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ABSTRACT

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This paper uses long-run real price and dividends series to investigate for the German stock market the questions asked of the U.S. market by Shiller (1989). It tries to determine in what periods and to what degree the German stock market has also possessed "excess volatility" in the past century. It finds no evidence of excess volatility in the pre-World War I German stock market. By contrast, there is some evidence of excess volatility in the post-World War II German stock market. The role played by the German *Großbanken* in the pre-World War I stock market might be the cause of the low comparative volatility of German stock indices before 1914.

I. Introduction

This paper examines "excess volatility" in the German stock market, investigating for that market the issues examined by Robert Shiller (1981, 1986, 1989) for the U.S. stock market.[2] It finds some evidence that post-World War II German stock index prices have been too volatile (relative to naïve estimates of fundamentals) to have been rational forecasts of the present value

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[2]The literature sparked by Shiller and by LeRoy and Porter (1981) has for the most part assumed that the real interest rate at which future dividends are discounted is a constant. This assumption is surely false: for example, the *ex ante* real rate of discount for the U.S. stock market at the end of World War I was on the order of thirty percent per year for the first two years after the war in anticipation of the forthcoming postwar deflation. Thus it was much higher than the discount rate during normal times. However, investigators have had little success accounting for stock price volatility via shifts in the real riskless rate, or in the real spread between riskless and market rates of discount driven by changes in risk tolerance (see Shiller, 1989).

of future dividends. Alternatively, pre-World War I stock prices were not volatile enough (relative to naïve estimates of fundamentals).[3] In either case, the efficient markets hypothesis appears inconsistent with observed behavior in one or the other of the periods.[4] The focus of this paper is on the divergence of market outcomes in the two periods, and the difficulty of reconciling *both* patterns simultaneously with the efficient markets hypothesis.

This paper examines the volatility of prices relative to dividends in order to avoid most of the biases in estimated volatility ratios generated by Shiller's (1981) original tests. Thus normalized, the pre-World War I German stock market shows not excess but deficient volatility: the market price-dividend ratio is surprisingly far down in the lower tail of the distribution under the null hypothesis that prices are rational forecasts of fundamentals. Throughout the pre-World War I era, the market average dividend yield fluctuates in a narrow band between four and a half and five and a percent. By contrast, the post-World War II stock market (and especially the post-*Wirtschaftswunder* market) shows some evidence of "excess" volatility. The evidence of excess volatility in post-World War II German data is weaker than but of the same order of magnitude as the evidence using U.S. post-World War II data.

The behavior of the pre-World War I German stock market thus is in sharp contrast to the behavior of the post-World War II German stock market, and to the behavior of the U.S. stock market in either the pre-World War I or the post-World War II period. We speculate that the dominance of the German *Großbanken* in the securities industry in the years before World War I may be the cause of the exceptional behavior of the pre-World War I German market.

After this introduction, the second section of this paper describes the data used. The third section explains the approach used and documents the divergence between the pre-World War I and the post-World War II behavior of German stock market aggregates. The generating processes necessary to reconcile the post-World War II behavior of German stock index prices with the efficient markets hypothesis lead to the conclusion that the market's small degree of

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[3]Understood to also include the ancillary assumption of a constant real discount rate.

[4]Little can be said about the relative excess volatility of the German stock market over 1914–50; there are too many "peso problems" present for any analysis to be convincing; see Eichengreen (1991).

volatility in the pre-World War I era is anomalous. Generating processes that fit the market's low pre-World War I volatility lead to the conclusion that the post-World War II market exhibits excess volatility. Unless the specification of the dividend process is itself a free variable that shifts substantially from World War I to post-World War II reconstruction, it is very difficult to reconcile *both* periods with the dividend discount model.

Section IV speculates that the role played by the *Großbanken*, the "great banks" that were at once investment bankers, long-term stockholders in corporations, and depositories of savings, may be responsible for the exceptional behavior of the pre-World War I German market (Riesser, 1906 and 1911). Perhaps the pre-World War I German stock market behaves differently because its prices are not driven by the "animal spirits" of speculators, but are instead administered assessments of fundamental values made by a handful of large and well-informed institutions.

Section V provides a brief summary of the argument. Appendices discuss the choices made in constructing the data, and the statistical significance of some of the results obtained.

II. German Data

Donner (1934) compiles and reports a monthly nominal share price index—with attached estimates of average yearly dividend yields for the companies included in his aggregate index—for the German stock market from January 1870 to December 1913. His index covers only twelve companies from 1870 to 1875.[5] The number of companies covered reaches twenty-one in 1876 and is nearly sixty by 1890. The original twelve companies covered in 1870 include four banks, four railroads, and four mining companies.[6] Railroads disappear from the index with their nationalization in 1890. Companies in other industries are added as industrialization proceeds.[7]

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[5]Earlier indices covering the 1856–70 period are also available from Däbritz (1929). Unfortunately, they too are based on a very small sample of securities.

[6]Two mining companies—the Bochumer Verein für Bergbau and Gußstahlfabrik and the Hoerder Bergwerks- und Hüttenverein—also had metal fabrication or railway divisions.

[7]On the eve of World War I, the index covers eight banks, two shipping companies, fourteen mining and steel producers, four electrical machinery manufacturers, four utilities, nine metalworking manufacturers, six in chemicals, seven in textiles, two in paper and wood products, three makers of building materials, two construction companies, three glass and porcelein manufacturers, and four breweries.

Especially in the years from 1890 on, the Donner index is a sample of Germany's largest companies, weighted toward those heavy industries in which Germany's companies were largest and its international comparative advantage greatest. We begin our study in 1876, when the number of companies in the index rises above twenty.

Donner's index ends with the beginning of World War I. An official index—unfortunately without dividends attached—covers the period from 1914 up to the 1923–24 hyperinflation (Statistisches Reichsamt, 1922a, 1922b). A second official index covering three hundred corporations extends from 1924 to the middle of World War II, reporting both the stock index price and a dividend yield (Statistisches Reichsamt, 1928, 1929). We splice the first official *Statistisches Reichsamt* (National Bureau of Statistics) series onto Donner's in 1914 to track the course of the German stock market up to the hyperinflation. We splice the second *Reichsamt* index onto the first to provide information about the course of the German stock market between the hyperinflation and the middle of World War II.

For the post-World War II period, the stock price series we use links four official portfolio index series constructed by the post-World War II *Statistisches Bundesamt* (Federal Bureau of Statistics). We link from each series to the next in the first year in which the following sequence becomes available (see Herrman, 1956; Spellerberg and Schneider, 1967; Silberman, 1974; Lützel and Jung, 1984; Statistisches Bundesamt, 1985).

For the later interwar and the post-World War II periods, the yield series used is the yield on all traded stocks. Thus the yield is calculated from a different and larger sample of corporations than are the price indices. Nevertheless, the post-World War II dividend series—calculated by multiplying price and yield—is a good estimate of the dividend corresponding to the index.[8]

The nominal price and dividend series are deflated by the German consumer price index endorsed by the Deutsche Bundesbank (1976). This index runs continuously, with one gap covering World War II and the post-war reconstruction period.[9]

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[8]The post-World War II price index series covers close to ninety-five percent of the par value of stocks traded on the German exchanges.

[9]It was assembled from four different sources. Up until 1914 the cost of living figures come from Kuczynski (1947), who investigated the standard of living of Geman workers since 1800. Kuczynski's cost of living index consists of

Appendix 1 presents the various alternative stock price and dividend yield series available for the German market. Its table A.1 reports the underlying real stock price, yield, and consumer price index series used here. In all cases we use annual average prices and annual average dividend yields. The ways in which earlier authors report their results make annual average data more readily available than point-in-time data. Moreover, markets for many of the securities in the indices are thin. Transitory episodes of market disruption—like the liquidity crunch that followed the bankruptcy of the Austrian Creditanstalt during the Great Depression—are not uncommon. With point in time data, such events could introduce noise into a market that may be exhibiting relatively good performance save for transitory disruptions of its microstructures.

Figure 1 plots the log values of real price and dividend indices for the German stock market since 1876. Between 1876 and 1913, stock prices rise by approximately 125 percent, with prices being nearly a constant times dividends—the aggregate dividend yield for the market (although not the yield for individual firms) is always close 5 percent. The pre-World War I price-dividend ratio is slightly countercyclical, rising when dividends fall and falling when dividends rise.

The first interwar price series tracks the fall in real stock values by more than four-fifths from 1913 to 1922. In the first years after the hyperinflation and before the Great Depression, real prices nearly quadruple from their hyperinflation-era lows. Prices then fall by two thirds in the early years of the Depression, with a sharp drop in 1931.[10] Stock prices recover as Germany recovers from the Depression and real wages are squeezed by Nazi rule.

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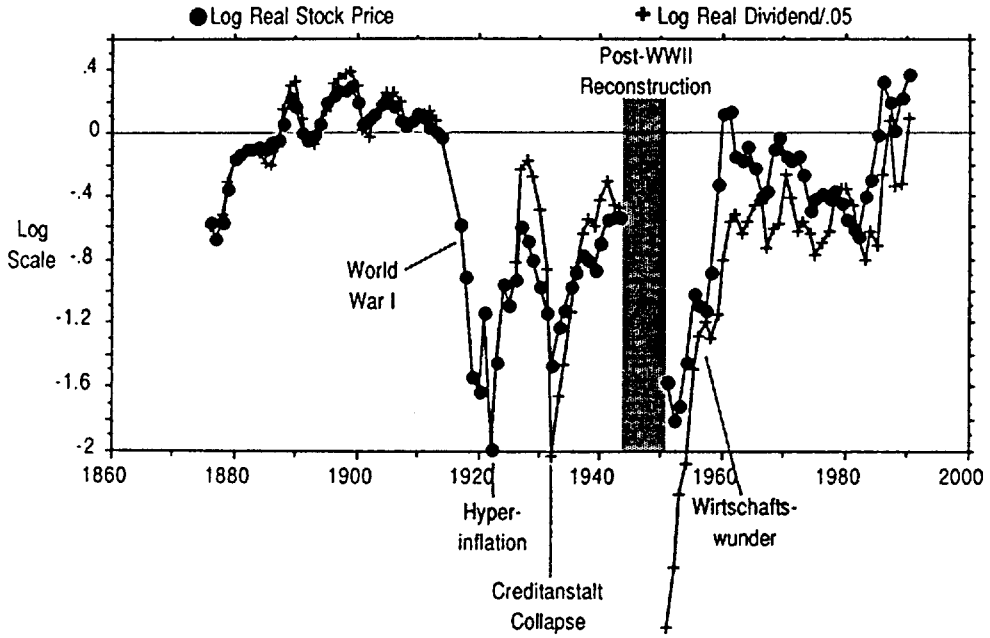
estimates of food prices and housing costs. From 1915 to 1919 the index is derived from calculations by the *Statistisches Bundesamt*, the Federal Statistical Bureau of post-World War II West Germany, made after World War II in order to close the gap between Kuczynski's and the subsequent indices. From 1920 to 1940 the cost of living index is that compiled for a five-person working-class household by the *Statistisches Reichsamt*, the National Statistical Bureau of first the Weimar Republic and then the Third Reich. For the post-World War II years from 1949 to the present, the cost of living index used is that calculated for a four-person middle-class household by the *Statistisches Bundesamt* (1990). The different consumer price series have different base years. They chart the changes in the price level for different consumption bundles, and are not completely consistent. The Deutsche Bundesbank (1976) reports similar indices for wholesale prices, and a less complete national product deflator.

[10]The year that sees the bankruptcy of the Austrian Creditanstalt Bank and a severe liquidity crisis throughout Europe that was especially severe in German-speaking nations.One of the extended repercussions of the Creditanstalt crisis was the fall of the Labour government and the abandonment of the gold standard in Britain. See Kindleberger (1973), Temin (1989), or Eichengreen (1991).

Figure 1
German Real Stock Prices and Dividends 1876–1990
(Log Scale)



Note that decade-by-decade fluctuations in German real dividends before World War II are of larger proportional magnitudes than decade-by-decade fluctuations in real price indices. In this respect the pre-World War II German stock market is different from the United States, where decade-by-decade price fluctuations are proportionally larger than dividend fluctuations (see Barsky and De Long, 1989 and 1990).

Post-World War II data begin in 1951. Throughout the 1950's real prices and dividends rise very rapidly—by a factor of eight—with the price-dividend ratio reaching a high near fifty in 1960. Since 1960 the index has recorded relatively slow growth in real prices and dividends. Even so, price changes have been substantial: the real stock index falls by nearly half between 1960 and 1966. It more than doubles over the short four year period between 1981 and 1985.

From 1960 on, fluctuations in prices have been proportionately larger than fluctuations in dividends. Over 1960–66, the log of real stock prices falls by 0.55 while log real dividends fall by only 0.2; over 1966–72, log prices rise by 0.3 while log dividends rise by 0.2; over 1972–82,

log prices fall once again by 0.55 while log dividends fall by only 0.15; and over 1982–1990 log prices rise by 1.1 while log dividends rise by 0.8. This post-*Wirtschaftswunder* pattern, in which swings in dividend levels are paced by more than proportional swings in prices, is reminiscent of the behavior of the U.S. stock market, as analyzed by Barsky and De Long (1989). It suggests that investors value the market by extrapolating recent dividend changes into the future.

The real stock price series constructed here has a gap covering the second half of World War II and the postwar reconstruction period from 1943–1950. We have been unable to recover sufficient data on dividend yields and price indices to link the series across this period. The real price indices are *not* comparable across the break at the end of World War II.[11]

The real dividend series has two breaks. One covers World War I and the interwar period up to the hyperinflation. The second covers the end of World War II and the postwar reconstruction period. Thus we do not have enough data to conduct Shiller-like analyses of the era from the beginning of World War I to the beginning of the 1950's.

This paper analyzes the pre-World War I and the post-World War II periods separately. For the pre-World War I period, it takes 1913 as its terminal condition: the level of real stock prices in 1913 is a proxy for the rational expectation, on the eve of the unexpected coming of World War I, of the fundamental value of German securities. The level of stock prices in 1990 stands in for the rational expectation of the expected value of German securities today.

