda_{t+1}(j)}{\lambda_t(j)} \right\} \tag{5}$$

The optimal choice of money holdings by the household is determined by the following first-order condition:[15]

$$[m_t(j)]^{\eta_m(1-\sigma)-1} + \beta \frac{\lambda_{t+1}}{1+\pi_{t+1}} = \lambda_t \tag{6}$$

5.3 Wage Stickiness and Labor Packer

I extend the baseline BB model by introducing wage stickiness in a similar fashion as Kimball (1995). If wages are sticky and prices are flexible, this will imply that real wages are countercyclical, as during a recession prices fall more quickly than wages. As discussed by Silver and Sumner (1995), real wages were countercyclical during the U.S. interwar period, in contrast to the real wage procyclicality of the postwar.[16] Madsen (2004) and Bernanke and Carey (1996b) find evidence for both price and wage stickiness during the Depression. Thus wage stickiness is an appropriate addition for this period while price stickiness alone fits postwar data better.[17]

Wage stickiness is introduced through a quadratic adjustment cost to nominal wages of the Rotemberg (1982) type, in a similar fashion as for price stickiness. The quadratic adjustment cost to change wages is as follows:

$$\frac{\psi_W}{2} \left(\frac{W_t(j)}{W_{t-1}(j)} - 1 \right)^2 L_t$$

[15]Recall that inflation π_t is defined as $1+\pi_t = \frac{P_t}{P_{t-1}}$. This means that $\frac{M_{t-1}}{P_t} = \frac{M_{t-1}}{P_{t-1}} \frac{P_{t-1}}{P_t} = \frac{m_{t-1}}{1+\pi_t}$

[16]See Bils (1985), for example. The debate over the cyclicality of real wages goes back to Dunlop (1938) and Tarshis (1939), who argued for real wage procyclicality, as opposed to Keynes (1964), who in the *General Theory* argued for real wage countercyclicality

[17]As has been often argued, wages are probably more rigid downward than upward, as workers are more resistant to cuts in pay than to nominal pay increases. As I use perturbation methods to solve this model no kinks or discontinuities are permitted, so I cannot model an asymmetry of this type. As the purpose of this modeling exercise is to examine the negative impact of uncertainty shocks, especially during 1929-1933, ignoring this asymmetry is not problematic.

The household's budget constraint is modified slightly to include this cost:

$$\frac{M_t(j)}{P_t}+C_t(j)+\frac{P_t^E}{P_t}S_{t+1}(j)+\frac{1}{R_t^R}B_{t+1}(j)+\frac{\phi_W}{2}\left(\frac{W_t(j)}{W_{t-1}(j)}-1\right)^2 L_t \leq \frac{W_t(j)}{P_t}L_t(j)+\left(\frac{D_t^E}{P_t}+\frac{P_t^E}{P_t}\right)S_t(j)+B_t(j) \tag{7}$$

The households also supplies differentiated labor to a "labor packer", which combines the differentiated labor inputs and then sells a labor aggregate in a perfectly competitive labor market to the intermediate firms. The wages paid to individual households are denoted $W_t(j)$ for differentiated labor $L_t(j)$ and the labor aggregate L_t is paid wages W_t. This yields the following budget constraint for the labor packer:

$$W_t L_t - \int_0^1 W_t(j)L_t(j)dj \geq 0$$

The labor packer set wages for the labor aggregate at a markup (μ_L) over marginal cost. In this case the relevant marginal cost is the marginal rate of substitution between leisure and consumption.

$$\frac{W_t(j)}{P_t} = \mu_L\left(\eta\frac{C_t(j)}{1-L_t(j)}\right) \tag{8}$$

The labor packer has the following packing CES packing technology:

$$\left[\int_0^1 L_t(j)^{\frac{\theta_l-1}{\theta_l}}dj\right]^{\frac{\theta_l}{\theta_l-1}} \geq L_t$$

Labor packer optimization, subject to the above technological constraint, yields the following first-order condition:

$$L_t(j) = \left[\frac{W_t(j)}{W_t}\right]^{-\theta_l} L_t$$

The market for the labor aggregate is perfectly competitive which implies zero-profits in equilibrium. Combining the labor packer's objective function with the zero-profit condition and the first-order condition for the labor packer yields the following wage index:

$$W_t = \left[\int_0^1 W_t(j)^{1-\theta_l} dj\right]^{\frac{1}{1-\theta_l}} \tag{9}$$

There is now an optimality condition for choosing wages:

$$\phi_w L_t \frac{W_t}{W_{t-1}(j)} \left(\frac{W_t(j)}{W_{t-1}(j)} - 1\right) = (1-\theta_l)\left[\frac{W_t(j)}{W_t}\right]^{-\theta_l} \frac{W_t(j)}{P_t} L_t$$

$$+\frac{1}{\mu_L}\frac{W_t(j)}{P_t} + \beta E_t \left\{Y_{t+1}\frac{\lambda_{t+1}}{\lambda_t}\phi_w \left(\frac{W_{t+1}(j)}{W_t(j)} - 1\right)\left(\frac{W_{t+1}(j)}{W_t(j)}\right)\right\} \tag{10}$$

5.4 Final Goods Producers

Price stickiness are formalized in the same way as wage stickiness. A representative final goods producer uses $Y_t(i)$ from all the intermediate goods firms. The inputs are combined to produce final goods output using the following technology:

$$\left[\int_0^1 Y_t(i)^{\frac{\theta-1}{\theta}} di\right]^{\frac{\theta}{\theta-1}} \geq Y_t$$

The final goods firm maximizes the following expression for profits by choosing final output Y_t and its use of all intermediate inputs $Y_t(i)$ for $i \epsilon [0,1]$:

$$P_t Y_t - \int_0^1 P_t(i) Y_t(i) di$$

Combining profit maximization with the technology constraint immediately above results in the following optimality condition:

$$Y_t(i) = \left[\frac{P_t(i)}{P_t}\right]^{-\theta} Y_t$$

Recall that the final goods producer producing in perfectly competitive markets which has as a result that the representative final goods firm earns zero profits in equilibrium. Combining the zero-profit condition with above conditions yields the following price index P_t:

$$P_t = \left[\int_0^1 P_t(i)^{1-\theta} di \right]^{\frac{1}{1-\theta}}$$

5.5 Intermediate Goods Producing Firms

Intermediate goods producers are indexed on i∈[0,1]. These firms produce goods for productivity level Z_t by combining the capital stock K_t which these firms own, by purchasing a labor aggregate L_t from the labor packer. These firms produce intermediate goods in a monopolistically competitive environment which are combined into a final goods aggregate by the final goods firm. Intermediate goods firms can choose their price $P_t(i)$, though this is subject to a quadratic adjustment cost *à la* Rotemberg. Each firm finances its capital stock either through equity share $S_t(i)$ or bond sales $B_t(i)$. The ith firm chooses its labor purchases from the labor packer $L_t(i)$, its investment in new capital $I_t(i)$, and its price $P_t(i)$ to maximize discounted firm cash flows $D_t(i)/P_t(i)$ for given aggregate demand Y_t and price P_t for final goods. The intermediate firm returns are discounted by the households' discount factor, as they are the ultimate recipients of firm earnings.

$$\max \mathrm{E}_t \sum_{s=0}^{\infty} \beta^s \left(\frac{\lambda_{t+s}}{\lambda_t} \right) \left[\frac{D_{t+s}(i)}{P_{t+s}} \right] \tag{11}$$

These firms are subject to the same constant returns to scale Cobb-Douglas production function with fixed cost Φ:

$$\left[\frac{P_t(i)}{P_t} \right]^{-\theta} Y_t \leq K_t(i)^{\alpha} [Z_t L_t(i)]^{1-\alpha} - \Phi \tag{12}$$

There is also a capital accumulation equation that shows how new capital is formed. There is an adjustment cost to changing the investment rate as a ratio of the existing capital stock.

$$K_{t+1}(i) = (1-\delta) K_t(i) + I_t(i) \left(1 - \frac{\phi_I}{2} \left(\frac{I_t(i)}{I_{t-1}(i)} - 1 \right)^2 \right) \tag{13}$$

Dividend are paid out of profits as follows:

$$\frac{D_t(i)}{P_t} = \left[\frac{P_t(i)}{P_t}\right]^{-\theta} Y_t - \frac{W_t}{P_t} L_t(i) - I_t(i) - \frac{\phi_P}{2}\left[\frac{P_t(i)}{\Pi P_{t-1}(i)} - 1\right]^2 \tag{14}$$

