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Output, Stock Volatility, and Political Uncertainty in a Natural Experiment: Germany, 1880–1940

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ABSTRACT

Why does stock volatility increase when output declines? The theory of investment under uncertainty implies that political uncertainty may simultaneously increase volatility and reduce output. Though cause and effect are typically hard to separate, the transition from Imperial to Weimar Germany offers a natural experiment because major political events left clear traces on stock prices. Current and past increases in volatility are associated with output declines, consistent with U.S. experience. However, political events are more clearly the source of volatility, and the results support the view that the relationship between volatility and output reflects the joint effects of political factors.

WHY DOES STOCK VOLATILITY CHANGE over time, and why is it higher in recessions? Though the basic facts are well established (Huang and Kracaw (1984), Schwert (1989a), Romer (1990), Pindyck (1991a)), the causal link between volatility and business slumps is unclear. Slumps may cause volatility, volatility may cause slumps, or both may be the consequence of some other, more clearly exogenous factor.

Political uncertainty may represent such an exogenous factor. Consider the Great Depression in the United States. Major changes in economic policy occurred in the 1930s, and even larger changes were a possibility. The highly volatile stock market of the 1930s may very well have reflected a nonnegligible, fluctuating probability that the United States would "go socialist." The same uncertainty about economic policy may also have caused a slump in business investment and reduced consumer spending.

Though the explanation has appeal, political uncertainty was not clearly exogenous. A critic could say that higher volatility and the radical nature of policy debate were consequences of the decline in output, and the Depression itself had other causes. As Schwert (1989b) points out in a more general context, we can easily construct links between volatility and the business cycle, but causation is hard to pin down.

This paper looks at stock volatility and output in a case marked by a clear, exogenous political shock. Until the start of World War I in 1914, Imperial Germany had a stable, limited government. Weimar Germany after the war

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was marked by revolution, an unstable republic, insurrection, the rise of anti-capitalist parties on the left and right, a major expansion of government, hyperinflation, and a protracted struggle over reparations. With ample justification, economic historian Gerald Feldman (1993) calls the period from 1914 to 1924 "The Great Disorder."

I use this natural experiment to make three contributions to the study of stock volatility. First, the switch in regimes throws light on the sources of volatility. Stock volatility was low before 1914, it increased markedly after the war, and a number of large market movements are clearly linked with specific political events. Second, I use the theory of investment under uncertainty to forge a natural connection between political uncertainty, stock volatility, and output. This theory is related to the analysis of contingent investment or "real options" (see Baldwin (1982), Bernanke (1983), McDonald and Siegel (1986), Pindyck (1991b), Dixit and Pindyck (1994), and Trigeorgis (1996)). Finally, my empirical results for Germany confirm earlier work for the United States; volatility increases before and during business slumps. However, the clear political origins of volatility in Germany cast doubt on the view that causation runs from spontaneously generated, exogenous volatility to output. Rather, German experience suggests that political uncertainty generated both stock volatility and output declines. I should add that this paper represents the first application of formal statistical methods to Gielen's (1994) stock price index, which, unlike earlier German series, covers the First World War and adjusts for dividends.

Section I of the paper reviews the theory of investment under uncertainty and the empirical work linking volatility and the business cycle for the United States. Section II turns to the German experience, in particular the connection between political events and stock prices during and after the First World War. Section III provides statistical estimates for the period 1880 to 1940 which show that changes in stock price volatility explain changes in output, much as they do in the United States. Section IV offers an overview and conclusion. Data sources are detailed in the Appendix.

I. Volatility, Output, and Political Uncertainty

Three strands of literature recognize the possible effects of political uncertainty: studies of stock price volatility, some of the older work on business cycles, and recent theoretical work on investment under uncertainty. However, the empirical literature that links stock volatility and the business cycle in the United States often plays down political factors, focusing instead on stock volatility as a reflection of generic uncertainty of indeterminate origin.

In the most general setting, stock volatility may reflect diffuse and easily changed beliefs about the future, especially the chance of "bad news." Though bad news could have various sources, government action is likely to loom

large on any list. In fact, the "peso problem"—a fluctuating but substantial likelihood of bad news that is unrealized in the sample—is often linked with political instability. For example, Schwert (1989a) shows that stock volatility increases with aggregate leverage, is correlated with interest rate and bond volatility, increases with trading volume, and increases during recessions. However, he notes that most of the observed variation in volatility is unexplained, especially during the Great Depression, and he suggests that Depression-era volatility may have originated in concerns about the survival of the United States as a capitalist country. Along similar lines, De Long and Becht (1992) exclude the years 1914 to 1950 in their study of excess volatility in Germany, citing "too many 'peso problems' for any study of excess volatility to be convincing." In these and similar cases, political uncertainty is the leading suspect.