III. Excess Volatility and the German Stock Market

Shiller's (1981, 1989) first key insight was that the level of the stock market is a forecast of the *ex post* perfect-foresight fundamental. An investor who buys and holds, and pays less than

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[11]The failure of the German stock market to fall in real terms during the war or during the approach to war is somewhat surprising. To some degree, wartime prices are false prices. Although trading on the Frankfurt exchange continues until three days before the arrival of the American army, prices on the exchange are frozen in March 1943. Foreign quotations on the market had been prohibited as early as 1937. And dividends had been regulated from early in the National Socialist era. After December 1934 dividend payments to shareholders could not exceed six percent. Any excess was paid into a "Patriotic Fund." Although credited to shareholders' accounts with the "Patriotic Fund," such forced loans were not liquid—and of course were never repaid.

the *ex post* fundamental, receives a supernormal return. Arbitrage, therefore, pushes prices in an efficient market to be efficient forecasts of the perfect-foresight fundamental.

Shiller's second key insight was to apply the principal that efficient forecasts are less volatile than the *ex post* realized values of the quantities being forecast. If a forecast is more volatile, a better forecast could be constructed easily: shrink the original forecast toward its *ex ante* unconditional mean, and the resulting improved forecast will have a smaller mean squared error. These two insights imply that if the efficient markets hypothesis holds then stock prices should be less volatile—relative to their *ex ante* unconditional means, a notion that needs to be made precise—than the realized track of the *ex post* perfect-foresight fundamental.

Biases in Testing for Excess Volatility

As Flavin (1985), Scott (1985), Kleidon (1986a and 1986b), Mankiw, Romer, and Shapiro (1985, 1991), and many others have argued, Shiller's (1981) original comparison of the variance of detrended prices and of detrended *ex post* perfect-foresight fundamentals is subject to biases. Especially in small samples, such tests may well find apparent excess volatility even if in fact the efficient markets hypothesis holds.

It is easiest to understand the source of these biases by examining the trading strategies associated with tests of excess volatility and return predictability. Each test of market rationality is implicitly associated with a portfolio strategy. If prices are too volatile relative to trend, investors at the time could have made better forecasts of *ex post* fundamentals—and earned high profits—by taking as their forecast some linear combination of the market price and a time trend, and betting that returns would be low whenever the market price was above the trend. If returns are predictable from a variable like the price-dividend ratio (Scott, 1985), investors could have earned supernormal profits by buying when the ratio was low and selling when it was high.

If investors could in fact have followed the trading strategy implicit in the tests of market efficiency—and did not—then the rejection of market efficiency is genuine. But under some conditions the implicit trading strategy could not have been followed because it required more information for its execution than investors at the time possessed. In such a case, the rejection of

market efficiency may well be spurious: investors may well have taken advantage of all profit opportunities open to them, and given the information at their disposal prices may have been the best available forecasts of the present value of fundamentals.

For example, suppose log dividends follow a random walk with drift:

$$(1) \qquad d_t = d_{t-1} + g + \varepsilon_t$$

Where g is the long-run upward rate of drift of dividends, and ε_t is an innovation, unforecastable before period t. With a constant discount rate r, the efficient markets log real stock price will be:

$$(2) \qquad p_t = -\ln(r-g) + d_t$$

Suppose an *ex post* time trend π is fitted to the first and last observations, t=0 and t=T:

$$(3) \qquad \pi_t = p_0 + \frac{t}{T}\left(p_T - p_0\right)$$

Calculate the covariance between the one-year realized return $r^*_t{}^1$:

$$(4) \qquad r^*_t{}^1 = r + \varepsilon_t$$

and the price relative to the *ex post* time trend (conditional on knowledge of the current price p_t and of the current value π_t of the *ex post* trend):

$$(5) \qquad E\left\{ r^*_t{}^1 (p_t - \pi_t) \mid p_t - \pi_t \right\} = -\left\{ \frac{t}{T} \right\} E\left\{ \varepsilon^2_{t+1} \mid p_t - \pi_t \right\}$$

Equation (5) shows that there are excess returns from buying when the price is low relative to the *ex post* trend, and selling when it is high. Such a strategy eans excess returns off of the correlation between the deviation of the price from the *ex post* trend and future innovations.

Why don't rational investors take advantage of this correlation? Because at the time they must trade they do not yet know what the end-of-sample value π_T will be, and so cannot calculate the current value of the *ex post* time trend π_t. Investors would love to know π_T—such knowledge would allow them to calculate the value of the sum of the ε innovations yet to come.

But they do not.

The return predictability in equation (5) comes solely from the use of the realized values of future shocks—shocks dated later than t—in constructing the value π_t of the time trend, and in assessing whether prices are relatively low or high. Without this use of information about the realizations of future shocks, there are no excess returns to be earned: returns are uncorrelated with the deviation of the price from an *ex ante* time trend π'_t constructed by extrapolating drift from the series starting point.

$$\pi'_t = p_0 + tg \tag{6}$$

$$E\{r^{*1}_t(p_t - \pi'_t) \mid p_t, \pi'_t\} = 0 \tag{7}$$

In this example, a regression of returns on prices and an *ex post* time trend is indeed likely to find significant return predictability and excess volatility. But such a finding is spurious: it arises from an implicit assumption that rational investors had more information about future shocks than they in fact possessed future shocks.

Normalizing by the Level of Dividends

To compensate for such biases, Mankiw, Romer, and Shapiro (1985 and 1991) proposed an alternative benchmark for the calculation of excess volatility. They argued that it is plausible that past investors knew naïve forecasts of perfect-foresight fundamentals made by assuming them to be a constant dividend multiple. Tests of excess volatility relative to this alternative naïve-forecast benchmark that takes fundamentals to be a constant multiple of dividends assume less in terms of investors' knowledge of the parameters and outcomes of the dividend process.

This paper uses such a naïve constant dividend multiple forecast as the benchmark against which to evaluate the efficient markets hypothesis.[12] It normalizes real prices and *ex post*

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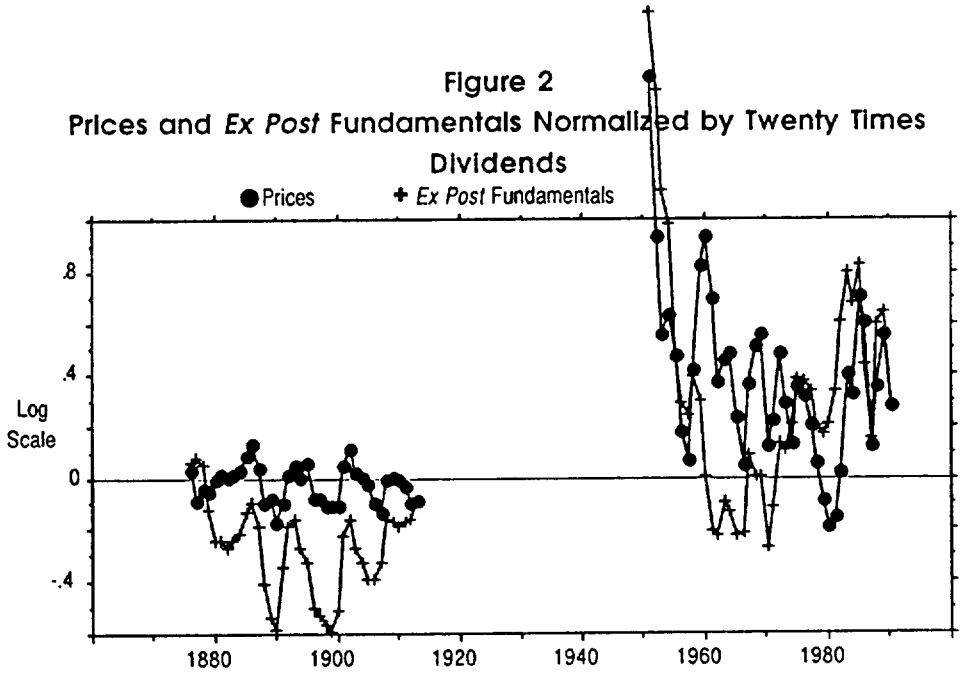
[12]Note, however, that it is possible to imagine situations—especially in circumstances of rapid development and uncertain long-run growth paths—in which even the assumption that investors know *ex ante* of the average price/dividend ratio is incorrect, and in fact attributes to past investors information that they do not but would dearly wish to know. See Barsky and De Long (1989).

fundamentals by the current level of dividends. Figure 2 plots real prices and *ex post* fundamentals normalized by a constant—twenty—multiple of dividends, for a real discount rate of 8 percent chosen to match real returns over the century as a whole.



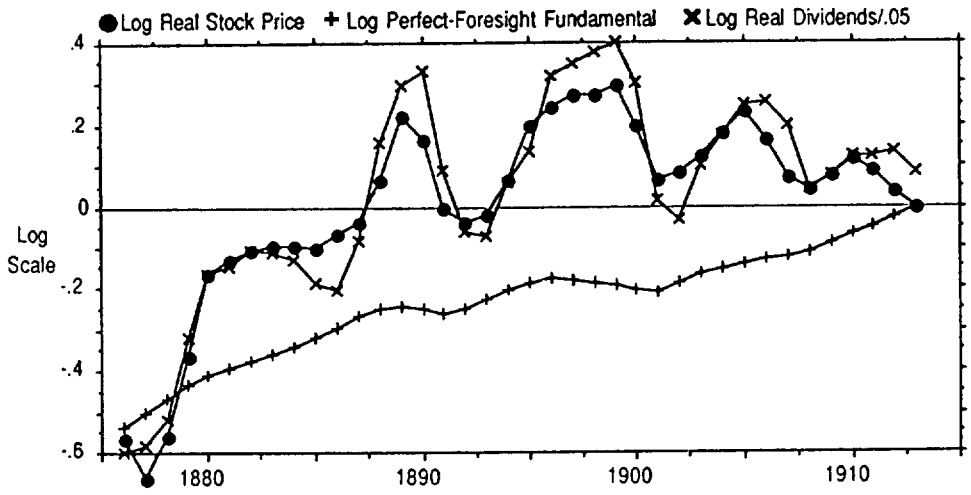
In figure 2 the pre-World War I stock market does not appear excessively volatile to the eye: the volatility of prices relative to the benchmark of twenty times dividends is smaller than the volatility of *ex post* fundamentals. The post-World War II market does see a larger volatility for prices relative to the twenty times dividends benchmark than for *ex post* fundamentals after 1960. The decade before 1960 sees both prices and *ex post* fundamentals very far from normal multiples of dividends.

Pre-World War I and Post-World War II Prices, and Perfect-Foresight Fundamentals

Figures 3 and 4 provide individual looks at the behavior of prices, dividends, and perfect-foresight fundamentals in the pre-World War I and post-World War II periods. They plot for

each of these periods the log levels of prices, the log *ex post* perfect-foresight fundamental (calculated using an eight percent per year real discount rate), and also the log level of dividends (multiplied by twenty in order to place it on the same scale as the other two series).

Figure 3
German Real Stock Market Values, Perfect-Foresight Fundamentals, and Dividends for the Pre-World War I Period
(8% Discount Rate; Terminal Condition in 1913)



Note the wider variability of stock prices in the post-World War II period that leads figure 4 to have a much larger vertical scale than figure 3. Figure 3 has a vertical scale that shows less than a tripling of real prices and dividends. By contrast, figure 4 has a vertical scale that captures a twelvefold multiplication in the level. Figure 3 shows that stock price and dividend indices move together throughout the pre-World War I period. The mean price-dividend ratio is approximately twenty. The maximum proportional deviation of the price-dividend ratio from its mean is less than a tenth; from 1876 to 1913 the dividend yield stays in a restricted range between four and a half and five and a half percent.

Figure 4
German Real Stock Market Value, Perfect-Foresight Fundamentals, and Dividends for the Post-World War II Period
(8% Discount Rate; Terminal Condition in 1990)

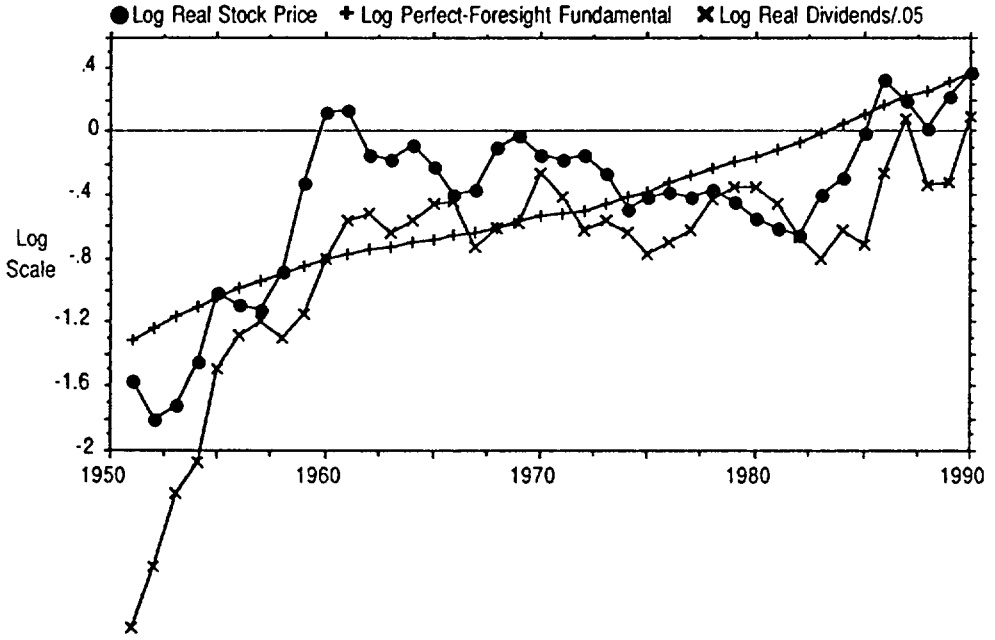


Figure 3 also shows that the price-dividend ratio moves countercyclically. Boom years like 1890 or 1899 see real dividends at local peaks. Such years also see the price-dividend ratio at relatively low levels. Slump years like 1886 or 1902 which see dividends at local minima see relatively high price-dividend ratios. Thus stock price fluctuations are damped, not amplified, images of dividend fluctuations.[13] In booms the stock market expects future real dividends to fall. In depressions the stock market expects future real dividends to rise.