The first order conditions that result for the representative firm are as follows:

$$\frac{W_t}{P_t} L_t(i) = (1-\alpha)\Xi_t K_t^{\alpha}[Z_t L_t(i)]^{1-\alpha} \tag{15}$$

$$\frac{R_t^K}{P_t} K_t(i) = \alpha \Xi_t K_t^{\alpha}[Z_t L_t(i)]^{1-\alpha} \tag{16}$$

$$\psi_P \left[\frac{P_t(i)}{\Pi P_{t-1}(i)} - 1\right]\left[\frac{P_t(i)}{\Pi P_{t-1}(i)}\right] = (1-\theta)\left[\frac{P_t(i)}{P_t}\right]^{-\theta} + \theta \Xi \left[\frac{P_t(i)}{P_t}\right]^{-\theta-1}$$

$$+\beta \psi_P E_t \left\{\frac{\lambda_{t+1}}{\lambda_t}\frac{Y_{t+1}}{Y_t}\left[\frac{P_{t+1}(i)}{\Pi P_t(i)} - 1\right]\left[\frac{P_{t+1}(i)}{\Pi P_t(i)}\frac{P_t}{P_t(i)}\right]\right\} \tag{17}$$

$$1 = E_t \left\{\left(\frac{\beta \lambda_{t+1}}{\lambda t}\right)\left(\frac{R_{t+1}^K + q_{t+1}(1-\delta)}{q_t}\right)\right\} \tag{18}$$

$$\lambda_t = \lambda_t q_t \left\{1 - \frac{\psi_I}{2}\left(\frac{I_t(i)}{I_{t-1}(i)} - 1\right)^2 - \psi_I \left(\frac{I_t(i)}{I_{t-1}(i)} - 1\right)\left(\frac{I_t(i)}{I_{t-1}(i)}\right)\right\} +$$

$$\beta E_t \left\{\lambda_{t+1} q_{t+1}\left[\psi_I \left(\frac{I_{t+1}(i)}{I_t(i)} - 1\right)\left(\frac{I_{t+1}(i)^2}{I_t}\right)\right]\right\} \tag{19}$$

Where $\Xi_t = \frac{1}{\mu_t}$ is the marginal cost of one more unit of the intermediate good, with the markup μ_t being the markup of prices over marginal costs. The price of capital is q_t. The firm finances a fixed fraction υ of its capital stock every period with risk-free bonds. These bonds pay the one-period risk-free rate. The quantity of bonds is given by $B_t = \upsilon K_t$. Total firm cash flows are divided between payments to bond holders and equity holders as follows:

$$\frac{D_t^E(i)}{P_t} = \frac{D_t(i)}{P_t} - \upsilon \left(K_t(i) - \frac{1}{R_t^R} K_{t+1}(i) \right) \tag{20}$$

This simple financial structure is useful because it generates an implied equity price. As capital is financed by debt and equity, a model-implied volatility of equity prices is generated endogeneously by the volatility of preferences and productivity and through the general equilibrium effects of the DSGE model.

5.6 Shocks

The shock processes are autoregressive in the level of preferences and productivity, as well as autoregressive in the volatility of preferences and productivity.

$$ln(a_t) = (1 - \rho_a) ln(a_{t-1}) + \sigma_t^a \epsilon_t^a \quad , \quad \epsilon_t^a \sim N(0,1) \tag{21}$$

$$ln(\sigma_t^a) = (1 - \rho_{\sigma^a}) ln(\sigma^a) + \rho_{\sigma^a} ln(\sigma_{t-1}^a) + \sigma^{\sigma^a} \epsilon_t^{\sigma^a} \quad , \quad \epsilon_t^{\sigma^a} \sim N(0,1) \tag{22}$$

$$Z_t = (1 - \rho_Z) ln(Z_{t-1}) + \sigma_t^Z \epsilon_t^Z \quad , \quad \epsilon_t^Z \sim N(0,1) \tag{23}$$

$$\sigma_t^Z = (1 - \rho_{\sigma^Z}) ln(\sigma^Z) + \rho_{\sigma^Z} ln(\sigma_{t-1}^Z) + \sigma^{\sigma^Z} \epsilon_t^{\sigma^a} \quad , \quad \epsilon_t^{\sigma^a} \sim N(0,1) \tag{24}$$

5.7 Equilibrium

As all households and firms are symmetric, all firms and households make the same choices. That means that in equilibrium, all markets clear, all intermediate firms choose the same prices ($P_t(i) = P_t$), and output ($Y_t(i) = Y_t$), and all households choose the same wages ($W_t(j) = W_t$) and the same labor supply ($L_t(j) = L_t$), and so on. While heterogeneity is necessary to generate the nominal frictions of wage and price stickiness in this model, in the end the dynamics of the model can be analyzed through a representative agent.

5.8 Monetary Policy

In general, New Keynesian models determine the interest rate by using a Taylor Rule where, unlike in Real Business Cycle models, the interest rate is not set in the capital markets, but instead is chosen by the central bank (Taylor, 1993). The Taylor rules are set as a function of inflation and the output gap, with the nominal interest rate increasing in the inflation rate and in the output gap. Taylor rules are a reasonable characterization of monetary policy in the United States since the 1980s. The Federal Reserve came into being in 1913, and it is generally seen that it did not follow a rule-based framework for setting monetary policy and interest rates until many decades in the future.[18]

$$ln(R_t) = \rho_r ln(R_{t-1}) + (1 - \rho_r(ln(R) + \rho_\Pi ln(\frac{\Pi_t}{\Pi}) + \rho_y ln(\frac{Y_t}{Y_{t-1}})) \tag{25}$$

There is also the issue of the zero-lower bound for interest rates, as a Taylor-Rule may predict a negative interest rate which is not possible for the central bank to achieve. The zero-lower bound was likely in effect in the U.S. by 1934 (Hanes, 2006). I do not explicitly model the zero-lower bound constraint, but the zero-lower bound can make the Taylor-Rule inappropriate as a Taylor Rule may predict an impossible negative rate. To model the Fed's monetary policy in the recession phases of the Great Depression, I use a simple money rule where the money base is constant (zero-money growth rule). This is a passive monetary policy where the Fed does not offset any negative shocks by expanding the money supply. This is a good description of monetary policy in the 1929-1933 and 1937-1938 recessions, when the Fed did not follow a countercyclical monetary policy, following Friedman and Schwartz's view of the Federal Reserve during the 1930s. Thus the money growth rule will simply be set to keep real balances constant:

$$\tau_t = 1 \ , \forall \text{ t}$$

[18] See Taylor (1999)) and Friedman and Schwartz (1971) *inter alia.* Orphanides (2002, 2003) has a more favorable view of the Fed's major "failures" of the 1930s and 1970s.

5.9 Calibration

The calibrated parameters are largely drawn from BB, who themselves largely draw from Ireland (2003, 2011) and Jermann (1998). The behavior of preferences and productivity is estimated in a similar fashion as in BB. The following ordinary least squares reduced form autoregressive equation is estimated for quarterly stock volatility of the DJIA from 1929-1941.[19]

$$\ln(V_t^D) = (1-\rho_{V^D})\ln(V^D) + \rho_{V^D}\ln(V_{t-1}^D) + \sigma^{V^D}\varepsilon_t^{V^D} \quad , \quad \varepsilon_t^{V^D} \sim N(0,1) \tag{26}$$

Here V^D is the observed stock volatility. This estimation yields a value of 0.798 for ρ_V, 2.97% for V^D, and 101.9% for σ^{V^D} with an R^2 of 0.64. Relative to BB's results for the modern era, the autoregressive coefficient is slightly lower and the variance term much higher for this period reflecting the massive swings in volatility in the 1930s. This means that a one-standard deviation increase in regression implied volatility shock essentially doubles stock volatility. I calibrate the preference and productivity shocks to match the model prediction for volatility to the implied volatility process in the data.

5.10 Model Simulations

To solve my model, I use the PerturbationAIM program of Swanson et al. (2006) which solves DSGE models using a perturbation method. A perturbation method solves for non-linear dynamics in a neighborhood around the steady-state.[20] The impulse responses show the impact of a one percent standard deviation shock to productivity or preferences on important endogeneous variables in the model.[21]

Figure 3 shows the impact of a demand uncertainty shock with a constant money supply with

[19] I exclude October 1929 as this is a stock volatility event that does not correspond to the other uncertainty measures as explained above

[20] To obtain results for time-varying volatility, I use a third-order perturbation. For constant volatility to matter, at least a second-order approximation is required, so for time-varying volatility, a third-order approximation is needed. It is possible to use an even higher-order approximation, but a third-order approximation is very close to the underlying nonlinear model, while higher order approximation are very computationally expensive.

[21] Percent standard deviations rather than whole standard deviation shocks are used to ensure that no explosive paths are encountered. As these non-linear approximations are valid close to the steady-state, smaller shocks are, if anything, more accurate than larger shocks. I rescale the shocks in the impulse responses by multiplying by 100 so magnitudes are easier to see.

price stickiness and wage stickiness. One can see that uncertainty shocks generate persistent declines in output, investment, consumption, and labor hours. All these variables fell when uncertainty was high in the 1930s, so the model matches the behavior of quantities well. The simulations look similar to the responses found in the empirical section though the magnitude in the model is somewhat lower, with a peak effect of about 0.35%. As output was falling at approximately 2.5% per quarter over the recession of 1929-1933, and the average standard deviation uncertainty shock implied by the autoregressive model over than period is 0.72, my model is explaining approximately 10% of the decline in output. The effect of a volatility shock is gradual, with the maximum impact on output taking place after 10 quarters, which is fairly persistent. As price and wage stickiness were present in the 1930s and the Fed largely followed a passive monetary policy while uncertainty shocks were hitting the economy, the persistence of this result is consistent with intuition. The behavior of prices is less accurate, as the model predicts inflation while deflation was what occurred during recession in the 1930s, though the magnitude is quite small.

