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Did High Wages or High Interest Rates Bring Down the Weimar Republic? A Cointegration Model of Investment in Germany, 1925–1930

HANS-JOACHIM VOTH

This article offers a new interpretation of the low level of investment in Germany during the interwar period. Earlier contributions attributed the slow expansion of capital stock either to excessive wages due to state intervention and unionization or to the high cost of capital. These hypotheses are tested by estimating a cointegration model of investment. Counterfactual simulations demonstrate that lower wages would have lowered investment still further and that high interest rates acted as the main brake on investment during the second half of the 1920s.

Before World War I, Germany was one of the most dynamic economies in the world. As output per capita expanded rapidly, the population grew at an unprecedented rate.[1] Net social product in constant prices roughly doubled between 1890 and 1913.[2] Unemployment was virtually unknown. The dynamic expansion of the economy was accompanied by a high level of savings and investment—the German economy during the last years before World War I devoted 16 percent of domestic product to capital formation.[3]

Weimar Germany's economic record is in stark contrast to the prewar period of expansion and economic confidence. Accelerating inflation during the early 1920s, eventually culminating in hyperinflation, undermined the social and economic foundations of society.[4] During the Great Depression, the German slump in output was arguably among the most dramatic in Europe, leaving six million unemployed and democratic institutions in ruins.[5] The intervening period from 1925 to 1929 was long regarded as the exception to the general rule of economic malaise during

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[1] The coincidence of both was a source of particular pride for contemporaries. See Helfferich, *Deutschlands Volkswohlstand*, p. 11.

[2] Hoffmann, *Wachstum*, pp. 13–16, 827–28.

[3] The figure is for 1910–1913. See Borchardt, *Perspectives*, p. 254.

[4] Feldman, *Great Disorder*.

[5] James, *German Slump*, table 14, p. 160.

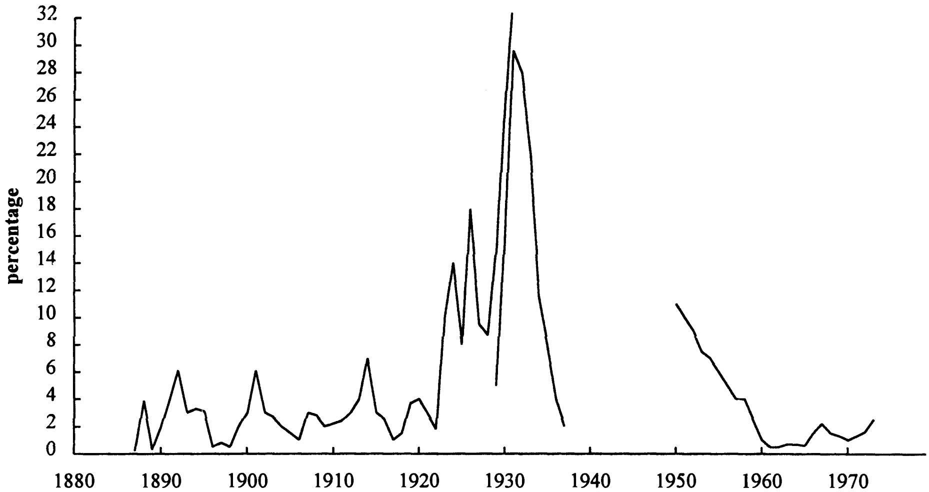

FIGURE 1

UNEMPLOYMENT AS SHARE OF EMPLOYEES

Source: Borchardt, *Perspectives*, p. 81.

the Weimar republic. After the stabilization of the currency in 1923, Germany experienced a few years of domestic calm and economic prosperity, of rising output, exports, and employment.[6] Recent reinterpretations of the German interwar experience, however, have found that Weimar's "golden years" already contained the seeds of the catastrophe that was to come, and that a "crisis before the crisis" beset the economy.[7]

THE NEW ORTHODOXY

A generation of revisionist historians has argued that, on closer inspection, Weimar's "golden years" lose much of their lustre. Compared to both the late Empire and the *Wirtschaftswunder* during the 1950s, structural weaknesses loom large. Unemployment, virtually nonexistant before World War I, already reached unprecented levels before the onset of the Great Depression in Germany (Figure 1). Output per capita grew at much less than the trend suggested by prewar performance.[8] Even worse for the long-term growth potential of the economy was the slow expansion of capital stock. Whereas fully 16 percent of national product had been used to this end during the late Empire, investment even during the second half of the 1920s amounted to a mere 10.5 percent (Figure 2).[9]

According to the new orthodoxy, political interference in the wage-

[6] Winkler, *Schein*; and Balderston, *Origins*.

[7] Borchardt, *Perspectives*, p. 160.

[8] Ibid., fig. 9.3, p. 154.

[9] Ibid., p. 154, 254. James ("Economic Reasons," p. 34) has also stressed that a large portion of this investment was devoted to restocking.