Figure 4 shows another pattern. Dividends rise quickly from very low levels in the 1950's —the period of the "economic miracle." In 1955 real dividends are five times their 1951 level. In 1960 real dividends are eighty percent above their 1955 levels. Real prices rise rapidly from 1951 to 1960, rising by a cumulative factor of more than eight over the decade. The price-dividend ratio is almost one hundred at the beginning of the 1950's as firms skimp on payouts to increase

[13]In the U.S. market they are amplified images of dividend fluctuations. See Barsky and De Long (1989, 1990).

capital available for reinvestment. The price-dividend ratio falls until 1957, reaching a value in the low twenties. It then rises and reaches another peak, near fifty, at the end of the 1950's.

Since 1960 and the end of the *Wirtschaftswunder*, the real value of the German stock market index has risen by relatively little. Real values in 1989 were only some twenty-five percent above their 1960 levels. By contrast, real dividends have doubled over their 1960 levels. This stagnation in the level of the market over the past generation has been accompanied by substantial short-run swings in the real index price. Of these, the largest in magnitude is the four-year bull market from 1981 to 1985. It saw real prices nearly triple.

Volatility Ratios

Table 1 presents summary statistics on the volatility of the German stock market. For comparative purposes it reports similar statistics for the United States stock market as well. If actual prices were rational estimates of fundamentals, they should exhibit less volatility relative to some naïve forecast than do the *ex post* perfect-foresight fundamentals themselves.[14] Table 1 follows Mankiw, Romer, and Shapiro by normalizing prices and *ex post* fundamentals by the value of dividends: implicitly take the "naïve" forecast to be a constant multiple—twenty—times dividends. Such a forecast based on dividends and the average price-dividend ratio was available to investors at the time under the relatively weak assumptions that investors knew the required rate of return and the average annual upward rate of drift—not the *ex post* time trend—of dividends.

The third column of table 1 analyzes the post-*Wirtschaftswunder* period on its own. This is motivated by the likelihood that the rapid postwar-recovery régime and economic structure found in Germany in the 1950's had different characteristics than the rest of the post-World War II period. In the 1950's real dividends were very low and dividend growth was very high, as corporations sought to retain earnings and plow them back into investment. The assumption that

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[14]Mankiw, Romer, and Shapiro have an illuminating discussion distinguishing between "variance ratios" and "volatility ratios." Volatility ratios are mean squared errors around *ex ante* means or naïve forecasts. Variance ratios are mean squared deviations from *ex post* sample averages. The difference between them can be neglected only if the *ex post* sample average is a very good and precise measure of the *ex ante* mean.

even a naïve forecast of fundamentals would take them to be the same multiple of dividends in the 1950's as later is potentially hazardous. In addition, the nearly twenty percent per year average realized rate of return in the 1950's is far from the eight percent per year realized rate of return found on average in the pre-World War I and post-1960 periods, and suggests a different underlying structure.

Table 1
Volatility Tests for the German and American Stock Markets

Germany	Pre-WWI (1876–1913)	Post-WWII (1951–90)	Post-Miracle (1960–90)	Pre-WWI and Post-WWII
Volatility of $p-p^*$...	0.082	0.168	0.182	0.123
Volatility of $p-d$...	0.005	0.264	0.171	0.136
Volatility of p^*-d...	0.101	0.324	0.142	0.159
Volatility ratio: $p-d$ and p^*-d...	0.05	0.81	1.20	0.77
Volatility ratio: $p-p^*$ and p^*-d...	0.81	0.62	1.28	0.86
Sum of ratios	0.86	1.43	2.48	1.63
Significance: IMA(1,6)	0.98	0.01	0.01	0.02
Significance: ECM (θ=0.5)	0.99	0.07	0.01	0.03

United States	Pre-WWI	Post-WWII	Entire Century
Volatility of $p-p^*$...	0.041	0.157	0.131
Volatility of $p-d$...	0.029	0.057	0.062
Volatility of p^*-d...	0.019	0.056	0.055
Volatility ratio: $p-d$ and p^*-d...	1.53	1.02	1.13
Volatility ratio: $p-p^*$ and p^*-d	2.16	2.80	2.38
Sum of ratios	3.69	3.82	3.51
Significance: IMA(1,6)	0.01	0.01	0.01
Significance: ECM (θ=0.5)	0.01	0.01	0.01

The first line of table 1 shows the volatility of log prices (p) around the log of the perfect-

foresight fundamental (p*), calculated using an eight percent per year real discount rate. Volatility about perfect-foresight fundamentals is smaller before World War I than after World War II by a factor of three. This difference does not arise from the period of rapid stock market price and dividend growth in the 1950's. When the *Wirtschaftswunder* decade of the 1950's is excluded from the post-World War II sample, the mean squared error of log prices around perfect-foresight fundamentals is almost unchanged.[15]

The second line shows the volatility of the log price-dividend ratio (p - d) around a fixed constant of twenty, the average *ex post* price-dividend ratio for the pre-World War I period. The second line thus calculates the volatility of prices about the "naïve" forecast that would have been made by an investor who knew the mean trend drift of dividends and the required rate of return over the pre-World War I period, and nothing more. The price-dividend ratio shows almost no volatility in the pre-World War I period, and considerable volatility in the post-World War II period. The third line of table 1 shows the volatility of the log *ex post* perfect-foresight fundamental to dividend ratio (p* - d), about the same constant of twenty.

If prices are more volatile relative to "naïve" forecasts than perfect-foresight fundamentals, investors could and should have constructed a better forecast: a weighted average of the market price and the naïve forecast would have generated smaller forecast errors. Thus the second line of the table, the volatility of the price-dividend ratio, should under the efficient markets hypothesis be smaller than the third line, the volatility of *ex post* perfect-foresight fundamentals about the naïve constant dividend multiple forecast. Line four reports this volatility ratio.

Line five in table 1 calculates another volatility ratio. The volatility of the perfect-foresight fundamental about the actual price should be less than the volatility of the perfect-foresight fundamental about the naïve forecast. If this is not so, the actual price is a worse estimate of fundamentals than the naïve forecast.

A final implication of the efficient markets hypothesis is that the two ratios of lines four and five—the sum reported in line six—should add up to one. If not, the log difference between the

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[15]The variance is smaller before World War I than after World War II in the United States stock market as well.

price and the perfect-foresight fundamental (p - p*) is correlated with the log price-dividend ratio (p - d). Profits could have been earned by trading on this correlation of the price-dividend ratio and value relative to price. Lines seven and eight report monte carlo estimated significance levels for tests of the efficient markets hypothesis using the volatility ratio in line 6, assuming that log dividends follow either an IMA(1, 6) or an error correction model. These monte carlo significance levels are discussed at greater length below.

The bottom panel of table 1 reports analogous statistics for the United States stock market, for analogous periods.

Much of the excess volatility literature over the past decade has been concerned with the finite-sample distributions of volatility ratios like those in table 1. Advocates of the efficient markets hypothesis have argued that high volatility ratios are not strong evidence against it because test statistics have large tails under the efficient-markets null.

Believers in the efficient markets hypothesis have no need to resort to such defensive arguments in the case of pre-World War I Germany. Both the volatility ratios in lines four and five are less than one. The volatility ratios in lines 4 and 5 for the pre-World War I period are smaller than on average under the null. Prices are not too volatile relative to dividends, they are insufficiently volatile. Prices are much less volatile than perfect-foresight fundamentals relative to the naïve forecast. The market price is a better estimate of the perfect-foresight fundamental than is the naïve constant dividend multiple forecast. Thus tests based on market volatility ratios show no traces at all of excess volatility in the German stock market before World War I.

The post-World War II German stock market does show volatility ratios in line 6 of table 1 greater than one, and thus might provide some evidence of excess volatility. Table 1 also reports monte carlo estimates of the finite-sample statistical significance of the volatility ratios reported in line 6. Significance levels are calculated for two sets of assumptions about the true process generating dividends: first, that the log level of dividends follows an IMA(1, 6) with coefficients known to investors; second, that the log level of dividends follows an error-correction model—in which each year brings a shock to the fundamental value of the market, and the market's dividend level adjusts to close half of the gap between last year's dividend and the current

sustainable dividend/price ratio—set out in appendix 2.

The IMA(1, 6) process was chosen because its integrated component allows shocks to the level of dividends to persist permanently, yet its inclusion of six moving-average coefficients provides the monte carlo dividend process with sufficient flexibility to closely match the actual short-run dividend impulse response function. The error correction process (with its adjustment parameter θ=0.5) was chosen because it was the process used by Mankiw, Romer, and Shapiro (1991), because it was used by Merton and Marsh (1986) in their critique of Shiller, and because it can, with sufficiently slow adjustment, generate very persistent shifts in rates of dividend growth close to those postulated by Barsky and De Long's (1989) interpretation of U.S. long-run stock market fluctuations.

The post-World War II period considered as a whole generates volatility ratios that are significant rejections of the null hypothesis on the high side for the two generating processes considered.[16]

There is a strong argument that the post-World War II *Wirtschaftswunder* decade of the 1950's sees the German stock market following a different stochastic process than the later years of slower growth. When the post-*Wirtschaftswunder* 1960–90 period is considered in isolation, its volatility ratios are high enough to be very significant rejections of the null hypothesis.

As appendix 2 shows, the distributions of these test statistics are sensitively dependent on the assumed parameters of the generating process. Sufficient smoothness in the dividend level and instability in dividend growth, for example, can lead to high estimated volatility ratios even if the null efficient markets hypothesis holds. But shifting to a dividend generating process that possesses larger and more persistent changes in dividend growth does not make German data fit

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[16]Appendix 2 considers additional generating processes. Nevertheless, the post-World War II era continues to show signs of excess volatility for all proposed generating processes save the error correction models with high values of θ. When θ is near one, year-to-year dividend level changes are small and shifts in dividend growth rates are persistent. Accordingly, the variability of the price-dividend ratio is large: a value of θ=0.8 implies that each year dividends adjust only one-fifth of the way to the "permanent" sustainable dividend level. This is a greater degree of relative smoothness in real dividends vis-a-vis prices than is in fact found in the sample. A value of θ=0.1 implies that each year dividends adjust ninety percent of the way to the "permanent" dividend level: this makes the price-dividend ratio too close to a constant to be consistent with the data. Appendix 2 also plots sample price and dividend series for various values of θ from monte carlo simulations of significance levels.

the efficient markets hypothesis more closely: the pre-World War I era would then exhibit deficient, not excess volatility.

There are surely dividend process that have a high probability of generating volatility ratios as large as those observed for the post-*Wirtschaftswunder* period. But for such a process, volatility ratios as low as those observed for the pre-World War I era are extraordinarily unlikely. Similarly, assuming a dividend process that generates volatility ratios as low as the values observed for the pre-World War I era would magnify the significance of the excess volatility of the post-*Wirtschaftswunder* era. Only under the assumption of a major shift from a dividend process nearly a random walk before World War I to a process with substantial dividend smoothing after World War II would there be any possibility of using the efficient markets hypothesis to account for the behavior in both periods—and there is no sign in dividend autocorrelations of such a major shift in the dividend process between the pre-World War I period and the post-1960 period.

An Alternative Benchmark

The conclusions reached using the constant dividend multiple benchmark are not fragile. They do not depend sensitively on the choice of this particular naïve forecast benchmark against which to assess volatility. Shiller (1990) argues that the use of a constant multiple of a long moving average of dividends as a naïve forecast benchmark is preferable to the use of current dividends. In the U.S. dividends appear to have a substantial short-run mean-reverting component, and a long moving average of lagged dividends is a lower variance estimate of *ex post* fundamental values. Shiller (1990) finds stronger violations of volatility bounds using such a smoothed naïve forecast benchmark.

Table 2 presents volatility ratios using a ten-year moving average of lagged dividends as a benchmark. The substantive conclusions are unchanged: the post-World War II era shows some evidence of excess volatility, while the pre-World War I era shows no such evidence. Using the Shiller (1990) benchmark pre-World War I era German stock market indices no longer appear insufficiently volatile to be efficient market estimates of fundamentals, but the volatility ratios

for the pre-World War I period are close to the center of the distributions calculated in the monte carlo simulations. As noted above, calculated significance levels should be regarded with suspicion, and used gingerly. Nevertheless, the sharp difference in the characteristics of the pre-World War I and the post-*Wirtschaftswunder* markets remains.

Table 2
Volatility Tests for the German Market Using a Moving Average of Lagged Dividends as the Naïve Forecast Benchmark

p^0 a 10-Year Moving Average of Dividends	Pre-WWI (1876–1913)	Post-WWII (1951–90)	Post-Miracle (1960–1990)
Volatility of $p-p^*$...	0.082	0.164	0.176
Volatility of $p-p^0$...	0.023	0.316	0.204
Volatility of p^*-p^0...	0.090	0.338	0.109
Volatility ratio: $p-p^0$ and p^*-p^0...	0.26	0.93	1.86
Volatility ratio: $p-p^*$ and p^*-p^0...	0.91	0.49	1.59
Sum of ratios	1.17	1.42	3.45
Significance: IMA(1,6)	0.27	0.06	0.01
Significance: ECM (θ=0.5)	0.38	0.08	0.01

Still other naïve forecast benchmarks could be used. Few today would argue for Shiller's (1981) original *ex post* time trend as an admissable naïve forecast benchmark. But some might argue that the constant dividend multiple benchmarks themselves attribute to investors in the past knowledge that they did not in fact possess (see Barsky and De Long, 1989; Bulkley and Tonks, 1989). If the long-run growth rate of the economy, and of dividends, and if future real interest rates are not known with certainty, how then could past investors calculate the appropriate multiple by which to mark up current dividends? Bulkley and Tonks (1989) argued that apparent violations of volatility bounds on the post-World War I London market did not exist in fact once it was recognized that investors had to estimate the parameters of the dividend process, and did not know them *ex ante*.