Figure 4 shows the model simulation for price stickiness and wage flexibility. Here the effect is smaller than in in the case of both price and wage stickiness, as price stickiness magnifies the effect of wage stickiness. But otherwise, the effects are largely the same qualititively as for both price and wage stickiness. Figure 5 shows the case where prices are flexible and wages are sticky. Again, the results are qualitatively similar as for both price and wage stickiness, though different quantitatively. Figure 6 shows the effect of a demand uncertainty shock on the model economy with price and wage flexibility. We can see that this setting does not generate recognizable business cycles, as consumption, output, and hours all rise counterfactually. Inflation also rises. This basic result does not change with recalibration to the 1930s. A frictionless model cannot generate plausible business cycles as BB showed, due to a precautionary effect. Uncertainty shocks under flexible prices and wages would drive a boom in this model, rather than a recession.

Figure 7 shows the impact of a productivity uncertainty shock in the model. While the magnitude of productivity uncertainty is actually larger than for demand uncertainty, the response of labor is much larger than that of other quantities. Also, the negative effects of an uncertainty shock are much less persistent for productivity uncertainty as for demand uncertainty. While the effects for productivity uncertainty are larger in magnitude as for demand uncertainty, the interpretation of a large second-moment to productivity seems harder to justify even than a large change in the first moment of productivity. Figure 8 shows the model under a Taylor-Rule with wage stickiness and price stickiness. Due to the Taylor-Rule, the central bank offsets the negative effect of uncertainty shocks which reduces the magnitudes and persistence of the negative effects of uncertainty shocks. As these negative effects are offset by the central bank lowering interest rates, this diminished effect is intuitive.

Overall, I find that all specifications of the model generate declines in important macroeconomic quantities consistent with U.S. experience in the Depression. Many specifications of the model exhibit a small increase in inflation rather than deflation on impact of an uncertainty shock. This is due to a "precautionary markup" effect, where firms respond to uncertainty by marking up their prices more than they would under certainty. This effect generates an increase in inflation, as shown by Fernández-Villaverde et al. (2011). The other effect of an uncertainty shock is a decline in aggregate demand, which causes prices to fall as firms respond to a decline in demand by cutting prices. Here, the precautionary markup effect dominates the aggregate demand effect and generates an increase in inflation. While this increase in prices is counterfactual, this effect is small and is not a main channel of the model. Wage stickiness does generate a plausible business cycle on impact of an uncertainty shock, as output, investment, consumption, and hours all fall. The specifications with a passive monetary policy generate more persistent declines in output, consumption, investment, and hours than the specifications with the Taylor Rule. The Fed is not offsetting the negative effects of the uncertainty shocks in the former case so the effect of the uncertainty shock is allowed to persist. As the Fed conducted a fairly passive monetary policy during recessions in the 1930s, the effects of uncertainty shocks were larger and more persistent than if the Fed had offset these negative shocks. The nominal frictions of nominal and wage stickiness combined with a more passive monetary policy and the more unpredictable nature of uncertainty shocks all combined so that uncertainty shocks would have produced a much larger negative effect in the 1930s than they would have in the modern period.

6 Conclusion

This study has examined the effect of uncertainty shocks on the American economy of the 1930s. I constructed several measures of uncertainty to estimate how large uncertainty shocks were in the Great Depression, including stock volatility, a newspaper index, credit spreads, and a dichotomous volatility indicator. An economy calibrated to conditions of the 1930s was simulated to show that uncertainty shocks would have had a larger effect in Depression conditions than in the postwar. I added wage stickiness to existing models of price stickiness and simulated a passive monetary policy to emulate conditions of the 1930s. Wage stickiness generates similar effects as price stickiness on impact of an uncertainty shock, generating declines in consumption, output, investment, and hours. These new additions to New Keynesian DSGE models are both contribution to the uncertainty shocks DSGE literature as well as being important to modeling the effect of uncertainty shocks in the U.S. Great Depression.

Empirical evidence showed that the uncertainty measures are correlated with statistically significant declines in output, employment, and hours in later months. This result is robust to the indicator used. These structural vector auto-regressions show that uncertainty shocks have a similar effect both in the pre-war and post-war period and cause declines in employment, hours, and industrial production. I find a peak impact of uncertainty, as measured by stock volatility, of approximately -3% for hours worked, -1.5% for employment, and -2% for industrial production. Reverse causality can be ruled out statistically through Granger causality tests, as macroeconomics quantities like output have no future predictive power for stock volatility, while stock volatility does have predictive power for macroeconomic quantities. Finally, I constructed a historical timeline that identified uncertainty events in the Great Depression such as banking failures, uncertainty over the future of the gold standard and monetary policy, policy uncertainty, and war fears, to show that there were large uncertainty shock events made the 1930s an uncertain period.

Uncertainty has seldom been considered as a significant factor in the Great Depression, but uncertainty shocks provide a convincing way to think about the causes of the Great Depression in the U.S. While other explanations are obviously important, uncertainty shocks should be considered as one of several major determinants of the severity and length of the Great Depression. This paper should be placed within the broader literature studying the effects of uncertainty and risk shocks in macroeconomics as well, as novel features have been added and analyzed for this type of model. This burgeoning literature, fueled by the recent experience with the uncertainty resulting from the 2008 global financial crisis, will continue to progress in the future. While uncertainty was a major factor in the U.S. Great Depression, after the Second World War conditions became very certain and relative stability prevailed. Beginning in the mid 1980s, macroeconomic conditions became even more stable, resulting in the Great Moderation. This period of tranquility was shattered with the global financial crisis of 2008, which made for a much less certain outlook for the world economy. While conditions at the time of writing have stabilized, it is clear that the outlook for the world's economies has changed significantly. The prospect of a debt default by a major industrialized country or a catastrophic Euro exit has increased in likelihood by several orders of magnitude in the past few years. While policy responses have been much improved recently, especially compared to the 1930s, the world economy still experienced a severe recession driven by uncertainty shocks. It would be wise to look to the past for inference about how serious uncertainty shocks so we are better able to deal with our newly uncertain world.