The influence of that same sort of political uncertainty on real output has often been discussed casually and in the context of specific episodes. The founder of modern business cycle research, Wesley Clair Mitchell (1913), attributes the downturn and volatile market of 1911 to 1912 to uncertainty stemming from "trustbusting." Roose (1954) and Friedman and Schwartz (1963) point to political factors to explain the economy's slow climb out of the Great Depression. More recently, Cukierman (1980) and Bernanke (1983) provide formal models along these lines. Bernanke emphasizes the importance of irreversibility, the option-like quality of the ability to delay investment, and the implication that unfavorable future outcomes influence the decision to invest or wait. If investments can be costlessly reversed, if they can be salvaged without loss, then there is no gain from waiting. However, most investments cannot be costlessly undone. Unfavorable future outcomes matter because they result in a decision to delay—the "bad news principle." Bernanke also lists a number of macro-level factors that may increase uncertainty and influence the decision to invest now or wait. The list includes wars, oil price instability, governmental regulation, and the introduction of new technology. Pindyck's (1991b) review of the literature on uncertainty and irreversible investment also notes that political uncertainty may depress investment.

The possible effects of uncertainty on both stock volatility and investment provide a rationale for the empirical connection between volatility and changes in real output (Huang and Kracaw (1984), Schwert (1989a, 1989b)). A few recent studies have gone further and invoked the literature on uncertainty and investment to establish a causal link, but they view stock volatility as a measure of uncertainty of unspecified origin. Romer (1990) argues that increased uncertainty should cause a decline in *consumer* durables purchases, and she finds that stock volatility explains declines in durables purchases over the period from 1891 to 1986. Pindyck (1991a) shows that the growth of quarterly investment is predicted by the lagged variance of the NYSE index. He takes stock price volatility to be a reflection of underlying product price volatility, which in turn generates uncertainty about future profitability.

Both Romer and Pindyck leave open the question of the ultimate source of volatility, but a variety of considerations point to politics as an important source. For example, Bittlingmayer (1993) implicates "trustbusting" in the Panic of 1907 and the unsettled market of 1911 to 1912. In the case of the October 1929 crash, Bierman (1991) emphasizes Fed policy, and Wanniski (1983) the Smoot–Hawley Tariff. Bittlingmayer (1992) points to shifting antitrust policies and antibusiness initiatives to explain the October 1929 and October 1937 crashes. In the case of the October 1987 crash, Mitchell and Netter (1989) implicate proposed antitakeover legislation in some of the volatility before and after the crash. Finally, consider the 1975 and 1980 recessions. Both came on the heels of energy price shocks and stock price volatility. Arguably, the political reaction to increased energy prices rather than the energy price shocks themselves may have generated some of the volatility. The "energy crises" resulted in energy price controls, crude oil allocation programs, windfall profits taxes, and uncertainty about monetary policy. Consequently, even in the United States, political uncertainty may have generated aggregate stock volatility, though the role of politics may have been varied and often subtle.

II. Politics, Stock Prices, and Output in Germany

Germany at the end of the First World War offers a different and more dramatic testing ground. My findings below confirm what others have found for the United States: Stock price volatility increases when output declines. However, in the German case, the increase in volatility at the end of World War I seems more clearly related to political factors.

Figure 1 shows the natural log of real, dividend-adjusted German stock prices and returns at monthly intervals for the period from January 1880 to December 1940. Note that German stock prices experienced a one-time downward shift in the 1914 to 1920 period, coincidental with the war and its immediate aftermath. Stock returns became more volatile temporarily at the beginning of the war, then especially at the end of the war and in the early and mid-1920s, and again in the early 1930s. The standard deviation of monthly returns was 2.46 percent for 1880 to 1913, 17.26 percent for 1914 to 1923 (World War I through the hyperinflation of 1923), and 7.04 percent for 1924 to 1940.

Figure 2 explores the link between politics and stock volatility in more detail. It shows the natural log of the real, dividend-adjusted stock index in month s, the natural log of the rolling twelve-month standard deviation of returns around month s (months $s - 6$ through $s + 5$), and some key events in German history. The rolling "log volatility" measure includes future returns relative to month s, thus partly reflecting both expected and unexpected future volatility. The graph supports the view that some of the large stock market movements were clearly the result of sudden, specific political developments. I will discuss in detail the first three events marked