Such arguments, however, tend to explain away apparent excess volatility where it appears:

they would, if anything, make the existence of *deficient* volatility as seen in the pre-World War I German market even more anomalous.

IV. The *Großbanken* and the Stock Market

Explanations of the difference between the behavior of the pre-World War I and the post-World War II German stock market can take two roads. First, perhaps there is a sharp contrast between the processes generating dividends in the pre-World War I and post-World War II eras. Second, perhaps the institutions of the pre-World War I German stock market led it to have market prices that were better forecasts of fundamentals.

Unstable Growth Rates

If the post-World War II dividend process was significantly different from the pre-World war I process, the cause was presumably World War II. In the war's immediate aftermath was not clear to what degree the German economy would recover from the war, or what its long-run growth rate would be after the initial spurt of reconstruction had passed. The pace and the duration of the *Wirtschaftswunder* were unknown to contemporary investors. The lack of knowledge of the likely pace and duration of the spurt of post-World War II "super growth," or of the subsequent likely growth rate of the German economy meant that investors could not calculate the mean ratio of fundamental values to dividends, and so could not form the "naïve" forecast that table 1 implicitly assumes that they possessed.

This line of argument runs into potential difficulties. The pre-World War I German stock market lacks excess volatility. But Germany was then undergoing its industrial revolution (Clapham, 1963; Landes, 1969). It appears equally plausible to argue that the long-run growth rate of the economy and thus the mean price-dividend ratio *then* in the pre-World War I era was unknown, a changing parameter that investors learned only *ex post* and not a given that they could use *ex ante* to construct forecasts. Yet pre-World War I investors appear to have been very confident of the long-run growth rate of corporations, and so kept price-dividend ratios within a

very narrow range.

Moreover, the U.S. stock market has exhibited stronger signs of excess volatility than the German, without the excuse of defeat in war and wartime destruction to add instability to the process generating dividends. This line of argument would explain a deviation of the behavior of the post-World War II German market from standard experience. It does not account for the deviation of the behavior of the pre-World War I German market from other experience that we actually see.[17] Unstable and unknown trend divdiend growth rates may well have been a cause of high post-World Wa rII variability, but it cannot be the sole major cause of the contrast between pre-World War I and post-World War II behavior.

The Role of the Großbanken

This section points to the role played by the German *Großbanken* in issuing, analyzing, making a market for, and supporting the prices of German securities in the years before World War I. It speculates that their key position in the German economy is linked to the absence of excess volatility. The *Großbanken* dominated pre-World War I financial markets in Germany.[18] They had well-developed analytical abilities, strong views regarding the proper levels of stock prices, and an incentive to moderate fluctuations away from fundamentals.

In the middle of the nineteenth century continental Europe lacked the network of banking financial intermediaries found in Anglo-Saxon countries. Prevailing banking theory in Britain and the United States held that banks existed primarily to provide liquidity, that their assets should ideally liquidate themselves in a short period of time, and assets not self-liquidating should be held only if they were secured by assets that were themselves liquid and safe (Willis and Bogen, 1936). There was thus a sharp division of labor between commercial banks—which provided transactions services and liquidity—and investment banks, which underwrote the sale

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[17]For an exploration ofgrowth rate instability as a cause of apparent excess volatility in the United States, see Barsky and De Long (1989, 1990).

[18]They are still influential in the German economy today, although not nearly as important as they were before World War I, when leading social democrat Rudolf Hilferding (1910) could say that all that was needed in order to attain socialism was the nationalization of Germany's six largest banks.

and distribution of claims to the capital committed to the rapidly-growing corporate sector.

In continental Europe things were different (Landes 1956). German stock markets, especially, were not well developed and were illiquid. The fragmentation of the country meant that pre-1870 Germany had many securities markets, none of which possessed large volume or large supplies of capital (Pohl, 1976, 1982a, 1982b). The lack of well-developed and liquid bond and stock market made it harder for firms to raise money through the sale of securities, and harder for investment banks to conduct their business as short-term intermediaries only.

"Mixed" banks filled the gap. The growing need for external finance by industry and the absence of well-developed securities markets on which to raise money created a niche that the German "mixed" banks were to fill (Gerschenkron, 1952). The first true "mixed" bank in Germany—a dual commercial and investment bank, that not only accepted deposits and made short-term loans but also provided long-term capital financing for corporations—was the A. Schaaffhausen'scher Bankverein. Its main business activities were savings- and checking accounts, intra-German "foreign" exchange (for Germany did not yet have a uniform currency), the provision of short-term trade credit, and "stakes in industrial enterprises"—an item that features with Taler 375,000 in its 1848 balance sheet. These banks were investment trusts, development banks, commercial banks, investment banks, securities underwriters, investment advisors, and management consultants all at once (Weber, 1902; Riesser, 1911; Quittner, 1929; Neuberger, 1974).

By 1880 the banks had representatives on most industrial boards—contacts that could be used very profitably when deciding on the methods of corporate finance. The commitment of large proportions of their banks' capital to illiquid long-term industrial, transportation, and utility investments created obvious risks. Where British bankers needed only to fear that the collateral pledged for loans was of low quality, German bankers had to worry about the solvency of the firms in which they had invested. Potential profits from making long-term capital commitments to growing and capital-hungry German industry were too large to pass up, but bankers required

means to gather information and insisted on some degree of control to try to limit their risk.[19]

One way to limit risk was to use leverage to influence corporations. Wilhelm von Siemens, Chairman of Siemens and Halske (the second-largest German electrical machinery manufacturing company) describes his negotiations with the Deutsche Bank during a credit crunch as follows:

> ...I was urgently requested to come to the Deutsche Bank...the entire *Direktion*...was gathered there....Herr [Arthur von] Gwinner judged that [Siemens and Halske] needed 5 or 6 million [marks]. It was not possible to issue shares or bonds, and under no circumstances [would]...the Deutsche Bank...advance us the money....My comments [that the firm was well capitalized] were received with great skepticism[20]... my family was required to obligate itself...to lend the firm its last dividend...[21]

The implicit threat the Deutsche Bank used to persuade the Siemens family to provide high-risk "mezzanine" financing and commit an even greater share of the family's wealth to the family firm is clear: Deutsche Bank approval is necessary if the Siemens family wishes to continue to run the business (Neuberger, 1974).

The *Großbanken* had the power to carry out whatever threats they might make to or conditions they might lay down for corporation managers.Their organizations controlled a large part of the voting stock—and a still larger part of the stock voted. Banks voted the shares held in their own names. Through the institution of the *Depotstimmrecht*, banks also voted the shares of others. Investors would use the banks as brokerage houses, leaving their certificates in safe custody with the bank. In such a case, the bank would write and ask if the shareholder was

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[19]Neuberger (1974) cites Riesser (1911) as counting 819 representatives of the eight leading *Großbanken* on the boards of directors of German corporations in 1905.

[20]Wilhelm von Siemens is likely to have known little if anything more about Siemens and Halske's position than the men he was negotiating with. The Deutsche Bank's point men in the negotiation were Arthur von Gwinner, sometime director of Siemens and Halske, and Wilhelm's cousin Georg von Siemens. Later on the manager of one of Siemens' subsidiaries—the Siemens-Schuckert Company—would successfully appeal to the Deutsche Bank to protect him from the interference of his supposed superior Wilhelm von Siemens, chairman of the Siemens and Halske board.

[21]Quoted in Neuberger (1974).

planning to attend the annual meeting. If not, the bank would be very happy to vote the shares and so look after the shareholder's interest.[22] A bank like the Deutsche, owning perhaps five percent for its own account and voting an additional twenty percent through the *Depotstimmrecht*, might well have an absolute majority of shares voted.[23]

The key to the profitability of the *Großbanken* lay in its ability to securitize its credit commitments, and to place the bonds and shares of the corporations it sponsored at high prices. Successful "mixed" banks persuaded investors that the companies they sponsored were desirable investments. To please investors, banks sought to sell shares that would remain stable both in their yield relative to par and in their market value (Prion, 1910). To please firms, banks sought to get a "good price" for their capital issues. Furthermore, the quicker a bank could securitize its commitments and recover its capital from an issue transaction, the better: after 1880 the German capital market was so large relative to the capital of even the largest banks that none of them wished to have a large risk like a new issue on its books for too long (Riesser, 1906, 1911).

The *Großbanken* thus sought to enhance their "issue credit," defined by Riesser (1906, 1911) as their reputation as honest brokers selling sound securities, who would monitor corporations to protect both their own investments and the investments of those who had bought on the bank's recommendation. Riesser describes the connection between a company and a bank that was established by the bank's once underwriting a firm's security issue as so strong that:

> ...they are thereafter joined 'for better or worse'....[T]his connection finds further expression in the appointment of members of the bank directorate to the supervisory council of the industrial enterprises...caused by the necessity for the banks to maintain the influence [over the firm] which they have gained through the

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[22]The *Depotstimmrecht* was and is the subject of economic, political and legal debates. For a good account of the legal situation before the hyperinflation, see Gieske (1926).

[23]The role played by the *Großbanken* in issuing securities assisted them in their collection of shareholders' proxies. When a corporation issued new shares, existing shareholders had a *Bezugsrechte* claim—the right to purchase shares at less than the current market price in order to avoid involuntary dilution of their equity. To exercise this right they had to reveal their identity to the firm's bank. Passow (1922) argues that the German banks knew more about the composition and location of shareholdings than anyone else: more than private investors, more than the government, and more than the managements of the corporations themselves.

> issue...[and] by a regard for their issue credit, which makes it the duty of the bank...to retain...[supervisory] control.[24]

The Großbanken and the Stock Market

Even if ultimate investors are confident that the *Großbank* promoting a firm's securities will monitor it to ensure that it remains well-managed and profitable, they will not necessarily regard such securities as safe investments. Investors care not just about the present value of the income stream they would receive if they held the security permanently, but also about liquidity. If they have to sell, will they get a fair price? For investors with uncertain horizons and liquidity demands to count a bank-sponsored security as safe, the bank must take steps to ensure both that its fundamentals are and remain sound *and* that its market price will not fluctuate relative to fundamentals.

Thus the *Großbanken*, trying to create value for the investors to whom they sold newly-issued securities, sought also to support the prices of the securities they issued. Riesser states that sponsoring firms are "...not merely justified but positively... bound, by the requirement [that they take the] 'care of an ordinary issuing firm," to support the market prices of securities. According to Riesser, this support is "not...an attempt to produce an artificial rise of quotations, or to effect their artificial 'regulation'" to swindle the public. Instead "it is...a service to investors by making sure that their securities do not artificially lose value because of... speculators [who]...depress the market value...while there may be no intrinsic reason for a decline."

Did the *Großbanken* have sufficient resources to keep asset prices close to their own internal estimates of fundamentals? The *Großbanken* were by far the largest actors in the German economy. The banks shaped their underwriting and issuing strategies with an eye toward long-term support of share prices: they tried hard in securities issues to place bonds and stocks in the

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[24]Riesser's view is a banker's-eye view, and downplays possible desires of founders and managers of operating companies to retain their practical independence. On pages 367–8 of Riesser (1911), he does say that "this form of 'friendly' relations through the filling of positions on the supervisory board, it must be confessed, was sometimes effected only after considerable unpleasant argument...for instance, when the Dresdner Bank gained two places on the supervisory board of the Laurahütte."

hands of investors who would hold them and not immediately turn them back onto the market.

Some, like social democratic politician and future Weimar Republic finance minister Rudolf Hilferding (1910), believed that "finance capital" did dominate the stock market, and faced few limits in its manipulation of share prices. Hilferding believed that banks "as a result of their increasingly close relations with industry...have an intimate knowledge of the situation of particular enterprises...[and so] carry on their [stock market] speculations with considerable security" because of their important informational edge. Hilferding believed that the stock markets had become registers of banks' opinions of share values, for "a large bank represents in itself a volume of supply and demand [for securities] such as was previously represented only by one of the larger stock exchanges."[25] He quotes the *Frankfurter Zeitung* of 21 June 1907 as arguing that banks did not need to trade but only to announce their assessments of fundamentals to move prices. Speculators had such regard for banks' superior analytical capabilities and inside information that, for example, "the...impetus to the sudden collapse of security prices" the previous spring had been given by "an unfavorable forecast of business conditions by one of the big banks."

Riesser, by contrast protested that *Großbanken* support of prices was limited in scope. But he is more concerned with arguing that it was exercised in a good cause than that it was unimportant. While Riesser discusses the emissions process and the influence of banks on corporate managers extensively, he spends little space discussing the "maintenance" of prices on already-issued securities.[26]

Still others, like Prion (1910, 1929), claim that all important shares had patrons in the form of analysts at the banks. According to Prion, every day representative of the bank would meet with the exchange's market maker *"zur Kurfestsetzung"*—to set the price.[27] Prion argues as well

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[25]Hilferding, quoting the 1905 *Berliner Jahrbuch für Handel und Industrie.*

[26]He does say that economic prosperity depends on having a "thick" stock market, in which panics do not lead to waves of selling that overwhelm stabilizing speculation by banks and others. Riesser believes that if stock market values were not relatively stable, then it would be difficult to induce investors to purchase new issues on terms that corporations would be willing to offer.

[27]According to Prion (1910), this "was common knowledge in stock exchange circles...[though] hardly known to the general public; this manifests itself in the surprise shown by A. Wagner...[who, when he discovered the extent of] the regulation of *Pfandbriefe* by the *Pfandbriefbanken*...condemned [it] as cancer."

that the banks determined prices not because they possessed the capital to peg them directly, but because they were seen as informed investors and made the best estimates of the underlying "innerer Wert."[28] If the Deutsche Bank—known to have the most comprehensive network of analysts in Germany, and correctly believed to have inside information as well—decides that a company should be quoted lower, who will take the other side of the trade it offers?[29]

Are these observations of pre-World War I financiers and academic students of finance trustworthy? Riesser was an "insider," an executive of the *Bank für Handel und Industrie*. His volume on German banking was the single study of German finance that the U.S. National Monetary Commission translated in order to help it wrestle with the issues involved in trying to design a central bank for the United States. Prion was perhaps the leading academic student of finance at the time—he was the one commissioned to write the article "Börsenwesen" [literally: "the nature of the exchange"] for the authoritative *Handwörterbuch der Staatswissenschaften* [*Dictionary of the Policy Sciences*]. Hilferding was one of the intellectual and political leaders of the social democratic movement. Moreover, their views of turn of the century German finance are consistent with those of present-day historians like Pohl (1982).