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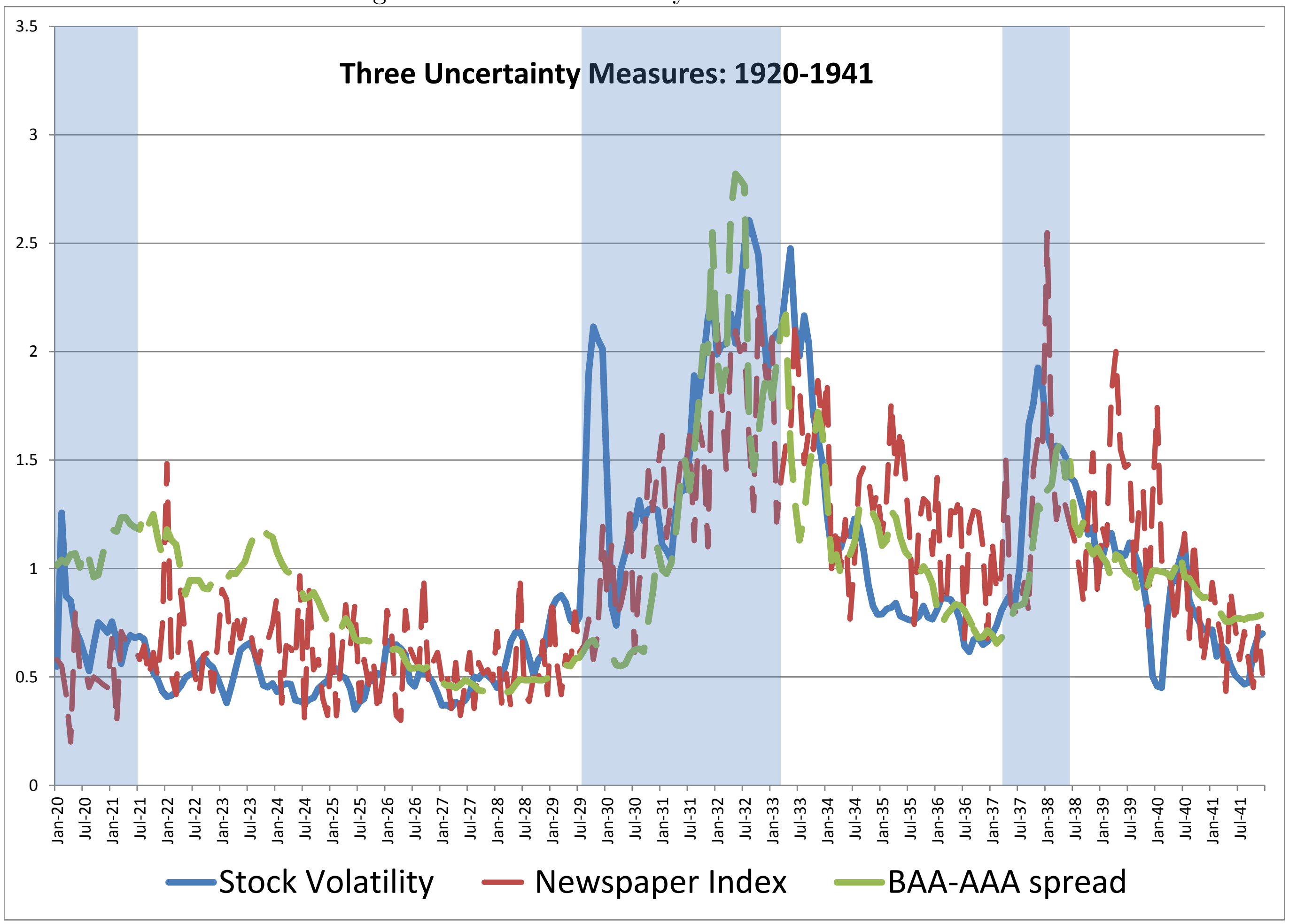
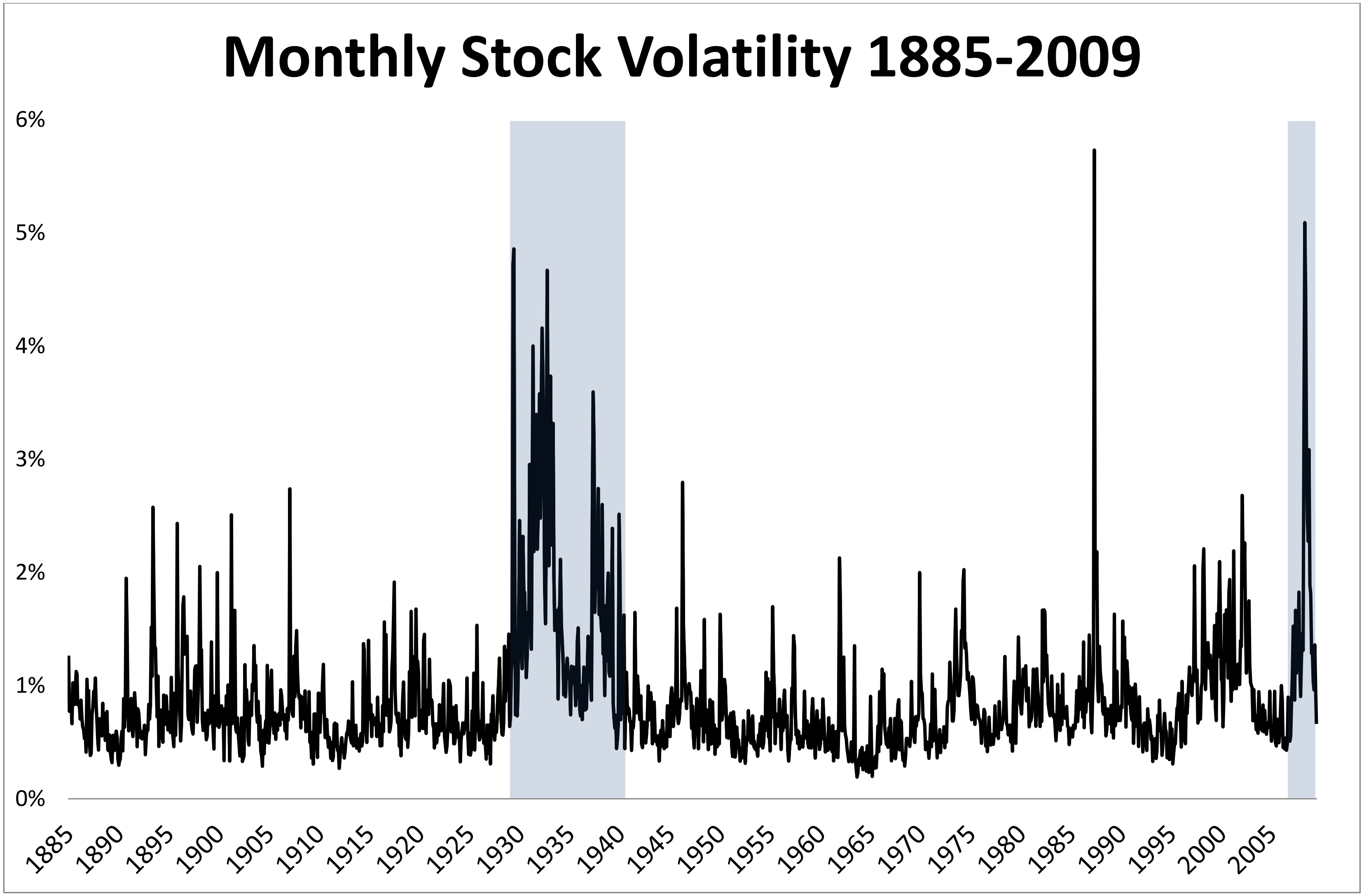
A Appendix

Figure 1: Three Uncertainty Measures: 1920-1941



Notes: "Stock Volatility" is 5-month moving-average of DJIA return volatility multiplied by 125. "Newspaper Index" is a newspaper index of economic uncertainty mentions in the New York Times per month. "BAA-AAA spread" is difference in interest rates between BAA and AAA rated bonds divided by 2. Blue bars are NBER recession periods.

Figure 2: Stock Return Volatility: 1885-2009



Notes: Monthly stock volatility calculated as standard deviation of log daily return. Dow Jones Industrial Average used from 1885-1962, Standard and Poor 500 Index used from 1926-2009. Shaded areas are Great Depression (1929-1941) and Great Recession (2008-2009).

Table 1: **Stock Volatility Dichotomous Indicator Variable: 1923-1941**

	1928	1929	1930	1931	1932	1933	1934	1935	1936	1937	1938	1939	1939	1940	1941
Jan					**X**										
Feb				**X**	**X**	**X**									
Mar					**X**	**X**					**X**				
Apr				**X**	**X**	X					**X**				
May				**X**	**X**	X									
Jun			**X**	**X**	**X**						**X**			X	
Jul					**X**	X	X								
Aug	X				**X**										
Sep			**X**	**X**	**X**					**X**					
Oct		**X**	**X**	**X**	**X**	X				**X**					
Nov	X	**X**		**X**	**X**					**X**					
Dec			**X**	**X**											

Notes: X indicates a month when stock return volatility is at least 1.65 standard deviations above mean volatility. Bold X is a high volatility event during NBER recession. No high volatility events 1923-1927.

Table 2: **Calibration Parameters**

Parameter	Title	Value
α	Capital's Share in Production	0.333
β	Household Discount Factor	0.9987
δ	Depreciation Rate	0.025
η	Elasticity of Household Labor Supply	2.9
η_m	Elasticity of Money Balances	1/9
ϕ_I	Parameter Governing Investment Adjustment Cost	2.5
ϕ_P	Parameter Governing Price Adjustment Cost	160.0
γ_w	Parameter Governing Wage Adjustment Cost	160.0
Π	Steady State Inflation Rate	1.00
ρ_y	Taylor-rule coefficient on output	1.50
ρ_π	Taylor-rule coefficient on inflation	0.50
σ	Household Risk Aversion Parameter	2.0
θ	Intermediate Goods Elasticity of Substitution	6.0
θ_l	Intermediate Goods Elasticity of Substitution	6.0
ρ_a	Persistence of First Moment Preference Shock	0.90
ρ_{a^σ}	Persistence of Second Moment Preference Shock	0.80
σ_a	Steady-State Preference Shock Volatility	0.03
σ_{σ^a}	Volatility of Second Moment Preference Shock	1.83
ρ_z	Persistence of First Moment Technology Shock	0.99
ρ_{σ^z}	Persistence of Second Moment Technology Shock	0.80
σ_z	Steady-State Volatility of Technology	0.01
σ_{σ^z}	Second Moment Technology Shock Volatility	1.923

Table 3: **Data Sources**

Source	Data	Frequency	Notes
National Bureau of Economic Research	Recession Dates		
Dow Jones/Cowles Commission	Dow Jones Industrial Average	Daily	m13009
Center for Research in Security Prices	Standard and Poor's 500	Daily	
Federal Reserve Board of Governors	Industrial Production	Monthly	
Federal Reserve Board of Governors	New York Fed Discount Rate	Monthly	m13009
Federal Reserve Board of Governors	Index of Durable Manufacturing	Monthly	m01234b
Bureau of Economic Analysis: NIPA	Gross Domestic Product	Annual	2005 Chained Dollars
Bureau of Economic Analysis: NIPA	Gross Fixed Domestic Investment	Annual	2005 Chained Dollars
Bureau of Labor Statistics	Manufacturing Employment	Monthly	m08010b
Bureau of Labor Statistics	Manufacturing Worker Manhours	Monthly	m08265a
Bureau of Labor Statistics	Consumer Price Index, All Items	Monthly	m04128
National Industrial Conference Board	Average Hourly Earnings	Monthly	m08142
National Bureau of Economics Research	Recession Dates	Quarterly	