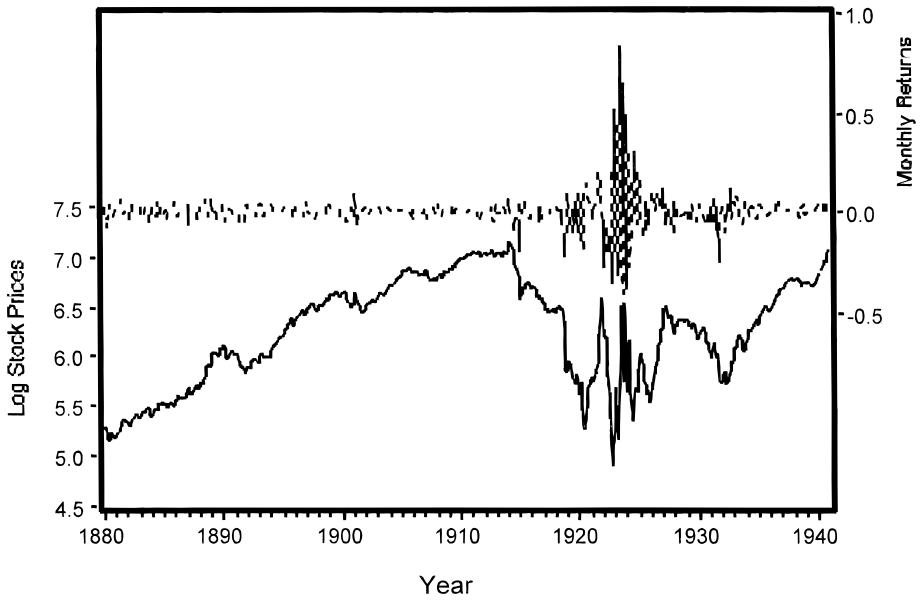

Figure 1. German stock prices and stock returns, monthly intervals, 1880–1940. The natural log of real, dividend-adjusted German stock prices (——) are shown on the left scale, and monthly returns (— — —) are shown on the right scale. Both series are shown at monthly intervals for January 1880 through December 1940. Data are from Gielen (1994).

in Figure 2 and cover subsequent events more briefly. (The account here is based on Stolper, Häuser, and Borchardt (1967), Kolb (1988), James (1986), and Feldman (1993).)

World War I starts. War broke out in August 1914. Stocks declined and became more volatile through December with the gradual realization that the war would not be brief. The net real decline for January to December 1914 was 43 percent. The wartime blockade probably affected output and earnings.

Armistice and revolution. Declines of 22 and 23 percent took place in October and November 1918 with the signing of the Armistice and abdication of the Kaiser. Strikes, insurrections, and the Versailles Treaty followed in early 1919. Germany lost one-eighth of its territory, one-tenth of its population, and substantial real assets (Graham (1930, pp. 17–23)). The sharp stock decline is consistent with the standard view that Germany's dire situation was not understood until the Armistice.

Putsch, strike, and insurrection. In 1920, real dividend-adjusted stock prices reached their lowest point in nearly forty years. The slump started with the failed Kapp Putsch and general strike, the refusal of the U.S.

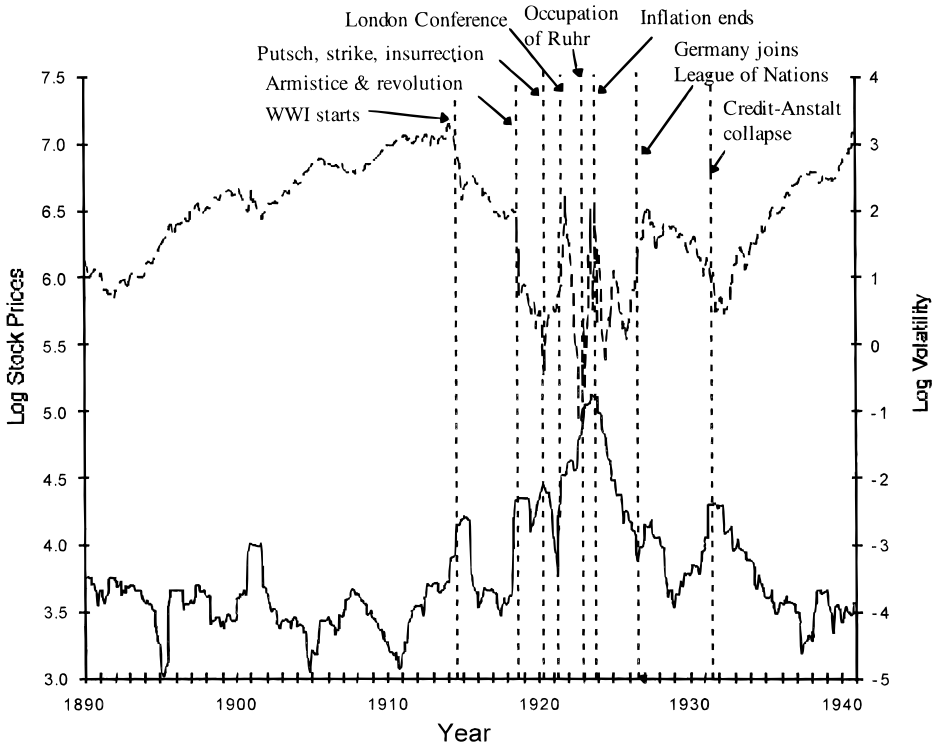

Figure 2. German political events, log of stock prices, and log volatility, monthly intervals, 1890–1940. The figure shows selected political events affecting Germany, the natural log of real, dividend-adjusted stock prices in month s (— — —), and the natural log of the twelve-month rolling standard deviation of returns in months $s - 6$ through $s + 5$. Both series are shown at monthly intervals for January 1890 through December 1940. Data are from Gielen (1994).

congress to join the League of Nations and sign the Treaty of Versailles—arguably removing a moderating influence on the reparations debate (all in March), and fighting in central Germany and the Ruhr in March and April.