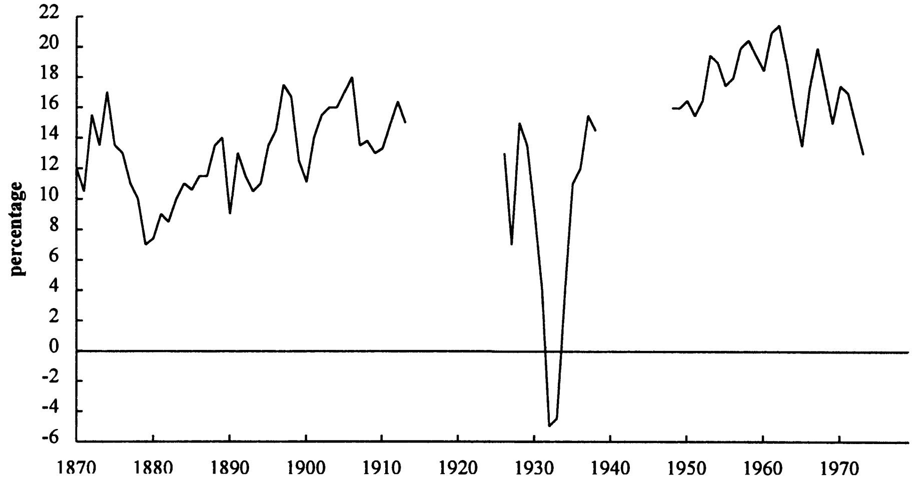

FIGURE 2

NET INVESTMENT AS SHARE OF NNP

Source: Borchardt, *Perspectives*, p. 75.

setting process was largely responsible for the weakness of Weimar's only economic boom. A decade of debate has focused on whether wages increased faster than productivity and whether the overall level of wage pressure in the economy was higher than in 1913. The consensus that has emerged upholds the initial claim of Knut Borchardt that wages were too high (Table 1), with debate focussing on the size of the difference between productivity and remuneration levels.[10]

Another remarkable feature of the new orthodoxy is that, although there is now widespread agreement that workers were paid too hand-

TABLE 1
WAGE PRESSURE IN GERMAN INDUSTRY
(1913 = 100)

Year	Ritschl (cumulative real wage position)	Balderston (unit wage costs)
1913	100	100
1925	115.56	136.24
1926	111.85	136.65
1927	109.30	132.9
1928	119.39	149.72
1929	118.65	150.82

Notes: The cumulative real wage position is calculated as $CRP = (W / P) / (Y / L)$, where W is an index of wages, P is a price variable, Y is output, and L measures labor input.
Sources: Ritschl, "Zu hohe Löhne," table 8, p. 398; and Balderston, *Origins*, row 2, table 3.2, p. 55.

[10] Ritschl, "Zu hohe Löhne"; and Balderston, *Origins*, table 3.2, p. 55.

somely by the standards of 1913, the labor market is no longer regarded as quite as troubled as before. Figure 1 seriously overstates the extent of unemployment in the economy, since it is expressed as a ratio of those who were insured, rather than the working population as a whole. Recent scholarship has shown that unemployment as a proportion of the population of working age was at anything but crisis levels: roughly 5 percent were out of work.[11] More people were in work in 1928 than the combined total of all unemployed and employed in 1925.[12] Further, employment increased faster in the second half of the 1920s than in other major industrialized countries. While the absolute size of the nonfarm private sector workforce grew by 10 percent in Germany during the period 1925 to 1928, it increased only by 4 percent in the United Kingdom and by 5 percent in the United States. In response to industry's demand for extra labor, which was largely driven by exports, participation rates rose sharply. This in turn suggests that Weimar's wages were not pushed up by state intervention in the labor market (as suggested by Borchardt, Albrecht Ritschl, and others), but that market demand was behind the wage increases.

The revisionist case against Weimar Germany's economic performance therefore rests on its disappointing investment record. Studies of the determinants of trends in long-run growth have repeatedly demonstrated the importance of investment, particularly in the case of machinery investment.[13] According to Borchardt, the excessive price of labor caused profits to slump. Since hyperinflation had devastated the capital market, firms had to rely primarily on the ploughing-back of profits as a means of financing investment. Consequently, wage levels acted as a brake on investment as credit-constrained companies were unable to fund their capital projects.[14] Borchardt argues that, in the end, frivolous consumption and excessive pay awards brought about Weimar's "small-cake economy"—investment was insufficient to deliver a quickly growing amount of goods and services. The distributional struggle became increasingly bitter because growth was too slow to provide both employers and the workers with what they regarded as their due. If it is true that "slow growth . . . killed the republic and democracy," then the adverse effects of excessive wages on investment feature prominently in the story of Weimar's demise.[15]

[11] Corbett, "Unemployment," table 1.1, p. 10. This must have been close to NAIRU, the level of unemployment that is consistent with nonaccelerating inflation.

[12] The increase in the participation rate was equivalent to more than 4 percent between 1924 and 1928. See Balderston, *Origins*, table 2.2, col. 3, p. 11.

[13] DeLong, "Productivity Growth"; DeLong and Summers, "Equipment Investment" and "Nexus." Most of the increase in labor productivity in prewar Germany was due to increasing capital intensity, with capital productivity diminishing between 1850–1852 and 1911–1913. See Hoffmann, *Wachstum*, table 4, p. 24.