Table 4: **Granger Causality Tests**: Volatility on Production, Employment, and Hours

H_0: Earlier Does *Not* Granger Cause Later
Reject → Granger Causal at 5% Significance

Earlier	Later	p-value	Reject?
Stock Volatility	Industrial Production	0.0312	Yes
Industrial Production	*Stock Volatility*	0.5174	No
Stock Volatility	Employment	0.0044	Yes
Employment	*Stock Volatility*	0.3735	No
Stock Volatility	Hours	0.0001	Yes
Hours	*Stock Volatility*	0.1826	No

Figure 3: IRF Results: Constant Money, Price and Wage Stickiness, Demand Uncertainty

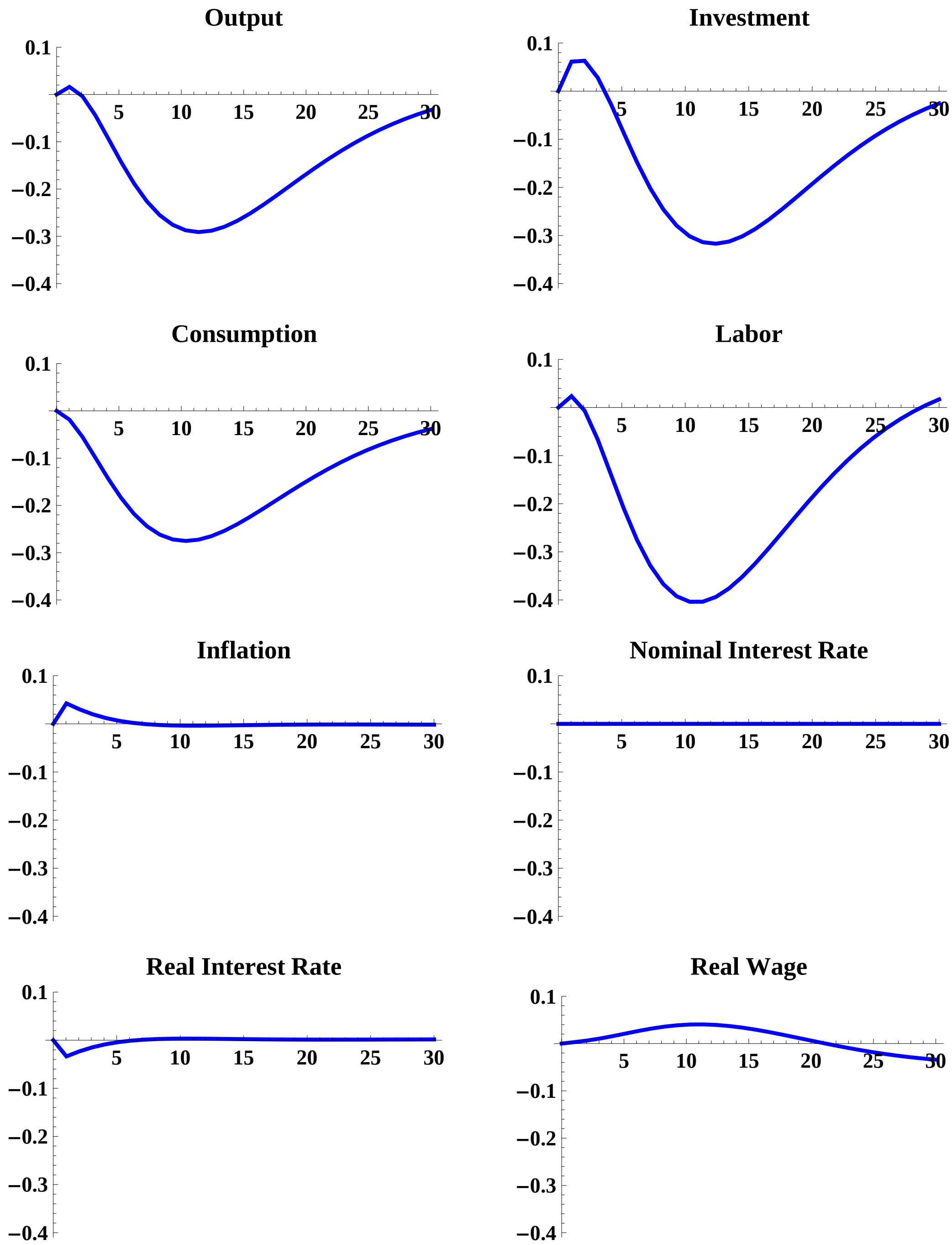


Figure 4: IRF Results: Constant Money, Price Stickiness, Wage Flexibility, Demand Uncertainty

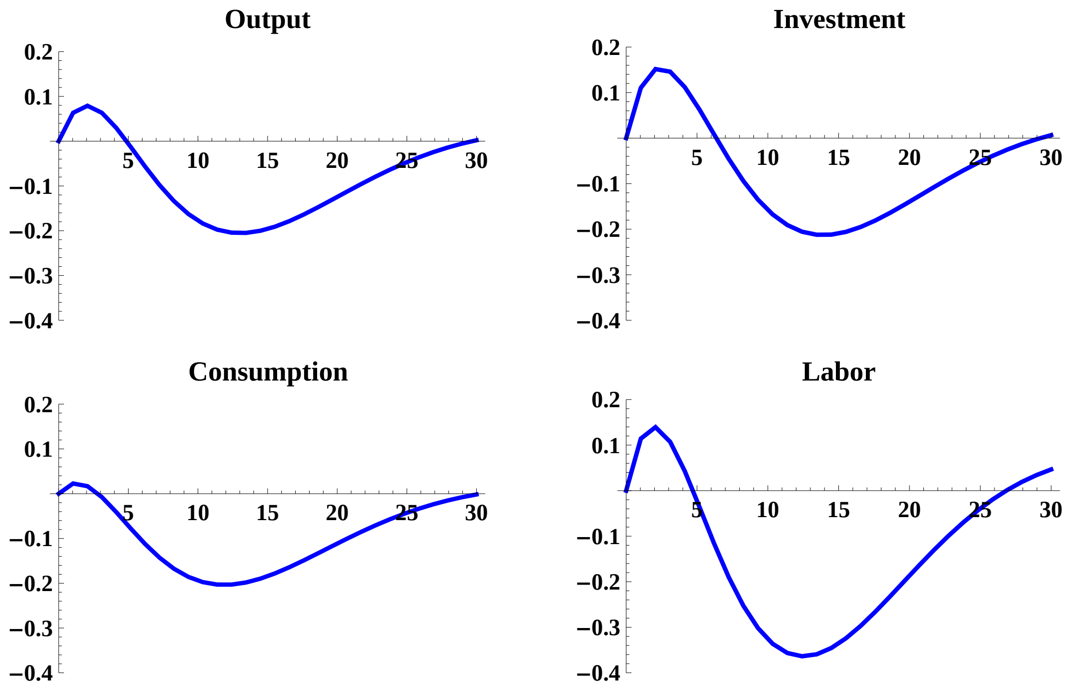


Figure 5: IRF Results: Constant Money, Price Flexibility, Wage Stickiness, Demand Uncertainty

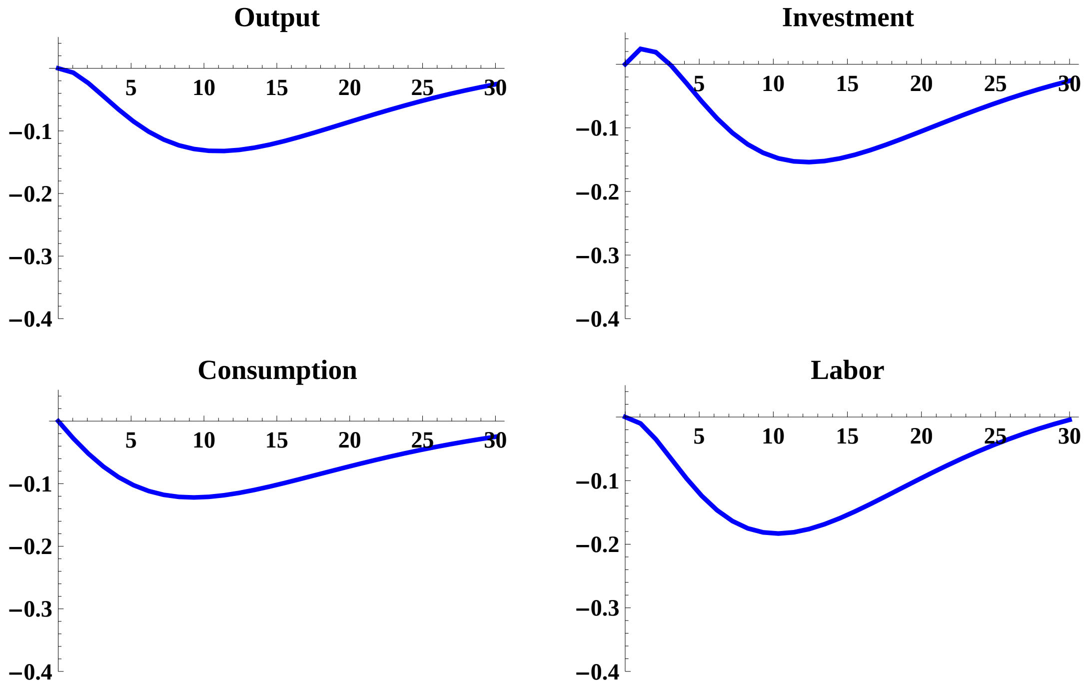


Figure 6: IRF Results: Constant Money, Price Flexibility, Wage Flexibility, Demand Uncertainty