Subsequent movements of stock prices also support the inference that political factors mattered. Reparations were the chief bone of contention from 1919 to 1924. The amount and nature of reparations affected Germany's tax burden, its exchange rate, and its internal political stability. In the event that the allies determined that Germany was not meeting its obligations, the allies reserved the right to impose export levies, occupy territory, and confiscate output or assets.

The allies set the amount of reparations more than two years after the Armistice, in the "London Ultimatum" of May 1921. Scheduled payments amounted to 10 percent of Germany's national product and 80 percent of its

exports, the amount increasing as Germany's economy grew (Webb (1989)). Germany viewed the reparations as illegitimate, and the allies were divided in their resolve to make Germany pay. Many observers doubted that it *could* pay. J. P. Morgan and others claimed that the extreme demands and uncertainty in fact hurt Germany's economic recovery.[1] Germany acquiesced to the London ultimatum, hoping, as everyone understood, for better terms later. By the end of the year, Germany announced that it was unable to make the scheduled payments.

As the conflict with the allies escalated in 1922, stock prices fell. In October 1922, on the eve of the January 1923 occupation of the Ruhr by French and Belgian troops and as inflation approached 100 percent per month, German stock prices reached their lowest point in real terms since 1879. Prices were volatile during the hyperinflation, which ended in November 1923, then finally recovered, increasing 69 percent from June to December of 1924. Two events—the August approval of the Dawes plan, which provided for substantially reduced reparations payments, and election losses in December by radical parties—offer possible explanations. The 1925 Treaty of Locarno scaled back some allied rights under the Treaty of Versailles, and Germany joined the League of Nations in September 1926. By February 1927, German stocks were nearly five times as valuable as in November 1922.

The final period of volatility occurred in 1931 to 1932 at the onset of the Great Depression. The decline in prices and the increase in volatility coincided with the collapse of Credit-Anstalt in Austria in 1932, marking the beginning of a larger European banking crisis. However, volatility declined steadily through 1935, even during the assumption of power by the National Socialists in 1933. Despite the declining volatility, stock prices failed to reach their pre-World War I levels by 1940. Surprisingly, the international political crises of the late 1930s and the start of World War II in September 1939 had very little influence on German stock prices. Beginning in 1941, German stock prices were subject to price controls, making December 1940 a logical stopping point.

Figure 3 brings together the stock volatility and output data. It shows the natural log of stock volatility and the natural log of real output at yearly intervals. (Quarterly output data are available only for the period from the mid-1920s to the mid-1930s.) German output increased at a comparatively steady pace from 1880 until 1913, and then declined through the war. After a brief increase it dropped in 1923 (the year of Ruhr occupation and hyperinflation) and recovered only partially by the end of the 1920s. It decreased a second time during the Great Depression. Stock volatility seems inversely related to output.

Table I provides summary statistics for real stock returns and changes in industrial production. The geometric mean monthly real return was 0.45 percent for the period 1880 to 1913. It declined to −1.18 percent for 1914 to

[1] See Feldman (1993), quoting the British chancellor of the Exchequer on Morgan's views, and Graham (1930).

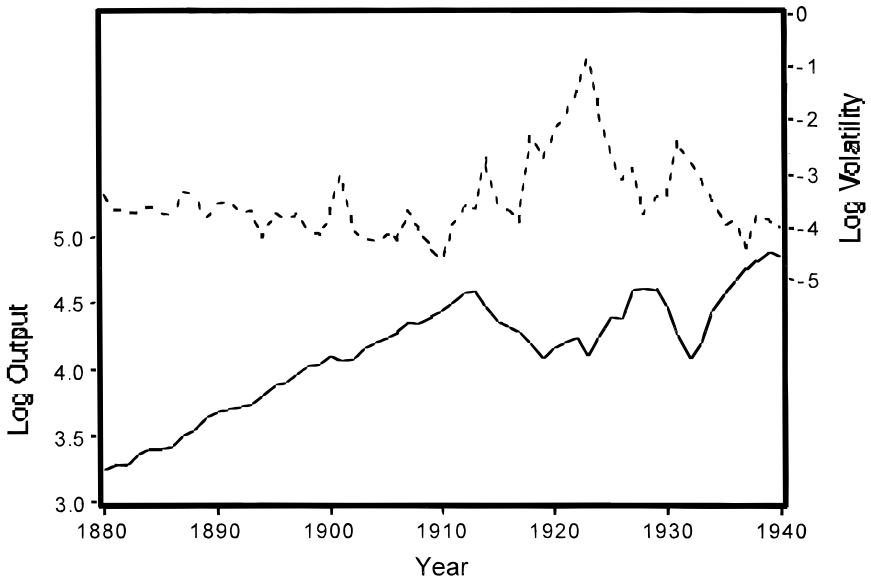

Figure 3. Log output and log volatility, annual intervals, 1880–1940. The natural log of industrial production for year t (——) is shown on the left scale, and the natural log of the standard deviation of monthly returns for January through December in year t (— — —) is shown on the right scale. Stock returns are from Gielen (1994). Industrial production data are from Hoffmann (1965) for 1880–1913, Witt (1974) for 1913–1925, and Petzina et al. (1978) for 1925–1940.