The fact that the heyday of "finance capitalism" in pre-World War I Germany sees the absence of excess volatility is food for thought. Historians of corporate development like Chandler (1990) argue that organizations like the Deutsche Bank were well informed. Perhaps

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[28]"Fundamental value" in very free translation. The "permanent" dividend that a company pays out discounted at a rate that takes account of the greater risk associated with stocks and with different industries.

[29]According to Prion (1910), bankers explicitly calculated the "innerer Wert" of shares by considering shares as a claim on the income stream of the corporation. Prion quotes discount rates of 1-1.5% above the interbank rate to capitalize dividends paid by bank shares and 1.5-2% above the interbank rate for mining and steel shares, and argues that banks' assessments of stock market values are based on their estimates of the *permanent* level of dividends, not the current level. (Prion also notes that such fundamental-value calculations are complicated by considerations of the liquidation value of the firm's capital in the event of bankruptcy.)

A focus of Donner's (1934) paper that is our principal source for pre-World War I data was to see whether the observed variability of pre-WWI stock prices could be explained by variation in the "innerer Wert" that Prion believed the banks used to assess fundamentals. Following Donner's example, we find that Prion's formula could account for 84 percent of the variation in nominal stock index prices over 1870–1913, and concluded that the quantitative time series confirmed the theory of price formation that Prion had arrived at through his study of the institutions and operating procedures of the stock exchange. We believe that Donner underestimated the extent to which pre-World War I data fit Prion's model: Donner used the current dividend rather than an estimate of the *permanent* dividend in his regression, and in the pre-World War I German stock market a low price-dividend ratio is a good forecaster of future declines in real dividends.

they did make better estimates of fundamentals than the speculators who would have dominated the stock market in their absence, who did dominate the American stock market throughout the past century, and who have played a more active role in the German stock market since World War II.

This hypothesis is itself speculation, and is not based on solid or inside knowledge. However, the strength of the *Großbanken* is an important institutional feature of the structure of the pre-World War I German stock market. The absence of excess volatility is an unusual feature of market performance. Perhaps the two are intimately linked.[30]

V. Conclusion

This paper has used German data to investigate issues similar to those that Shiller (1989) has investigated in his studies of the United States stock market. The German data give different answers. There is some evidence of excess volatility in the post-World War II German stock market. But there is no sign at all of excess volatility in the pre-World War I German stock market. Relative to a naïve forecast benchmark that takes fundamental values to be a constant multiple of dividends, the pre-World War I German stock market stands in contrast to both the post-World War II German market, and to the American market in either the pre-World War I or the post-World War II period.

The substantive results of this paper suggest two additional lines of thought. The first is that in a sense the absence of excess volatility in the German stock market before World War I strengthens Shiller's conclusions for the United States. It is harder to maintain that Shiller's findings of violations of market efficiency are due primarily to biases in test procedures or to inappropriate assumptions about the stochastic character of generating processes when the pre-

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[30]Even if the dominance of the *Großbanken* led the pre-World War I German stock market to be a better social calculating mechanism for determining the net value of new investment, their dominance may well have had other effects that reduced economic welfare. Their encouragement of cartels and monopolies is notorious. And under some interpretations they played a substantial role in the "marriage of iron and rye" that gave Germany conservative domestic politics and an aggressive foreign policy.

World War I German stock market—presumably subject to the same biases in test procedures — exhibits no signs of excess volatility. The U.S. stock market might have exhibited as low a degree of volatility relative to current dividends and perfect-foresight fundamentals as the pre-World War I German market. Yet it did not do so. This calls for explanation.

The second is that perhaps the unusual behavior of the pre-World War I German market—in not showing evidence of excess volatility—is linked to the institutional structure of finance under the German Empire. Perhaps the investors who were active at the margin in the pre-World War I German market were the well-informed *Großbanken*, which both formed good estimates of fundamental values and had an interest derived from their investment banking business in moderating swings of stock prices away from fundamentals.

This speculative possibility is intriguing. It suggests that a competitive stock market, in which prices balance the momentary demands and supplies of short-term traders who are relatively uninformed about fundamentals, may not perform as well—measured as a social calculating and capital allocation mechanism—as alternative institutional arrangements that rely more on "hierarchy" and less on "market exchange." If market performance is evaluated using a metric that penalizes "excess volatility," then the pre-World War I German stock market appears to have performed relatively well. Perhaps its "finance capitalist" structure had something to do with its good performance.

Cochrane (1991) asks believers in Shiller's (1989) arguments for "excess volatility" to suggest an alternative form of organizing securities markets that would produce better forecasts of fundamental values. He implies that there is no alternative, that a competitive market populated by atomistic, short-horizon speculators like the one the U.S. has possessed for the past century is the best option. If flawed forecasts are the cause of excess volatility, how could different institutions be immune to such flawed forecasts? The pre-World War I German hypothesis suggests a possible answer. Perhaps a U.S. stock market dominated by informed *Großbanken* would have been a better social capital allocation mechanism than the actual U.S. market has been over the past century. The absence of excess volatility in the pre-World War I German market indicates that we should think about whether this is in fact so.

Appendix 1: Underlying Data

Pre-World War I Indices

There are five different stock price indices available for the pre-World War I German stock market.

The index that covers the earliest time period is that of Däbritz, reprinted in Donner (1934). From 1925 on, Däbritz was the director of the *Institut für Konjunkturforschung* "West" in Cologne. As part of his business cycle research program, he calculated ratios of share value to registered capital over the period 1856-1870 for a relatively small number of publicly-traded companies.

There are two major shortcomings in Däbritz's index from our perspective. The first is that it is not a portfolio index at all. Instead, Däbritz's index is an average of ratios of market to par value for the corporations in the index. This means, first, that changes in the index are not capital gains or losses on a portfolio: the index value jumps when a new stock is added or an old stock dropped from the sample. Second, Däbritz did not collect any index of the dividends paid or the average yield on the stocks that make up his index.

The first of the pre-World War I indices ranked by the date of its composition is that of Dermietzel (1906). Dermietzel sought to advance the literature on the determinants of corporate profitability that had been started by Körösy (1901). He collected company specific dividend and share price statistics for German corporations between 1876 and 1902. Dermietzel (1906) himself, following his model Körösy, reports as his primary statistic the absolute value of all shares of all companies on the exchange. Dermietzel also reports the par values of the companies' registered capital, and so his index can be converted into an index of price relative to par value of a definition similar to that of Däbritz.

The Dermietzel index covered a very large sample of more than one hundred companies by the end of the nineteenth century. Even at its beginning in 1876, it still covered more than forty companies.

A slightly later study by Albert (1910) contains yet a third index, once more not a "portfolio" index but instead a ratio of market to par values. Albert's index is an average of individual stock price series for eleven companies over the period 1895 to 1908.

Albert's series is itself derivative. He compiled his tables from two sources. From 1895-1899 he averaged monthly numbers in Neumann's share price tables for the Berlin exchange. From 1900-1908 he used Conrad's article "Volkswirtschaftliche Chronik" in the *Handwörterbuch der Staatswissenschaften.*[31]

The first of the true portfolio indices ranked by date of composition was constructed by Wagemann and published in the *Wochenberichte* of his *Institut für Konjunkturforschung* in 1929. He was the founder (in 1925) of the Berlin *Institut für Konjunkturforschung*—a different "Institute for Business Cycle Research" than the *Institut für Konjunkturforschung* "West" of which Däbritz was head. Däbritz's institute was a largely independent but formally subsidiary branch of Wagemann's. Wagemann's organization was a Berlin-based non-profit, "free think-tank" for business cycle research. It was supported by the Weimar Republic's ministries and by private industry. It shared many of its personnel with the National Statistical Bureau, the *Statistisches Reichsamt.*[32] Wagemann's principal interest, however, was not so much in tracking the stock market as in capturing short-run fluctuations that would be useful for predicting the course of the business cycle.

The second of the true portfolio indices is that of Donner (1934). Donner (1934) is certainly the most ambitious German contribution to the international debate on the causes of stock market fluctuations that sprang up after the 1929 crash. He seeks to determine the economic causes of

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[31]The companies in Albert's sample are the Gelsenkirchener Bergbau, Harpener Bergbau (coal), Bochumer Gußstahl, Königs- und Laurahütte (steel), Berliner Maschinen bau Gesellschaft (machinery), Hamburg-Amerika Paket Fracht, Norddeutscher Lloyd (shipping), Stettiner Vulkan (shipbuilding), the Deutsche Bank, and the Diskonto Kommandite Gesellschaft (banking).

[32]Wagemann compares his Institut für Konjunkturforschung with similar institutions in the United States—like the Harvard Economic Service, Wesley Clair Mitchell's National Bureau of Economic Research, the Institute of Economics in Washington (a piece of what was to become Brookings), and the Russian "Business Cycle Service" run by Kondratieff before his arrest and execution under Stalin. Unlike the Americans, whom Wagemann characterized as "engineers," or the Russians, whom he called "astronomers," the Germans were supposed to follow an "organic-biological" methodology for research and forecasting—collecting and reporting as many economic time series as possible and combining them into "barometers" of economic activity.

German stock market fluctuations, thus following the track of Prion (1929). Donner put together a monthly index covering the period from January 1870 to December 1913 by taking averages weighted by their market capitalizations of stock price changes. His work was published by Wagemann in the Quarterly Supplements to the reports of his *Institut für Konjunkturforschung*.

Donner takes pains to purge his index of the effects of new share issues, and of the inclusion and exclusion of companies. Donner excludes from his calculations of month-to-month price changes any company that issues new shares (and, more likely than not, offers them at below market values to existing shareholders), is added to the index, or drops out of the index.

Donner's indices are superior to those of his contemporaries both from the point of view of coverage and from the point of view of the sophistication of their construction. The earlier indices compiled by Albert and others were simple calculations of the total market value of shares or of averages of share prices across companies.[33] Unlike Donner (1934), their indices made no attempt to correct for new issues of stock, or for the entry of new firms into the sample. Donner (1934) assembles period-to-period price changes for his index by taking the weighted average of price changes for firms that are quoted in both periods and do not issue any new shares.[34]

Donner's index covers only twelve companies from 1870 to 1875. The number of companies covered rises over time, reaching twenty-one by 1876 and nearly sixty by 1890. This rise in the number of companies proceeds alongside a shift mix of industries represented. The original twelve companies covered in 1870 include four banks, four railroads, and four mining companies.[35] Railroads disappear from the index with their nationalization in 1890. Companies in other industries are added as the industrialization of Germany proceeds.[36] Especially in the

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[33]German securities laws required that all shares of stock have a par value of 100 marks. Averages of stock prices are thus averages of nominal prices relative to par values as well.

[34]Such a procedure is potentially subject to a different bias because firms that go bankrupt and exit the sample will be omitted. But the only firms that exit Donner's sample are the German railroads. Donner makes a special correction for these railroads, which exit the sample not because of bankruptcy but because of nationalization.

[35]Two of the mining companies—the Bochumer Verein für Bergbau and Gußstahlfabrik and the Hoerder Bergwerks- und Hüttenverein—also had metal fabrication or railway divisions.

[36]On the eve of World War I, the index covers eight banks, two shipping companies, fourteen mining and steel producers, four electrical machinery manufacturers, four utilities, nine metalworking manufacturers, six in

years from 1890 on, the Donner index is a cross section of Germany's largest companies, weighted toward the heavy industries in which Germany's companies were largest and its international comparative advantage greatest.

Alongside his stock price index Donner reports a yield index for his sample. His yield index is available only on an annual basis: Donner believed that examining dividends at any frequency finer than an annual one ran the unacceptable risk of conflating real shifts in payout rates with shifts induced by changes in the timing of payments.

Figure A.1
Pre-World War I German Stock Price Indices Available

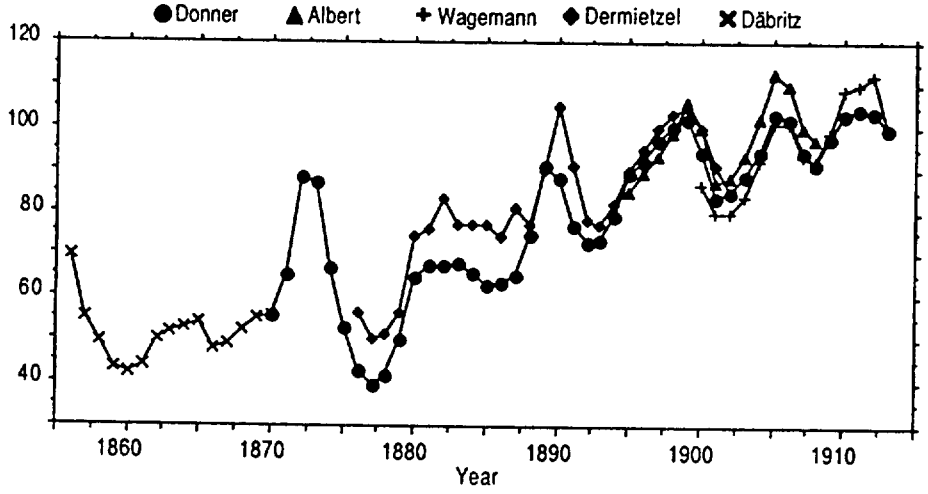

Figure A.1 graphs the nominal values of the five stock price indices available for the pre-World War I era. As can be readily seen, they track each other relatively closely. Especially after 1876—when Donner's index consists of more than twenty and Dermietzel's index of more than forty companies—it is possible to be confident that the indices do capture fluctuations in the German market. Before 1876 it is not so clear that this is the case, and dividend indices are not available before 1870. Thus the empirical work in the body of the paper begins in 1876.