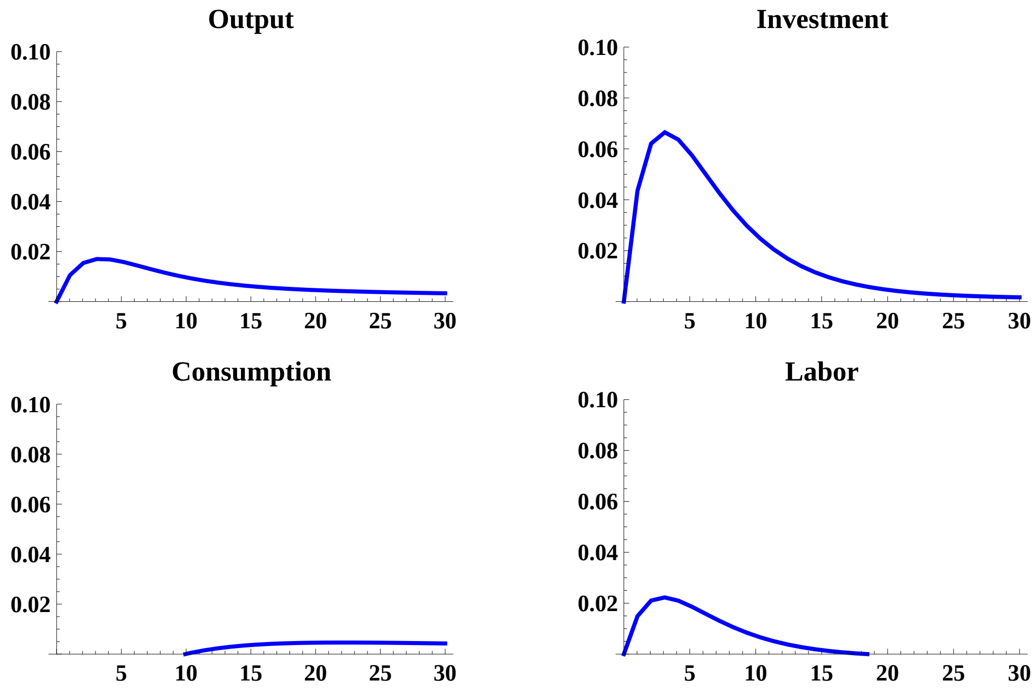


Figure 7: IRF Results: Constant Money, Price Stickiness, Wage Flexibility, Productivity Uncertainty

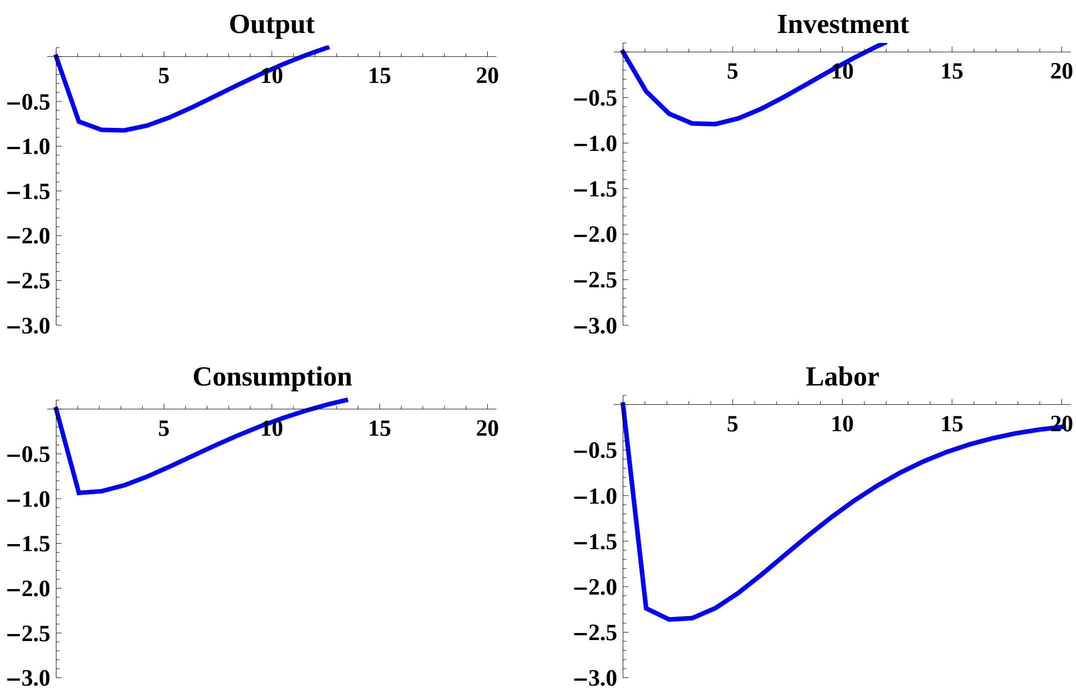


Figure 8: IRF Results: Taylor Rule, Price Stickiness, Wage Stickiness, Demand Uncertainty