1923, and increased to 0.71 percent for 1924 to 1940. Clearly, stock volatility increased dramatically after 1913. The measured increase in volatility during the period that includes the 1923 hyperinflation may be an overstatement. However, even without 1923, volatility increased appreciably.

III. Specification and Empirical Results

In the estimates that follow, I regress changes in industrial production on current and lagged changes in volatility, and other variables that can explain changes in output. At a mechanical level, these regressions recreate for Germany what Romer (1990) and Pindyck (1991a) did for the United States.[2]

[2] One difference stems from my use of industrial production rather than consumer durables or investment, the variables Romer and Pindyck use. Unfortunately, such data do not exist for Germany. Moreover, almost all German series have large gaps for the period from 1914 to 1924. Consequently, I use industrial production, with recently developed national income data in place of spotty industrial production data during the war and the immediate postwar years.

Table I

Summary Statistics for German Stock Returns and Changes in Output, 1880–1940

Stock returns and annual industrial production are shown for three subperiods: 1880–1913 (Imperial rule until World War I), 1914–1923 (World War I, revolution, Armistice, conflict over reparations, occupation of the Ruhr and hyperinflation), and 1924–1940 (currency stabilization, political stability, Great Depression, and National Socialist takeover). Mean returns, geometric mean returns, and standard deviations for real, dividend-adjusted stock prices are shown on a monthly basis in the upper panel. The geometric means are included because they are unaffected by volatility. Note that although the mean return was positive for the period 1914 to 1923, the geometric mean was negative. The mean and standard deviation of the annual change in industrial production appear in the lower panel. (The mean percentage change in annual industrial production is calculated as the change in the natural logarithm of industrial production.) Stock returns are from Gielen (1994). Industrial production data are from Hoffmann (1965) for 1880–1913, Witt (1974) for 1913–1925, and Petzina et al. (1978) for 1925–1940.

	1880–1913	1914–1923	1924–1940	1880–1940
Monthly real stock returns				
Mean	0.48%	0.17%	0.95%	0.56%
Geometric mean	0.45%	−1.18%	0.71%	0.26%
Standard deviation	2.46%	17.26%	7.04%	8.11%
Change in annual industrial production				
Mean	3.83%	−4.91%	4.46%	2.57%
Standard deviation	3.21%	7.75%	13.37%	8.58%

Table II shows regressions of the annual change in industrial production on current and past changes in annual log volatility and changes in stock prices of the form

$$\begin{aligned}\ln(IP_t) - \ln(IP_{t-1}) = a &+ b_1[\ln(SD_t) - \ln(SD_{t-1})] \\ &+ b_2[\ln(SD_{t-1}) - \ln(SD_{t-2})] \\ &+ b_3[\ln(S_t) - \ln(S_{t-1})] + e_t, \end{aligned} \tag{1}$$

where IP_t is the industrial production for year t, SD_t is the standard deviation of monthly returns for year t (January through December), and S_t is the stock price in April of year t. The log of SD_t for a given calendar year reflects actual volatility in that year and, ultimately, the exogenous factors generating volatility. I include both the change to the current year, t, and the change to the previous year, $t - 1$, to allow for lagged effects. The percentage change to April best predicts the change in production for the whole year, consistent with findings based on monthly and quarterly data showing that

Table II

Regression of Percentage Changes in Annual Production on Current and Lagged Changes in Log Volatility and on Changes in the Log of Stock Prices, 1880–1940

The variable $\ln(IP_t)$ is the natural log of industrial production in year t, $\ln(SD_t)$ is the log of the standard deviation of the monthly returns for the twelve months ending with December of year t, and $\ln(S_t)$ is the log of the stock price in April of year t. Reported t-statistics are based on heteroskedastic-consistent standard errors. Stock returns are from Gielen (1994). Industrial production data are from Hoffmann (1965) for 1880–1913, Witt (1974) for 1913–1925, and Petzina et al. (1978) for 1925–1940. The regression model is:

$$\ln(IP_t) - \ln(IP_{t-1}) = a + b_1[\ln(SD_t) - \ln(SD_{t-1})] + b_2[\ln(SD_{t-1}) - \ln(SD_{t-2})] + b_3[\ln(S_t) - \ln(S_{t-1})] + e_t.$$