Figure A.2 plots Donner's annual dividend yield series for the pre-World War I period. As

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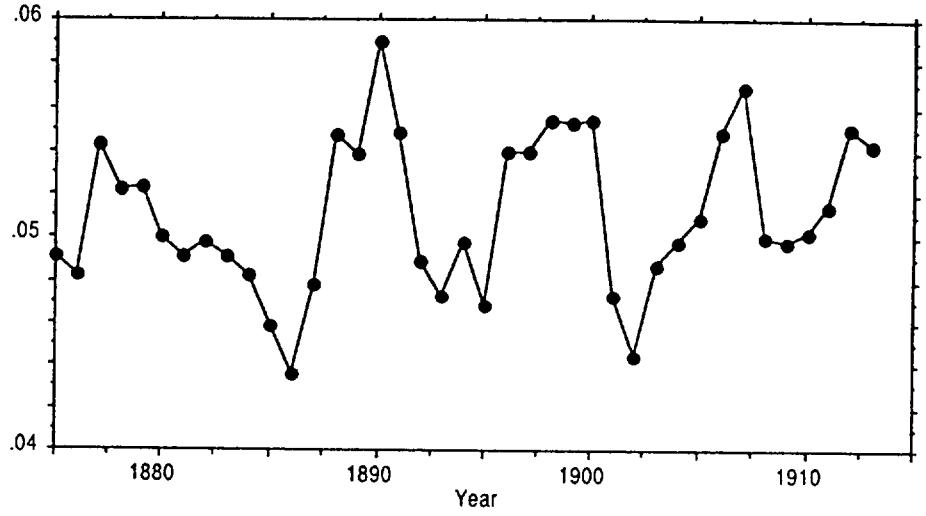
chemicals, seven in textiles, two in paper and wood products, three makers of building materials, two construction companies, three glass and porcelein manufacturers, and four breweries.

noted above, dividend yield fluctuations are contained within a relatively narrow band—between 4.3 and 5.9 percent.

Figure A.2
Donner Dividend Yield Series



Interwar Series

Donner's index ends on the eve of World War I. During the interwar period the *Statistisches Reichsamt* (National Bureau of Statistics), the official statistical bureau of first the democratic Weimar Republic and then the Third Reich, constructed a portfolio-based index covering the period from 1914 up to the 1923–24 hyperinflation. Its construction is outlined in the official *Wirtschaft und Statistik* (see Statistisches Reichsamt, 1922a, 1922b). This is the first, official stock market index for Germany.

The Reichsamt sought an indicator that would allow "first, to measure stock market trends in terms of some average, second, to show the effect of inflation on stock market prices" (1922a:168). A three-page article describes the index, constructed by averaging the prices of 300 companies, with weights corresponding to December 1913.

This first *Reichsamt* index is of the Laspeyres type. Its weights are derived from the

registered capital of all German corporations, including those not traded on the stock exchange. The companies are divided into 33 industrial groups, the industry average is then calculated as an arithmetic average of share prices, and the market average is then calculated as a weighted average of the industry averages. This index takes account of *Bezugsrechte*—the preferential right of existing shareholders to purchase new share issues on favorable terms.[37]

In 1928, the previous stock market index was revised: the distortions of the hyperinflation, the related change from Mark to Reichsmark, shifts in the industry composition of the corporate sector, and the desire by the official statisticians to slightly change their methodology (Statistisches Reichsamt 1928, 1929) all served as reasons to replace the first interwar index.

The replacement index—the second *Reichsamt* index—covers 329 share titles, and takes the average price between 1924 and 1926 as its basis. Once again the weighting across industries uses the registered capital of all corporations as of the end of December 1926, including those companies not traded on the exchange. Companies are classified into 24 industrial groups.

The 24 industry averages were grouped into three intermediate indices and the final index. The index excludes price movements induced by new share issues—thus the *Reichsamt* II index is also a portfolio index, using the same procedure as Donner (1934) to take account of new share issues, and changes in the sample. Bundesbank (1976) and the *Wochenberichte's* statistical supplements published by the *Institut für Konjunkturforschung* conveniently summarize the time series of values reported for this index.

The two interwar series can be linked, and in the body of the paper we do link them, to provide an estimate of real capital gains across the hyperinflation era, but we do not have great confidence in the reliability of the link. Real values of the indices across the interwar period are presented in figure A.3. Because of the hyperinflation, it makes no sense to plot nominal stock prices for the interwar period.

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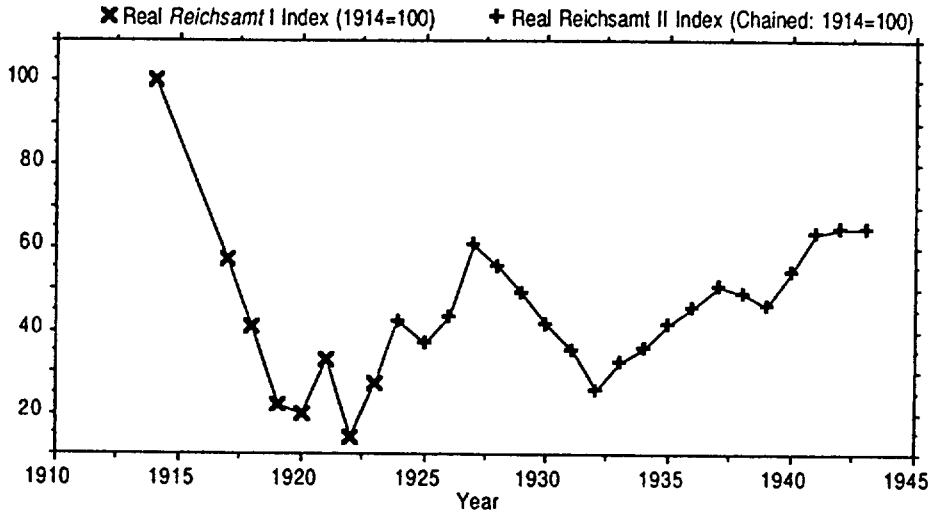
[37]The *Reichsamt* made an arithmetic mistake in the initial calculation of its index, which it repaired in a subsequent issue (Statistisches Reichsamt 1922b).

Figure A.3
Real Interwar Stock Price Series



Alternative indices of the ratios of book to par value are also available for the interwar period. They behave very differently from the portfolio indices calculated by the *Reichsamt*. The market-wide ratio of market to par values rises steeply in the early years of the Depression, reaching a peak in 1931: companies fail, and their subsequent omission from the index leaves only companies with high ratios of market to par value in the sample.

For the post-hyperinflation portion of the interwar period, the available yield series is the yield on all traded stocks, plotted in figure A.4.[38] This yield series is reported in the *Aktiengesellschaftsstatistik*—the statistics of corporations, computed to track corporation profits and performance, which contains other measures of profitability as well—as well as in the *Börsenstatistik*—the statistics of financial markets, computed to track relative asset values, which contains the price indices. The diverging orientation of these two bodies of statistics means that the different series are not built on consistent bases: while the *Reichsamt* took pains to make sure that its stock price index did represent the value of a broad-based portfolio, it thought it more important that its dividend index have comprehensive coverage than that it correspond to the stock price index. Thus the yield statistics are calculated from a different sample of corporations

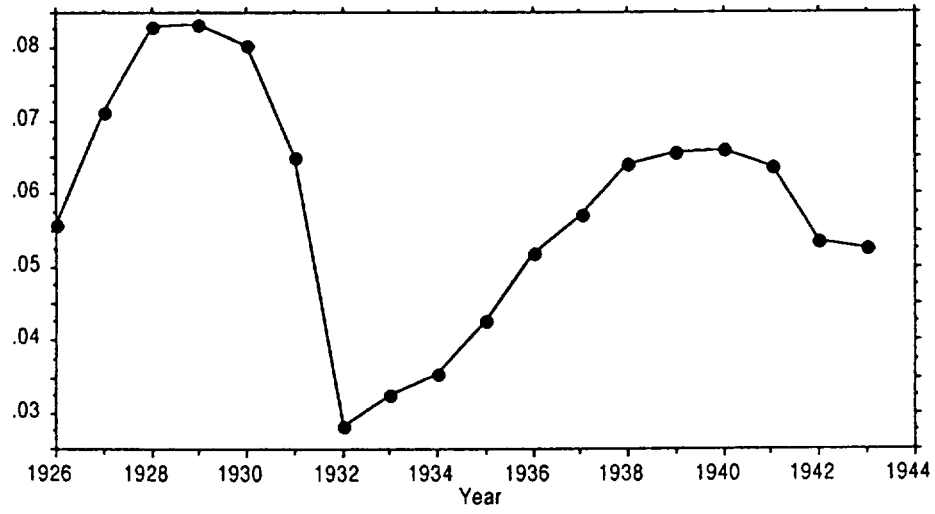
[38]Another dividend series is also reported: the yield of all corporations, publicly traded or not.

than are the price indices.

In the interwar period, this is extremely hazardous. Since the ratio of market to par value for all traded corporations does not track movements in the market portfolio, why should the dividend yield for all traded corporations track movements in the yield on the market portfolio?

The interwar yield index should therefore be used with caution. Nevertheless, it is reassuring to note that it is procyclical. If it were countercyclical—if yields rose during economic recessions and fell during economic booms—this would raise the possibility that low-yield companies were going bankrupt with high probability in the recession. If such low-yield companies in the market as a whole went bankrupt and disappeared from the stock market either more or less frequently than did companies in the index, then considerable inaccuracies would be sure to result.

Figure A.4
Interwar Dividend Yields



Note that there is no dividend series available for the time spanned by the first *Reichsamt* index.

Post-World War II Series

For the post-World War II period, the stock price series is constructed by linking official

portfolio index series constructed by the *Statistisches Bundesamt* (Federal Bureau of Statistics), the official statistical bureau of the post-World War II West German *Bundesrepublik*. Three different portfolio indices are chained together, shifting from each one to the next in the first year in which the following sequence becomes available (see Herrmann, 1956; Spellerberg and Schneider, 1967; Silbermann, 1974; Lützel and Jung, 1984; Statistisches Bundesamt, 1985).

The *Bundesamt für Statistik* began to publish its first new index of stock values for the Federal Republic of Germany in 1956 (see Herrmann, 1956)—but note that this index is not used in the construction of our data, as its replacement covers its complete sample period as well. The index begins in 1953, and uses 430 share titles with a registered capital of 9516.4 million DM. Prices are recorded four times a month.

The 1953 index weights the share prices of corporations in a given industry traded on the exchange by the registered capital of *all* corporations. Herrmann (1956) claims that the alternative procedure—weighting by market capitalization—would have discriminated against some industrial sectors, like the energy industry, underrepresented on the exchange.

The index is also adjusted for the lower share prices associated with new share issues in the same way as Donner (1934) and the interwar indices.

This index was replaced in 1967 (Spellerberg, Schneider 1967) by a new portfolio index using the end of 1965 as a base. This second post-World War II portfolio index covers 545 ordinary share titles, with a registered capital of 23.05 billion DM. As before, the index is adjusted for new share issues.

The 1953 "portfolio" was considered out of date for several reasons. First, in the twelve years from 1954 to 1965 the registered capital on the stock exchange had risen by 12.7 billion DM. Thus the previous index covered only some forty percent of the registered capital. Different industry groups had raised capital at different rates.

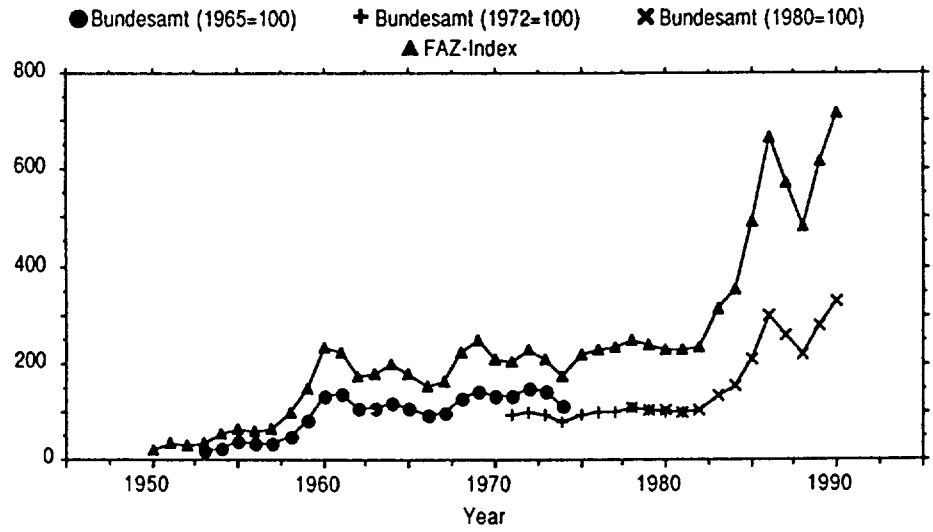
In addition, the new index introduced three important computational changes. First, the classification of industrial groups was revised according to the 1961 "Systematik der Wirtschaftszweige." Second, companies registered in West Berlin were included. Third, industry groups were once again weighted by the capital of corporations traded on the stock exchange—

not by the capital of all corporations in the industry.

In 1965, a total of 627 titles with a capital of 23.88 billion DM were registered on the German exchanges. The share price index represents 94.6% of the total registered capital. Once again, the index was adjusted for new share issues and changes in coverage.

This index was in its turn replaced by a new revised index in 1972. The 1972 revision was straightforward. The third portfolio index has the base date 29 December 1972, comprises 285 titles with a registered capital of 27.88 billion DM, and represents 96.4% of the total registered capital. In addition to correcting for *Bezugsrechte* (preference rights), it also adjusts for *Ausgabe von Berichtigungsaktien* (issues of correction shares) and for mergers.

Figure A.5
Post-World War II Nominal Stock Prices



Silbermann (1972) gives a detailed account of the computational procedures which, presumably, also apply to the 1953 and 1965 indices. The index is constructed in three stages. The first is the construction of unweighted industry group price averages. The second stage is the computation of sub-indices for "main industry groups" (*Hauptwirtschaftsgruppe*), weighting individual industry indices by the registered capital of all share titles traded on the exchange, *including those not contained in the share price index*. The third stage is the construction of the

general index from the *Hauptgruppenindex*. using the same procedure used to construct the *Hauptgruppenindex* from the industry averages.