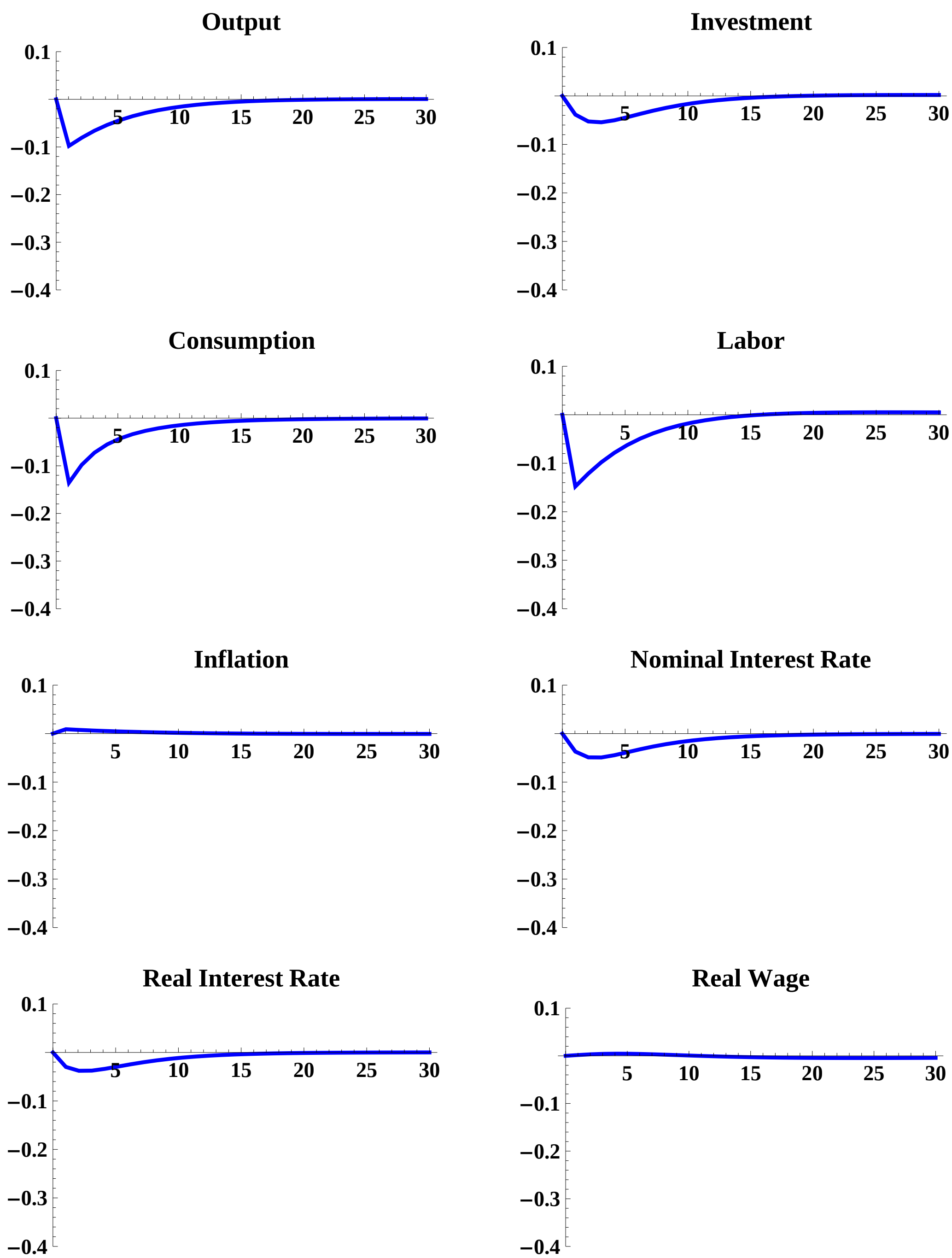


Figure 9: Impact of Stock Volatility on Output, Hours, and Employment

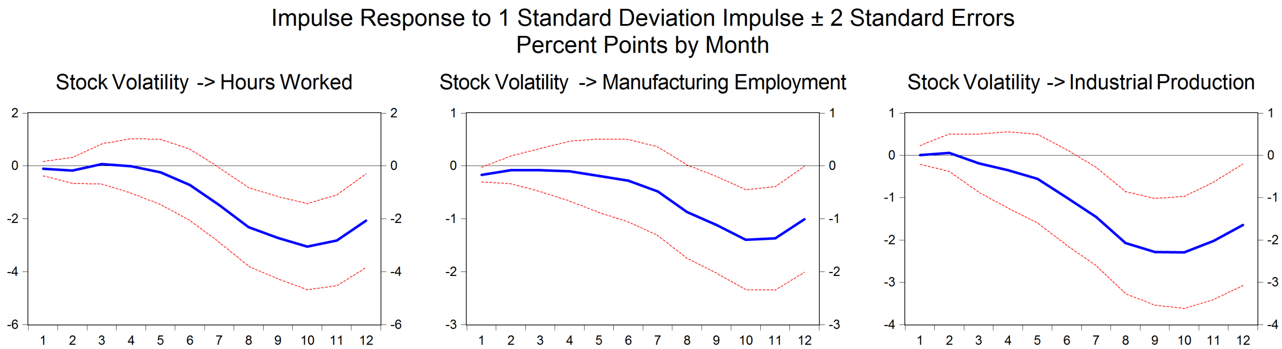


Figure 10: Impact of Stock Volatility on Output, Hours, and Employment without Stock Level

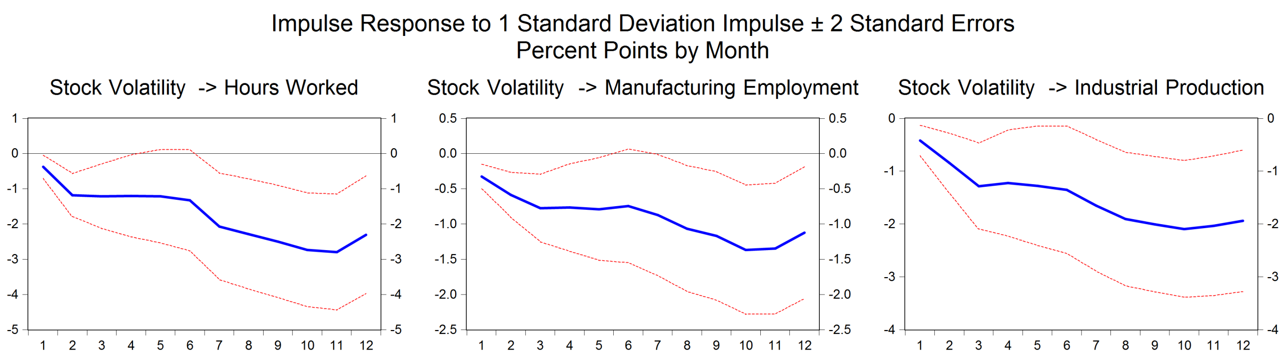


Figure 11: Impact of Stock Volatility Indicator on Output, Hours and Employment

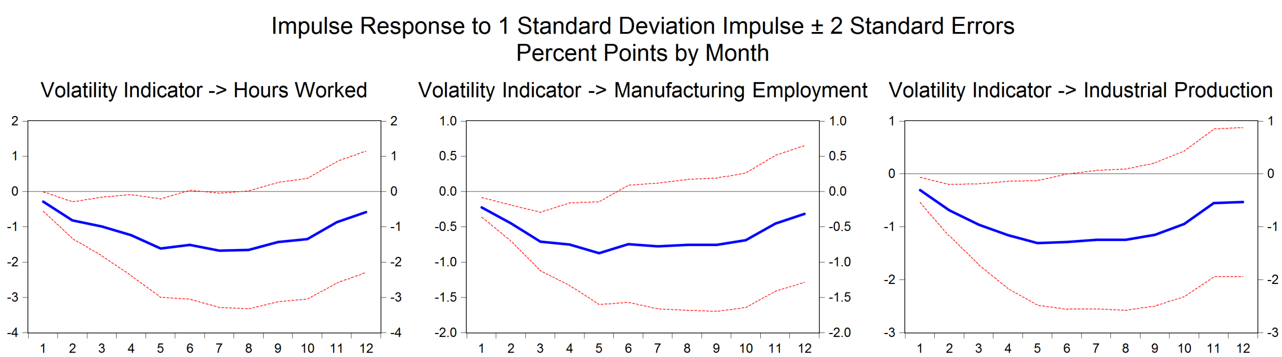


Figure 12: Impact of Stock Volatility Indicator on Output, Hours and Employment without Stock level

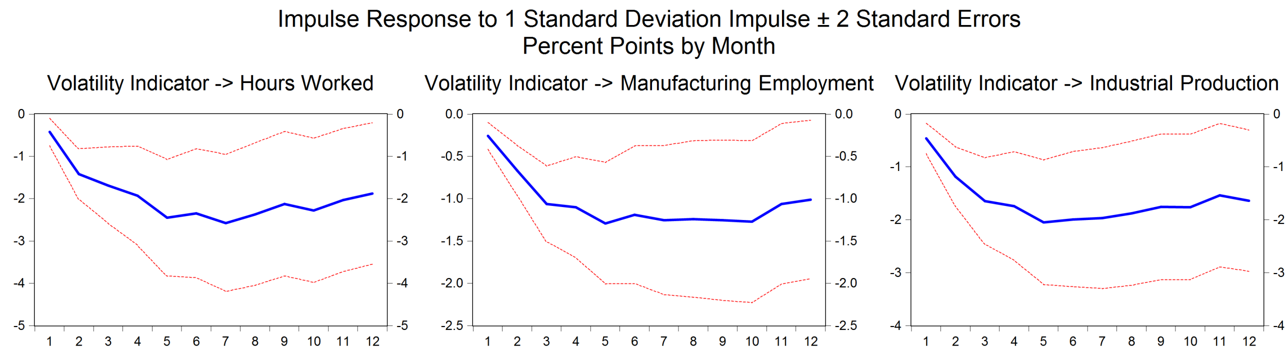


Figure 13: Impact of Uncertainty Newspaper Index on Output, Hours and Employment

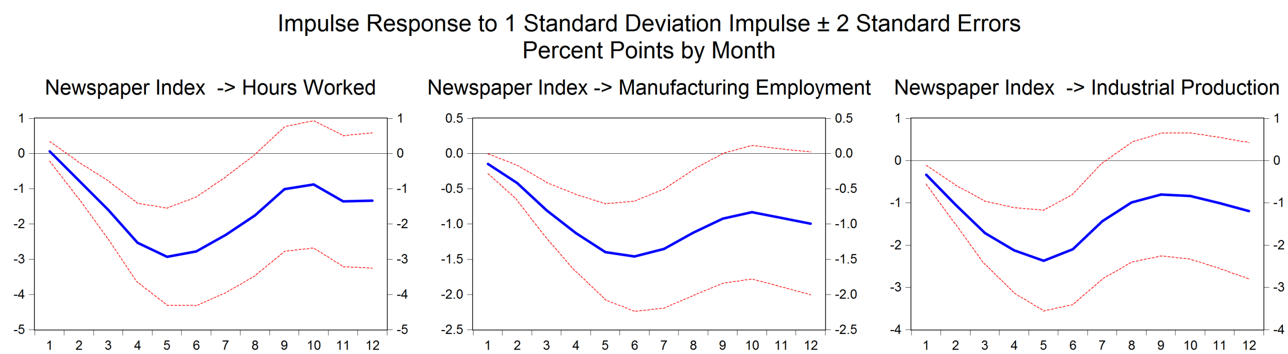


Figure 14: Impact of Uncertainty Newspaper Index on Output, Hours and Employment without Stock Level