	1880–1940		1880–1919		1920–1940	
	b	$t(b)$	b	$t(b)$	b	$t(b)$
Volatility						
Constant	0.0238	2.41	0.0206	2.45	0.0247	1.01
$\ln(SD_t) - \ln(SD_{t-1})$	−0.0514	−2.41	−0.0199	−0.78	−0.0865	−2.08
$\ln(SD_{t-1}) - \ln(SD_{t-2})$	−0.0709	−3.07	−0.0466	−1.87	−0.0919	−1.92
R^2	0.23		0.16		0.32	
Durbin–Watson statistic	1.39		0.87		1.69	
Volatility and stock prices						
Constant	0.0176	1.93	0.0149	2.06	0.0185	0.84
$\ln(SD_t) - \ln(SD_{t-1})$	−0.0413	−2.27	−0.0184	−0.80	−0.0644	−1.77
$\ln(SD_{t-1}) - \ln(SD_{t-2})$	−0.0286	−1.40	−0.0058	−0.33	−0.0544	−1.35
$\ln(S_t) - \ln(S_{t-1})$	0.2179	3.70	0.2080	3.14	0.2145	2.57
R^2	0.45		0.37		0.52	
Durbin–Watson statistic	1.39		1.51		1.34	

stock returns predict real output changes by several months. I include stock returns to control for other, omitted factors affecting output. Note, however, that a decline in stock prices may partly reflect greater systematic uncertainty not captured by the current standard deviation of aggregate monthly returns.

For the period 1880 to 1940, a one unit increase in log volatility is matched by an output decline of −12.23 percent (the sum of −0.0514 and −0.0709). If the regressions also take into account the stock returns—themselves endogenous to volatility and expectations about volatility—the sum of the two volatility coefficients becomes −6.99 percent (−0.0413 plus −0.0286). This result holds for the subperiod 1880 to 1919 and for 1920 to 1940, though the relationship is clearly stronger for the latter, more volatile period. The results for 1880 to 1940 are essentially unchanged if the war (1914–1918) or hyperinflation (1922–1923) are omitted.

Table III

Regression of Annual Percentage Changes in Production on Changes in Current and Lagged Log Volatility, the Rate of Deflation, a World War I Dummy, and Stock Returns, 1880–1940

The variable $\ln(IP_t)$ is the natural log of industrial production in year t, $\ln(SD_t)$ is the log of the standard deviation of the monthly returns for the twelve months ending with December of year t, DEFLAT_t equals the rate of inflation if inflation is negative in year t and zero otherwise, WWI_t is a dummy variable that equals one for 1914–1918 and zero otherwise, and $\ln(S_t)$ is the log of the stock price in April of year t. Reported t-statistics are based on heteroskedastic-consistent standard errors. Stock returns are from Gielen (1994). Industrial production data are from Hoffmann (1965) for 1880–1913, Witt (1974) for 1913–1925, and Petzina et al. (1978) for 1925–1940. The regression model is:

$$\ln(IP_t) - \ln(IP_{t-1}) = a + b_1[\ln(SD_t) - \ln(SD_{t-1})] + b_2[\ln(SD_{t-1}) - \ln(SD_{t-2})]$$
$$+ b_3 DEFLAT_t + b_4 WWI_t + b_5[\ln(S_t) - \ln(S_{t-1})] + e_t.$$

	b	$t(b)$	b	$t(b)$
Constant	0.0487	5.54	0.0400	4.67
$\ln(SD_t) - \ln(SD_{t-1})$	−0.0329	−2.11	−0.0289	−2.31
$\ln(SD_{t-1}) - \ln(SD_{t-2})$	−0.0539	−2.62	−0.0249	−1.41
$DEFLAT_t$	2.01	4.71	1.75	3.66
WWI_t	−0.1209	−6.96	−0.0938	−4.45
$\ln(S_t) - \ln(S_{t-1})$			0.1608	2.96
R^2	0.54		0.65	
Durbin–Watson statistic	1.89		1.74	

Table II provides estimates based only on changes in stock volatility and changes in stock prices. Additional results in Table III include two other variables. To account for the effect of the allied blockade and other wartime restrictions, I include a dummy equal to one for the war years, 1914 to 1918. To account for the effects of the price level decline in the early 1930s, I include a variable equal to the rate of inflation when that rate is negative and zero otherwise. A similar inflation variable has no significant effect—hence I exclude it.

Even with these other variables, Table III shows that volatility still matters, or, more accurately, that the factors that influence volatility matter. A one unit increase in log volatility is linked with an output decline of −8.68 percent (the sum of −0.0329 and −0.0539) in the first regression. Moreover, a 1 percent decline in the price level is linked with a 2.01 percent decrease in output, and each of the four war years is accompanied by an output decline of −12.09 percent. As is the case in Table II, the addition of stock returns lowers the apparent effect of current and lagged volatility. In this case the sum of the two coefficients declines to −5.38 percent (−0.0289 plus −0.0249).

Overall, as is apparent from Tables II and III, changes in measured volatility alone account for about 20 percent of output variability, and changes in measured volatility plus other factors account for more than 50 percent. However, this does not mean that exogenous, spontaneously generated volatility causes output declines, or even that expectations of exogenously generated output declines cause volatility. Rather, the strong link between major political events and large market moves suggests the underlying joint importance of political factors.