The most recent portfolio index was introduced by Lützel and Jung (1984). It is based on 295 shares with a registered capital of 37595 billion DM. It represents 95.2% of the registered capital that year, 39501 billion DM. Note, however, that this index is not a Laspeyres index but a chain index. The portfolio to which it implicitly corresponds is thus rebalanced every year.

The *Frankfurter Allgemeine Zeitung* (FAZ) index (graciously provided by the *Frankfurter Allgemeine Zeitung*) can also be used to track the rapid Korean-War era rise in German stock values. Even though the FAZ index is available for the entire post-World War II period, we prefer the sequence of overlapping *Bundesamt* portfolio indices because the FAZ index is a Paasche index. It is difficult to interpret its movements as the movements of a broad-based portfolio.

The nominal values of the post-World War II German stock market indices are plotted alongside each other in figure A.5. Once again, the series move together strongly.

For the post-World War II as well as for the interwar period, the available yield series used is the yield on all traded stocks—not the yield on all stocks covered in the index.[39] This yield series is reported in the *Aktiengesellschaftsstatistik*—the statistics of corporations, computed to track corporation profits and performance, which contains other measures of profitability as well. The diverging orientation of the *Aktiengesellschaftsstatistik* has the unfortunate consequence that the yield statistics are calculated from a different sample of corporations than are the price indices.

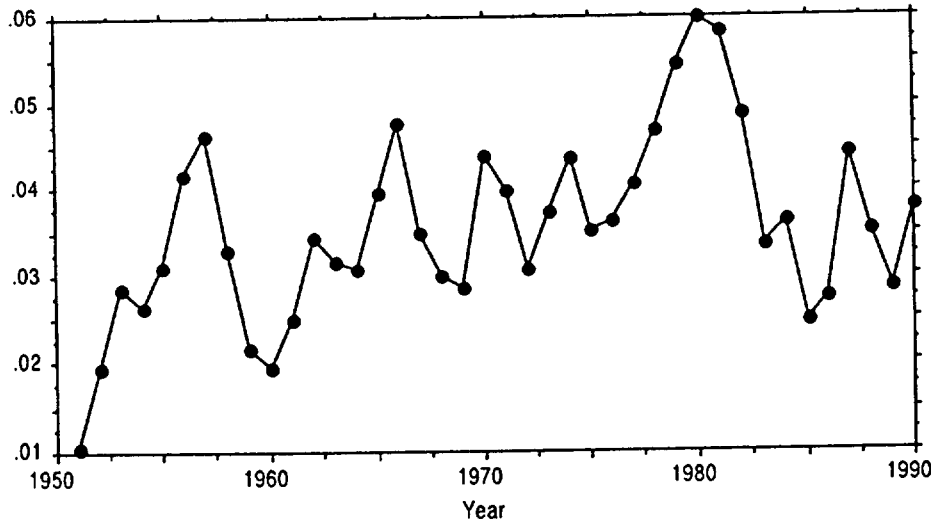
Nevertheless, the post-World War II dividend series—calculated by multiplying price times yield—is a good approximation to the true dividend series that would correspond to the price index series we use. The post-World War II price index series covers close to ninety-five percent of the par value of stocks traded on the German exchanges. The approximation error could become significant only if the uncovered five percent of stocks had truly extraordinary dividend

[39]Another dividend series is also reported: the yield of all corporations, publicly traded or not.

payout patterns. This is especially unlikely because the index sample was chosen to provide a good approximation to the size and industry distribution of the German corporate sector.

Figure A.6 plots the post-World War II yield series. Its variability is far, far greater than the variability of the pre-World War I yield series plotted in figure A.2. While pre-World War I market average dividend yields varied between four and six percent, post-World War II yields vary between one and six percent—and even post-*Wirtschaftswunder* yields vary between two and six percent.

Figure A.6
Post-World War II Yield Series



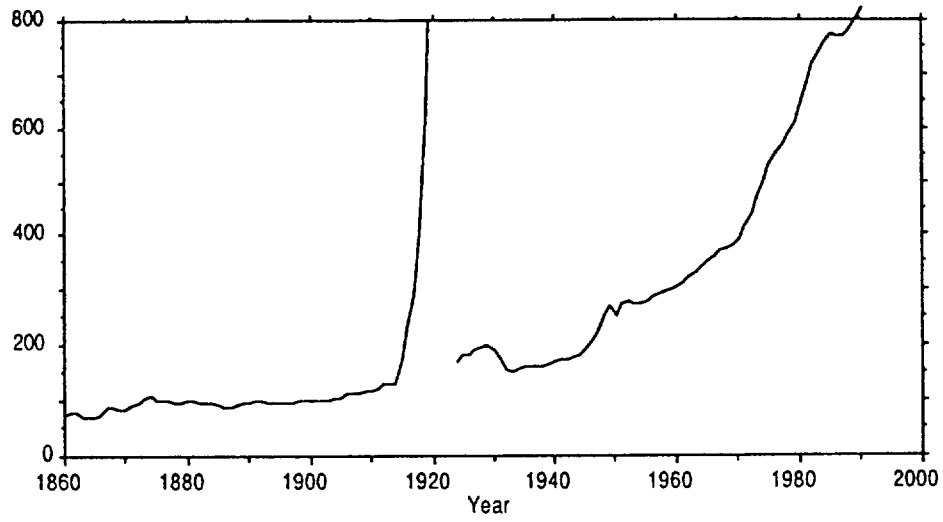
Price Deflator Indices

Figure A.7 plots the consumer price index used to deflate the series in this paper. The series used is endorsed by the Deutsche Bundesbank (1976), and runs continuously with the exception of one gap covering World War II and the post-war reconstruction period to the present day.

The index was assembled from four different sources. Up until 1914 the cost of living figures come from Kuczynski (1947), who investigated the standard of living of German workers since 1800. Kuczynski's cost of living index consists of estimates of food prices and housing costs. From 1915 to 1919 the index is derived from calculations by the *Statistisches Bundesamt*,

the Federal Statistical Bureau of post-World War II West Germany, made after World War II in order to close the gap between Kuczynski's and the subsequent indices. From 1920 to 1940 the cost of living index is that compiled for a five-person working-class household by the *Statistisches Reichsamt*, the National Statistical Bureau of first the Weimar Republic and then the Third Reich. For the post-World War II years from 1949 to the present, the cost of living index used is that calculated for a four-person middle-class household by the *Statistisches Bundesamt.*

Figure A.7
German Consumer Price Index

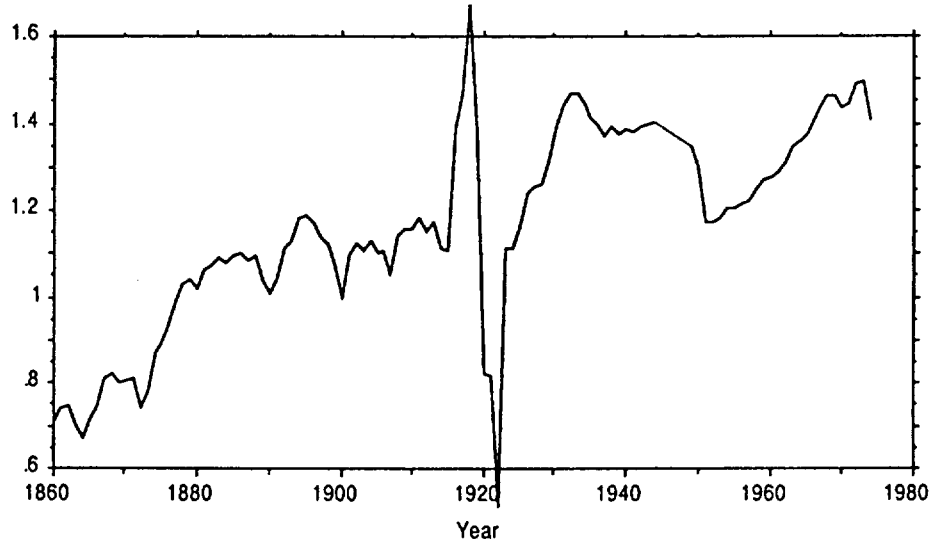


The different consumer price series have different base years. They chart the changes in the price level for different consumption bundles, and are not completely consistent. Nevertheless, the indices have a relatively broad coverage of commodities even in the mid-nineteenth century years.

The Deutsche Bundesbank (1976) reports similar indices for wholesale prices. Figure A.8 plots the ratio of the consumer price index to the wholesale price index. The ratio of the indices exhibits a sharp jump in the 1870's, extraordinarily erratic behavior during World War I and the post-World War I decade, and a substantial upward drift in the post-World War II era. The periods of greatest variation in the ratio of consumer to wholesale prices are, however, periods

during which dividend data are absent.

Figure A.8
Ratio of German Consumer to Wholesale Price Index



Final Series

Finally, table A.1 reports the final real stock prices and dividend series that we constructed, and that make up the data used in the body of this paper.

Table A.1
Underlying Data for the German Stock Market

Year	Dividend Yield	Log Real Stock Price	Log Real Dividend	Log Perfect-Foresight Fundamental
1876	0.048	-0.567	-3.598	-0.540
1877	0.054	-0.665	-3.578	-0.504
1878	0.052	-0.560	-3.513	-0.468
1879	0.052	-0.363	-3.312	-0.434
1880	0.050	-0.164	-3.160	-0.408
1881	0.049	-0.130	-3.142	-0.391
1882	0.050	-0.104	-3.104	-0.373
1883	0.049	-0.097	-3.109	-0.358
1884	0.048	-0.095	-3.124	-0.340
1885	0.046	-0.102	-3.184	-0.321
1886	0.044	-0.064	-3.197	-0.296
1887	0.048	-0.039	-3.079	-0.269
1888	0.055	0.066	-2.839	-0.248
1889	0.054	0.220	-2.700	-0.242
1890	0.059	0.164	-2.666	-0.249
1891	0.055	-0.004	-2.908	-0.259
1892	0.049	-0.038	-3.054	-0.249
1893	0.047	-0.019	-3.069	-0.228
1894	0.050	0.067	-2.933	-0.204
1895	0.047	0.200	-2.860	-0.188
1896	0.054	0.243	-2.675	-0.177
1897	0.054	0.272	-2.648	-0.179
1898	0.055	0.276	-2.618	-0.184
1899	0.055	0.297	-2.599	-0.193
1900	0.055	0.202	-2.691	-0.204
1901	0.047	0.069	-2.981	-0.207
1902	0.045	0.085	-3.028	-0.188
1903	0.049	0.126	-2.896	-0.165
1904	0.050	0.179	-2.821	-0.149
1905	0.051	0.233	-2.744	-0.138
1906	0.055	0.162	-2.740	-0.131
1907	0.057	0.070	-2.796	-0.124
1908	0.050	0.041	-2.953	-0.112
1909	0.050	0.079	-2.920	-0.089
1910	0.050	0.117	-2.874	-0.067
1911	0.052	0.092	-2.874	-0.045
1912	0.055	0.039	-2.861	-0.023
1913	0.054	0.000	-2.914	0.000

1914	.	-0.020	.	.
1915	.	.	.	.
1916	.	.	.	.
1917	.	-0.580	.	.
1918	.	-0.908	.	.
1919	.	-1.540	.	.
1920	.	-1.628	.	.
1921	.	-1.130	.	.
1922	.	-1.988	.	.
1923	.	-1.442	.	.
1924	.	-0.951	.	.
1925	.	-1.084	.	.
1926	0.056	-0.927	-3.813	-0.935
1927	0.071	-0.596	-3.237	-0.910
1928	0.083	-0.687	-3.177	-0.929
1929	0.084	-0.801	-3.285	-0.957
1930	0.081	-0.969	-3.488	-0.977
1931	0.065	-1.133	-3.866	-0.978
1932	0.028	-1.465	-5.031	-0.952
1933	0.033	-1.228	-4.651	-0.885
1934	0.035	-1.115	-4.458	-0.825
1935	0.043	-0.974	-4.130	-0.769
1936	0.052	-0.881	-3.843	-0.721
1937	0.057	-0.773	-3.638	-0.683
1938	0.064	-0.804	-3.553	-0.653
1939	0.066	-0.865	-3.590	-0.626
1940	0.066	-0.702	-3.421	-0.595
1941	0.064	-0.550	-3.301	-0.573
1942	0.054	-0.536	-3.464	-0.557
1943	0.052	-0.530	-3.479	-0.530
1944	.	.	.	.
1945	.	.	.	.
1946	.	.	.	.
1947	.	.	.	.
1948	.	.	.	.
1949	.	.	.	.
1950	.	.	.	.
1951	0.011	-1.567	-6.111	-1.316
1952	0.020	-1.800	-5.730	-1.241
1953	0.029	-1.717	-5.271	-1.169
1954	0.027	-1.445	-5.077	-1.102
1955	0.031	-1.017	-4.489	-1.038
1956	0.042	-1.094	-4.275	-0.986
1957	0.046	-1.115	-4.186	-0.941
1958	0.033	-0.876	-4.291	-0.898
1959	0.022	-0.324	-4.147	-0.848
1960	0.020	0.128	-3.805	-0.803
1961	0.025	0.132	-3.561	-0.770