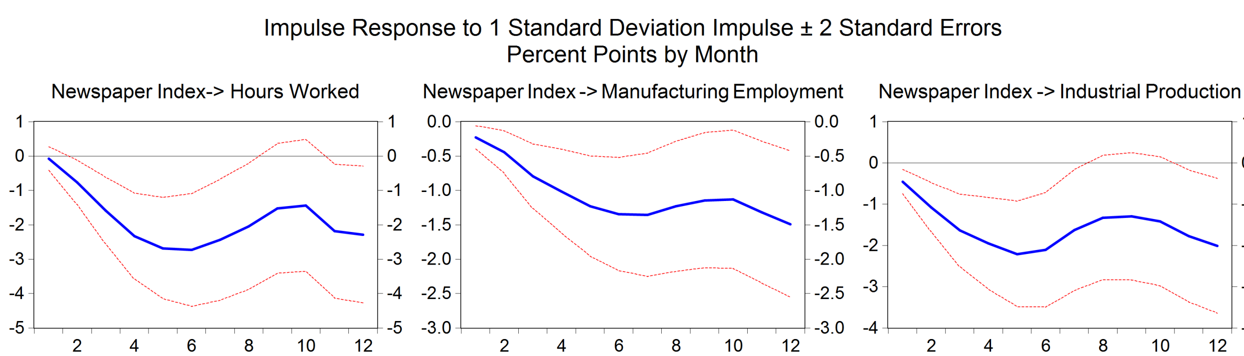


Figure 15: Impact of BAA-AAA spread on Output, Hours and Employment without Stock Level

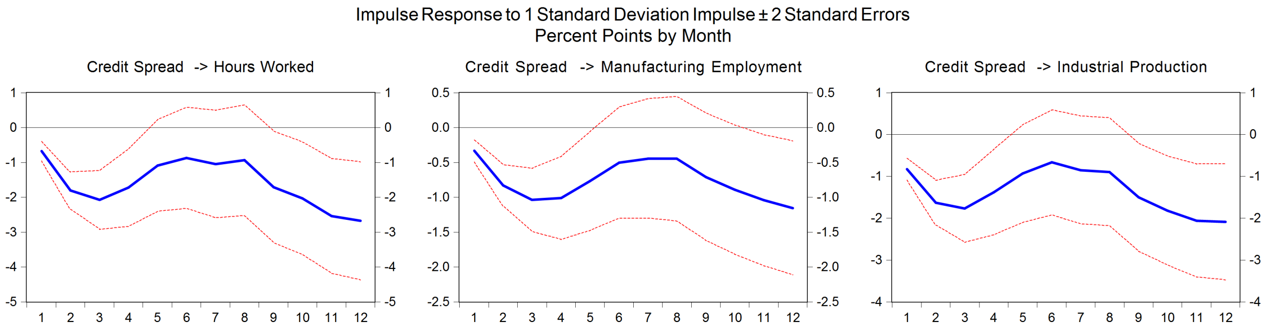


Figure 16: Trivariate: Stock Volatility, Employment, Output

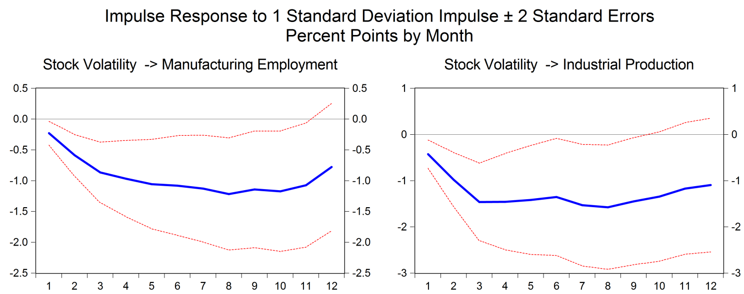


Figure 17: Quadvariate: Stock Volatility, Stock Level, Employment, Output

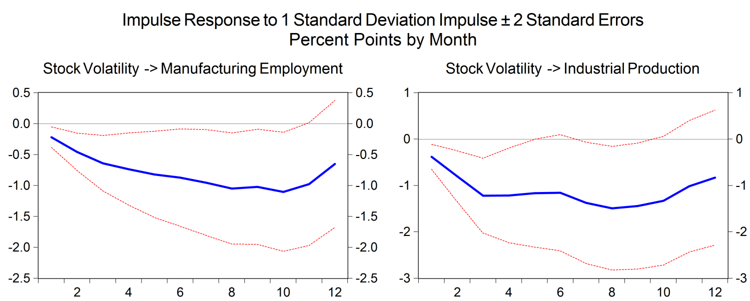


Figure 18: Reverse Quadvariate: Stock Volatility, Stock Level, Employment, Output

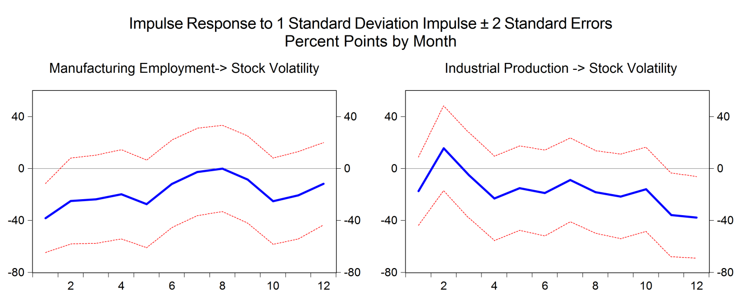
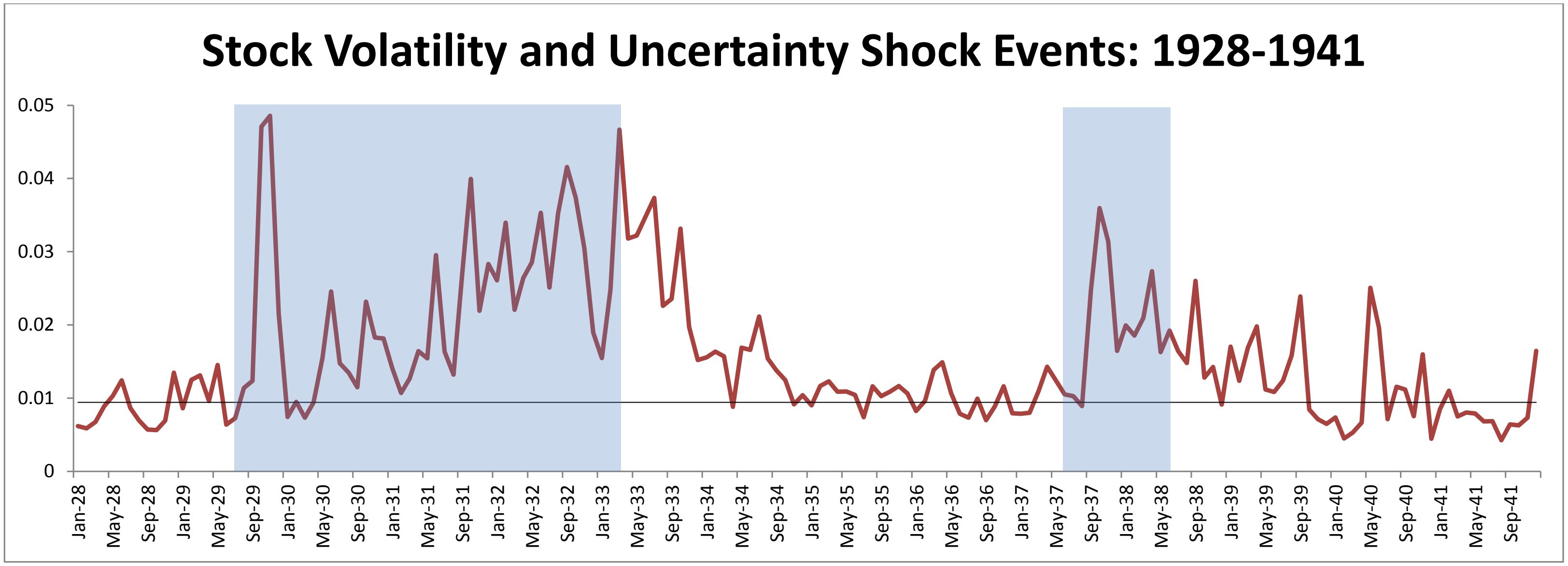


Figure 19: Stock Volatility and Events 1929-1941



Date	**Event**
Oct 1929	Great Crash
June 1930	Smoot Hawley
Dec 1930-Mar 1933	Banking Collapse/Crisis
	Threat of Revolution/Radical Change
Sep 1931-Jan 1934	Uncertainty over Future of Gold Standard
Mar 1933- Dec 1941 (?)	New Deal Policy Uncertainty (but not much after 1933)
Feb 1937-April 1938	Uncertainty over Monetary Policy/Mistake of 1937
Oct 1937-Sep 1939	War Fears
Notes: Monthly S&P 500 return volatility. Blue bars are NBER recession periods. Black line is average volatility 1928-2009.	