IV. Concluding Comments

What caused the 1929 and 1987 stock crashes? Why did the 1929 but not the 1987 crash mark the beginning of a major recession? Why was volatility high during the Great Depression? Most attempts to explain the sources of stock volatility have focused on the interplay of the stock market and easily observable real and financial variables. Cutler, Poterba, and Summers (1989) find that unexpected variation in current macroeconomic variables explain only about one-fifth of the variance in monthly stock returns for the period 1926 to 1985, and current and future macroeconomic variables explain at best half of the variance in annual returns. Fama (1990) and Schwert (1990) show that real and financial factors explain about half of the variance in annual returns.

Plausibly, something other than macro-variables moves stock prices, in particular on a day-to-day basis. However, existing research offers few clues. Cutler et al. (1989) link large daily movements with newspaper stories, but conclude that "it is difficult to link major market moves to [the] release of economic or other information." Similarly, Mitchell and Mulherin (1994) find that publicly available information, including major news stories, accounts for only a small fraction of observed daily volatility. The failure of "news" to account for stock price movements is easy to explain, however. A simple count of news stories treats all events alike, news stories may be anticipated with variable leads, and some important events may not be reported.

This paper adopts a different strategy and examines a dramatic political shift. In contrast to the United States, where the sources of volatility are subtle or controversial—even for the Great Depression—the increase in German volatility in the late teens and early and mid-twenties seems closely linked to the shift from ascendant empire to beleaguered republic. The start of World War I, the 1918 Armistice, and the political turbulence of 1920 each pushed the German stock market down and volatility up. Fluctuating hopes for a solution to the reparations problem, and the occupation of the Ruhr and the hyperinflation of 1923 were also associated with large stock market movements. Finally, the political stabilization of Germany in the mid and late 1920s was accompanied by steadily declining volatility. Politics matter. These results offer support for the view that causation runs from political

uncertainty simultaneously to stock prices and output, and recent theoretical work on uncertainty and irreversible investment offers a possible mechanism.

Future work on Germany would benefit from daily stock prices and at least quarterly if not monthly output series. Daily stock data would allow better estimates of volatility and a better assessment of the effects of particular events. Future work on the sources of stock volatility in general might benefit from the study of other "natural experiments"—other instances in which the political system and the stock market experienced large, clearly identifiable exogenous shocks. Brown, Goetzman, and Ross (1995) survey the hazards of focusing on markets that survive. Stock markets that were subject to extreme events, that ended in catastrophe or that barely escaped catastrophe, may offer new clues about what moves stock markets and about the causes and consequences of market volatility.

Data Appendix

Output

For the period from 1880 through1913, I use the production index from Hoffmann (1965). This series is based on a variety of industries covering metals, metal working, chemicals, textiles, food, utilities, and construction.

Hoffmann has no entries for the period 1914 to 1924, so I splice the estimates of national income for 1913 to 1925 from Witt (1974). Witt's estimates are based on tax information.

For 1925 to 1940, I use the industrial production series in Petzina, Abelshauser, and Faust (1978). Their series starts in 1913, but likely misstates movements for the period 1914 to 1918, for which it is based on mining data exclusively. However, I do use the 1913–1924 net movement in their series to adjust the trend in Witt's national income estimates for the intervening period. The Petzina series is composed of three broad components—consumer goods, producer goods, and mining.

Stock Index

The stock price index stems from Gielen (1994), who brings together information from various sources to construct a real, dividend-adjusted series for the period 1870 to 1993. For the years up to 1913, he uses the series from Otto Donner, 1934, "Die Kursbildung am Aktienmarkt," *Vierteljahreshefte zur Konjukturforschung*, Sonderheft 36, (Berlin). This series is composed of a simple average of twenty large stocks until 1889. Starting in 1890, the series becomes a capitalization-weighted average of forty-eight stocks. The series was further expanded to seventy-one stocks in 1905.

With the start of the First World War in August 1914, the Berlin stock exchange suspended official transactions (as did exchanges in other countries). Official trading resumed in November 1917. However, stocks were

traded over-the-counter in the meantime. Fritz Kronenberger (1920, *Die Preisbewegung der Effekten in Deutschland* (Berlin)), collects monthly values for this period for more then 115 firms. Gielen constructs an index from these data that bridges the gap.

For the period starting 1919, Gielen uses the nominal series of the Imperial Statistical Office (*Statistisches Reichsamt)*. This series was first calculated in 1924 using approximately 300 companies. (The Statistical Office reconstructed the series back to 1913. As Gielen points out, doing so introduces a survivor bias for 1913 to 1924 because only companies surviving to 1924 are included.) Gielen also constructs a dividend series from the same sources. The price-level index for the period up to 1919 is based on the annual consumer price index incorporated in official Bundesbank statistics, with wholesale prices used to interpolate monthly movements.

For the period after 1919, the consumer price level data stem from the Imperial Statistical Office.

REFERENCES

Baldwin, Carliss Y., 1982, Optimal sequential investment when capital is not readily reversible, *Journal of Finance* 37, 763–782.

Bernanke, Ben S., 1983, Irreversibility, uncertainty, and cyclical investment, *Quarterly Journal of Economics* 98, 85–106.

Bierman, Harold, Jr., 1991, *The Great Myths of 1929 and the Lessons to Be Learned* (Greenwood Press, New York).