1962	0.034	-0.149	-3.520	-0.750
1963	0.032	-0.179	-3.634	-0.732
1964	0.031	-0.088	-3.568	-0.705
1965	0.039	-0.217	-3.452	-0.680
1966	0.048	-0.400	-3.446	-0.661
1967	0.035	-0.373	-3.732	-0.642
1968	0.030	-0.103	-3.609	-0.605
1969	0.029	-0.021	-3.572	-0.572
1970	0.044	-0.140	-3.267	-0.540
1971	0.040	-0.182	-3.407	-0.524
1972	0.031	-0.145	-3.627	-0.499
1973	0.037	-0.271	-3.562	-0.460
1974	0.044	-0.496	-3.629	-0.423
1975	0.035	-0.415	-3.764	-0.381
1976	0.036	-0.380	-3.698	-0.332
1977	0.041	-0.414	-3.617	-0.283
1978	0.047	-0.368	-3.428	-0.236
1979	0.054	-0.447	-3.359	-0.195
1980	0.060	-0.545	-3.358	-0.155
1981	0.058	-0.608	-3.451	-0.113
1982	0.049	-0.650	-3.668	-0.066
1983	0.033	-0.408	-3.806	-0.010
1984	0.036	-0.303	-3.624	0.051
1985	0.025	-0.015	-3.717	0.108
1986	0.027	0.334	-3.264	0.170
1987	0.044	0.194	-2.926	0.220
1988	0.035	0.016	-3.336	0.260
1989	0.029	0.233	-3.326	0.315
1990	0.038	0.372	-2.905	0.372

Appendix 2: Monte Carlo Estimates of the Significance of Volatility Ratios

The post-World War II German stock market does show volatility ratios greater than one, and thus might provide some evidence of excess volatility. Table A.2 below reports Monte Carlo distributions of volatility ratios, computed to evaluate the statistical significance of the volatility ratios, calculated under the assumptions that the log level of dividends follows an error-correction model or that it follows an ARIMA process

The error correction model assumes that dividend policy is irrelevant to the firm's value—that all money not paid out as dividends but reinvested in the firms that make up the market yields an expected increase in firm value of r, so that:

$$E_t P_{t+1} = (1+r)[P_t - D_t] \quad \text{(A.1)}$$

Define the "permanent" level of dividends D^*_t as that level that allows real expected dividend payouts and prices to grow at an annual rate of g:

$$D^*_t = (r-g)P_t \quad \text{(A.2)}$$

Suppose the representative firm desires to maintain a constant dividend yield of r-g and thus keep the dividend near to its "permanent" sustainable level, but also is averse to rapid upward or downward changes in dividends. Take a given year's dividend is a weighted average of last year's actual dividend (scaled up by the growth factor g) and this year's "permanent" dividend:

$$D_t = \theta(1+g)D_{t-1} + (1-\theta)D^*_t \quad \text{(A.3)}$$

where θ is a weight between zero and one. The closer θ is to zero, the less inertia there is in the dividend process and the more closely to dividends approximate a random walk. The closer θ is to one, the slower are dividends to adjust and the larger are persistent shifts in the realized dividend growth rate.[40]

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[40]Barsky and De Long (1989, 1990) argue that the long swings in the U.S. stock market over the past century can be interpreted as due to investors'—perhaps irrational—expectations of such permanent or persistent shifts in dividend

Table A.2
Monte Carlo Distributions of the Volatility Ratio in Line 6 of Table 1 for Various Generating Processes

Probability	θ=0.1	θ=0.5	θ=0.8	Pre-WWI IMA(1, 6)	Post-WWII IMA(1, 6)
0.01	0.992	0.948	0.974	0.863	0.973
0.05	0.998	0.992	1.065	0.934	0.991
0.10	1.001	1.017	1.130	0.955	1.003
0.50	1.011	1.112	1.519	1.076	1.041
0.90	1.039	1.393	2.846	1.341	1.167
0.95	1.057	1.494	3.346	1.432	1.242
0.99	1.080	1.763	5.167	1.641	1.420

Table A.2 reports the Monte Carlo distributions of the volatility ratio in line six of table 1, if the dividend process is the error-correction model given by equations (A.1), (A.2), and (A.3) for various values of the parameter θ if the process is observed for a forty year period. The values of θ chosen are intended to more than span the range of reasonable error-correction models. In addition, table A.2 reports the Monte Carlo distributions of the volatility ratios if the dividend process is—and investors know it to be—the IMA(1, 6) in levels estimated for dividends in the pre-World War I and post-World War II periods.[41]

As noted above, the pre-World War I German market does not show any signs of excess volatility. If anything, the volatility of the price-dividend ratio in the pre-World War I period is deficient: in only one of the Monte Carlo simulations—that for dividends following and known to follow the IMA(1, 6) estimated for the pre-World War I era—is there even a one percent chance of a value of the summed volatility ratios in line 6 of table 1 as *low* as the actual value observed.

The post-World War II period considered as a whole generates volatility ratios that are significant rejections of the null hypothesis on the high side for all generating processes

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growth rates.

[41]The IMA process estimated was chosen to be integrated to allow shocks to the level of dividends to have permanent effects; the process was chosen to have a relatively large number of coefficients to allow it flexibility. Experiments with processes with AR components lead to similar significance levels.

considered save those with high values of θ. When θ is near one year-to-year dividend level changes are small and shifts in dividend growth rates are persistent. Accordingly, the variability of the price-dividend ratio is large.[42] A value of θ=0.8 implies that each year dividends adjust only one-fifth of the way to the "permanent" sustainable dividend level. This is a greater degree of relative smoothness in real dividends vis-a-vis prices than is in fact found in the sample. A value of θ=0.1 implies that each year dividends adjust ninety percent of the way to the "permanent" dividend level: this makes the price-dividend ratio too close to a constant to be consistent with the data.

Figures A.9 through A.11 plot sample paths of simulated log prices and dividends for values of θ equal to 0.1, to 0.5, and 0.8 in the Monte Carlo simulations underlying table A.2. These values of θ are intended to more than span the range of reasonable error-correction models. The low θ case has the current dividend move in a single year ninety percent of the way to the "permanent" expected annuity value of the stock market's future payouts. As a result, in figure A.9 dividends are nearly proportional to prices and the stochastic process followed by both is very close to a random walk.

Since dividends are nearly proportional to prices, the distribution of the sum of volatility ratios reported in table 2 is very tightly clustered around one: the variability of prices relative to dividends is small, and the variability of both prices and dividends relative to perfect-foresight fundamentals are approximately equal. If the Monte Carlo distribution calculated for θ=0.1 is the correct distribution of volatility ratios under the efficient-markets and constant real interest rate null, then the pre-World War I German stock market exhibits statistically significant deficient volatility, and the post-*Wirtschaftswunder* market exhibits statistically significant excess volatility.

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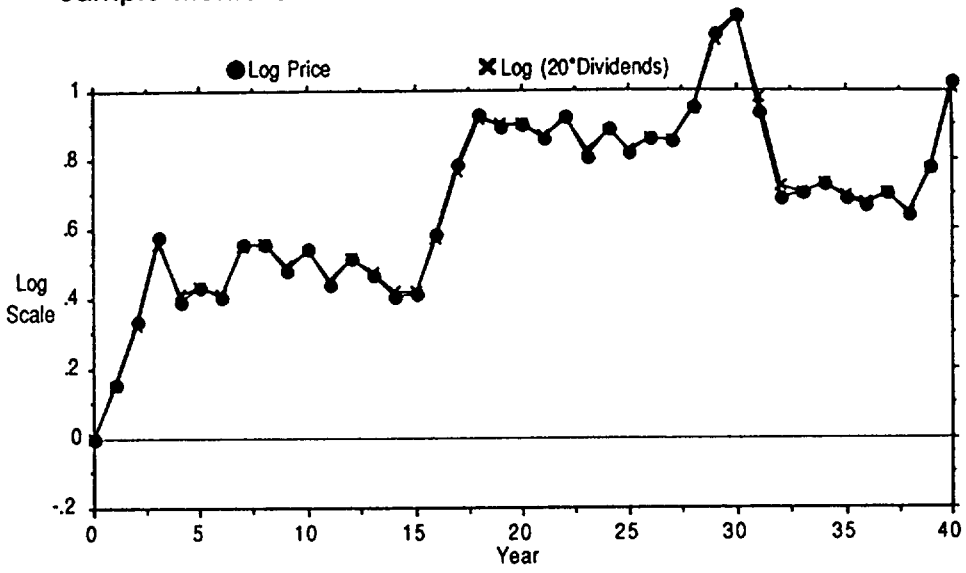
[42]A value of θ=0.8 implies that each year dividends adjust only one-fifth of the way to the "permanent" sustainable dividend level. This is a greater degree of relative smoothness in real dividends vis-a-vis prices than is in fact found in the sample. A value of θ=0.1 implies that each year dividends adjust ninety percent of the way to the "permanent" dividend level: this makes the price-dividend ratio too close to a constant to be consistent with the data. Appendix II plots sample price and dividend series for various values of θ from the Monte Carlo simulations underlying table 2.

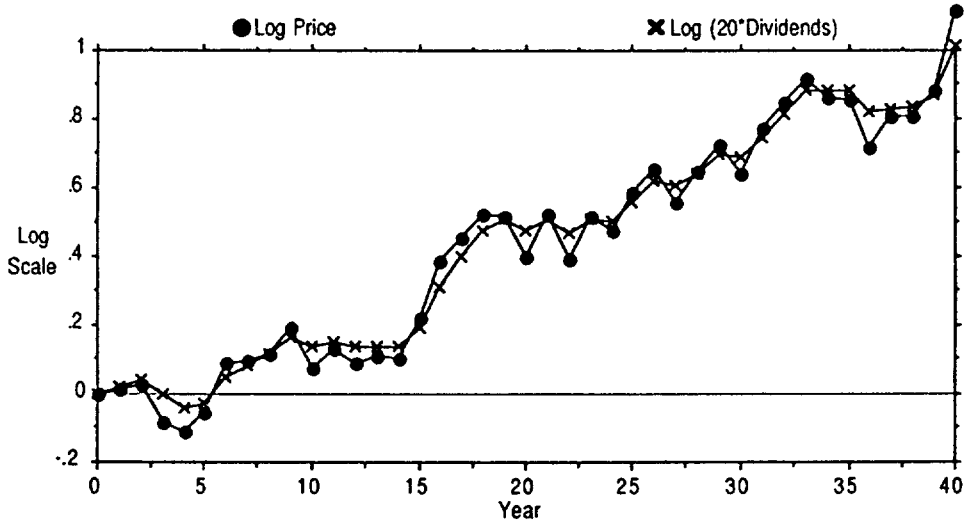
Figure A.9
Sample Monte Carlo Price and Dividend Realization for θ=0.1



The intermediate θ case has the current dividend move in a single year halfway to the "permanent" expected annuity value of the stock market's future payouts. In figure A.10 the year to year variability of relative changes in prices and dividends is closest to that observed in actual data. Dividends are not proportional to prices. Moreover, the sample average growth rate of prices and dividends is not known to investors *ex ante:* it depends on the average reinvestment rate, and the slow responsiveness of dividends to shifts in fundamentals makes the average reinvestment rate depend on shocks over the sample. Thus for θ=0.5 the sum of the volatility ratios reported in table A.2 does contain an upward bias—the median is 1.1 and not 1.0.

If the Monte Carlo distribution for θ=0.5 is a correct representation of the distribution of volatility ratios under the efficient-markets and constant real interest rate null, then the post-*Wirtschaftswunder* market exhibits statistically significant excess volatility, although less strongly so than was the case for θ=0.1; the post-World War II period considered as a whole, however, does not. Moreover, the upward bias in the distribution of the sum of the volatility ratios makes the gap between the actual volatility ratios of the pre-World War I German market and their expected values even greater.

Figure A.10
Sample Monte Carlo Price and Dividend Realization for θ=0.5



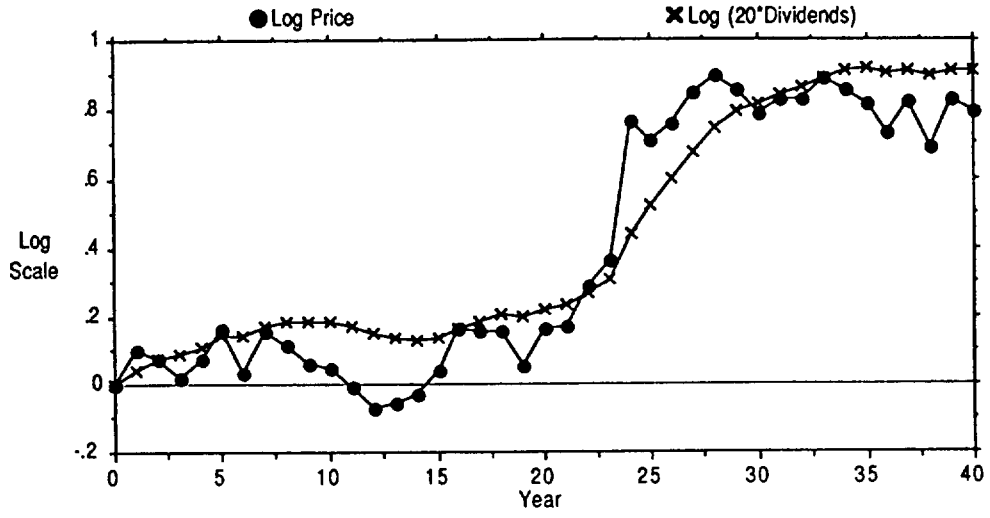
The high θ case has the current dividend move in a single year only twenty percent of way to the "permanent" expected annuity value of the stock market's future payouts. As a result, in figure A.11 the sample path of dividends is very smooth, and far smoother than is observed in actual data. The sample average growth rate of prices and dividends is once more not known to investors *ex ante:* it depends on the average reinvestment rate, and the very slow responsiveness of dividends to shifts in fundamentals makes the average reinvestment rate depend heavily on shocks over the sample. Thus for θ=0.8 the sum of the volatility ratios reported in table A.2 contains a substantial upward bias—the median is 1.5, and not 1.0.

If the Monte Carlo distribution for the error-correction model with θ=0.8 is the correct distribution of volatility ratios under the efficient-markets and constant real discount rate null, then even the post-*Wirtschaftswunder* market fails to exhibit statistically significant excess volatility. The upward bias in the distribution of the sum of the volatility ratios makes the behavior of the pre-World War I German market even more anomalous: if θ=0.8, then there is only a five percent chance of observing a value for the sum of the volatility ratios of less than

1.06—and yet the pre-World War I German stock market exhibits a value of 0.86.

Figure A.11

Sample Monte Carlo Price and Dividend Realization for θ=0.8



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