Bittlingmayer, George, 1992, Stock returns, real activity, and the trust question, *Journal of Finance* 47, 1701–1730.

Bittlingmayer, George, 1993, The stock market and early antitrust enforcement, *Journal of Law and Economics* 36, 1–32.

Brown, Stephen J., William N. Goetzmann, and Stephen A. Ross, 1995, Survival, *Journal of Finance* 50, 853–873.

Cukierman, Alex, 1980, The effects of uncertainty on investment under risk neutrality with endogenous information, *Journal of Political Economy* 88, 462–475.

Cutler, David M., James M. Poterba, and Lawrence H. Summers, 1989, What moves stock prices? *Journal of Portfolio Management* 15, 4–12.

De Long, J. Bradford, and Marco Becht, 1992, 'Excess volatility' and the German stock market, 1876–1990, Working paper, European University Institute.

Dixit, Avinash K., and Robert S. Pindyck, 1994, *Investment Under Uncertainty* (Princeton University Press, Princeton, N.J.).

Fama, Eugene F., 1990, Stock returns, expected returns, and real activity, *Journal of Finance* 45, 1089–1108.

Feldman, Gerald, 1993, *The Great Disorder: Politics, Economics and Society in the German Hyperinflation, 1914–1924* (Oxford University Press, Oxford and New York).

Friedman, Milton, and Anna Schwartz, 1963*, A Monetary History of the United States, 1867–1960* (NBER & Princeton University Press, Princeton, N.J.).

Gielen, Gregor, 1994, *Können Aktienkurse noch steigen?* (Gabler, Wiesbaden).

Graham, Frank D., 1930, *Exchange, Prices, and Production in Hyper-inflation: Germany, 1920–1923* (Princeton University Press, Princeton, N.J.).

Hoffmann, Walter G., 1965, *Das Wachstum der deutschen Wirtschaft seit der Mitte des 19. Jahrhunderts* (Springer Verlag, Berlin).

Huang, Roger D., and William A. Kracaw, 1984, Stock market returns and real activity: A note, *Journal of Finance* 39, 267–273.

James, Harold, 1986, *The German Slump: Politics and Economics, 1924–1936* (New York, Oxford University Press).

Kolb, Eberhard, 1988, *The Weimar Republic* (Unwin Hyman, Boston, Mass.).

McDonald, Robert, and Daniel Siegel, 1986, The value of waiting to invest, *Quarterly Journal of Economics* 101, 707–727.

Mitchell, Mark, and Jeffry Netter, 1989, Triggering the 1987 stock market crash—Antitakeover provisions in the proposed House Ways and Means tax bill, *Journal of Financial Economics* 24, 37–68.

Mitchell, Mark L., and Harold J. Mulherin, 1994, The impact of public information on the stock market, *Journal of Finance* 49, 923–950.

Mitchell, Wesley Clair, 1913, *Business Cycles* (University of California, Berkeley).

Petzina, Dietmar, Werner Abelshauser, and Anselm Faust, 1978, *Sozialgeschichtliches Arbeitsbuch: Band III; Materialien zur Statistik des Deutschen Reiches, 1914–1945* (Beck, Munich).

Pindyck, Robert S., 1991a, Irreversibility and the explanation of investment behavior; in D. Lund and B. Øksendal, eds.: *Stochastic Models and Option Values* (North-Holland, Amsterdam).

Pindyck, Robert S., 1991b, Irreversibility, uncertainty, and investment, *Journal of Economic Literature* 29, 1110–1148.

Romer, Christina, 1990, The Great Crash and the onset of the Great Depression, *Quarterly Journal of Economics* 105, 597–624.

Roose, Kenneth D., 1954, *The Economics of Recession and Revival: An Interpretation of 1937–38* (Yale University Press, New Haven, Conn.).

Schwert, G. William, 1989a, Why does stock market volatility change over time? *Journal of Finance* 44, 1115–1145.

Schwert, G. William, 1989b, Business cycles, financial crises, and stock volatility, *Carnegie-Rochester Conference Series on Public Policy* 31 (North-Holland, Amsterdam), pp. 83–126.

Schwert, G. William, 1990, Stock returns and real activity: A century of evidence, *Journal of Finance* 45, 1237–1257.

Stolper, Gustav, Karl Häuser, and Knut Borchardt, 1967, *The German Economy: 1870 to the Present* (Harcourt, Brace and World, New York).

Trigeorgis, Lenos, 1996, *Real Options* (MIT Press, Cambridge, Mass.).

Wanniski, Jude, 1983, *The Way the World Works* (Simon and Schuster, New York).

Webb, Steven, 1989, *Hyperinflation and Stabilization in Weimar Germany* (Oxford University Press, New York).

Witt, Peter-Christian, 1974, Finanzpolitik und zozialer Wandel in Krieg und Inflation, 1918–1924; in Hans Mommsen, Dietmar Petzina, and Bernd Weisbrod, eds.: *Industrielles System und politische Entwicklung in der Weimarer Republik* (Droste, Düsseldorf).