[14] Borchardt and Ritschl, "Could Brüning?"

[15] The quote is from James, *Slump*, p. 423.

Critics have advanced the alternative hypothesis that the high cost of capital compared to the late Empire was decisive in restraining investment.[16] The significantly slower expansion of the capital stock therefore becomes a result not of union pressure and heavy-handed state intervention, but a consequence of the peculiarities of the German capital market during the interwar years. The foreign currency that the Weimar Republic needed to pay for reparations could only be obtained in two ways: either by maintaining an export surplus, or by importing foreign capital.[17] For various reasons, among which growing trade barriers featured most prominently, only the latter was open to Germany. The taking of foreign loans was facilitated by the considerable interest rate differential—the German market rate was almost always a few percentage points above the U.S. one, for example. Although the reasons for high German long-term interest rates were thus structural, matters were not helped by monetary policy. The Reichsbank under Hjalmar Schacht was suspicious of all inflows of foreign capital in general and of the effect of this inflow on the domestic money supply in particular. In order to "sterilize" capital inflows, the German central bank increased interest rates. Against his own intentions, the president of the Reichsbank set into motion a powerful vicious circle:

> If the Reichsbank wants to avoid any increase in money circulation, it is imperative that the influx of foreign currency can only be exchanged into German Marks to the same degree as the Reichsbank's portfolio of bills are reduced. . . . If foreign capital is transferred nonetheless, the Reichsbank is forced to increase its discount rate . . . in order to obtain some breathing space.[18]

Schacht also believed that he encouraged long-term domestic capital formation, and that the adverse effects of hot money being attracted into Germany would only be transitory.[19] The impact of the Reichsbank's policy on both long- and short-term interest rates could only be so pronounced because of the precarious position of the German banking sector. Balance sheets never recovered from the effects of hyperinflation. In particular, the availability of cheap deposits in savings accounts had virtually disappeared.[20]

There are therefore two alternative interpretations of Weimar's most important shortcoming: the low level of investment. According to the interpretation advanced by Borchardt, investment was profit-constrained, with wages being responsible for most of the squeeze of corporate earnings. The alternative explanation, proposed by Carl-Ludwig Holtfrerich, stresses the role of high interest rates in depressing investment

[16] Holtfrerich, "Zu hohe Löhne," p. 135; and Hardach, *Weltmarktorientierung* pp. 148–49.
[17] James, *Slump*, pp. 22–23.
[18] Müller, *Zentralbank*, p. 63.
[19] See James, *Reichsbank*, p. 41.
[20] Balderston, "German Banking."

spending. The following section introduces a framework for testing these competing hypotheses.

A SIMPLE INVESTMENT MODEL

In this section I shall briefly discuss the available literature on investment theory. In addition to an outline of earlier empirical findings, two specifications for an investment equation are derived: a "true neoclassical specification" and one based on Dale Jorgenson's dynamic accelerator.

In the case of perfectly competitive markets, investment will only depend on prices and costs. The marginal productivity of production factors will be equal to their price:

$$Q = f(K,N) \tag{1}$$

$$\frac{\delta f}{\delta K} = \frac{c}{p} \tag{2}$$

$$\frac{\delta f}{\delta N} = \frac{w}{p} \tag{3}$$

where Q denotes output, K equals capital, N is labor, c denotes user cost of capital, and w equals wage.

With a Cobb-Douglas production function, demand for capital is equal to:

$$K = C\left(\frac{w}{p}\right)^{\frac{\beta}{1-(\alpha+\beta)}}\left(\frac{c}{p}\right)^{\frac{\beta-1}{1-(\alpha+\beta)}} \tag{4}$$

where C is a constant determined by the production-function parameters.

This is the simplest type of neoclassical capital demand function, in which the equilibrium level of factor inputs depends on relative prices alone. Intuitive as it is, empirical studies have often demonstrated the inadequacy of investment models based on equation 4.[21] Most investigations of the factors determining investment have stressed output as an important influence and assigned a considerably smaller role to relative factor prices.[22] Initially the user cost of capital in particular was seldom found to be significant.[23] Instead of using "true neoclassical models," these studies have followed Dale Jorgenson's suggestion to include a demand

[21] Clark, "Investment."

[22] Note, however, that there are considerable conceptual problems in distinguishing output from relative price effects. See Landmann and Jerger, "Unemployment," fig. 3, p. 701.

[23] Bruno, "Aggregate Supply," table 5, p. S44. Of the G7 plus Sweden, only three countries showed a significantly negative impact of interest rates.

variable in the equation directly.[24] Inclusion of demand proxies implies a relaxation of the assumption of perfectly competitive markets.[25]

Jorgenson starts with the value maximization of the firm:

$$W = \int_0^\infty e^{-rt}[R(t) - D(t)]dt \tag{5}$$

where W is net worth, t denotes time, R is revenue before taxes, D denotes taxes, and r is the rate of interest.[26] In the case of a Cobb-Douglas production function, the desired capital stock will then be given by[27]

$$K^d = K\left[Q, \frac{c}{w}\right] \tag{6}$$

Investment is therefore influenced not only by relative prices but also by output. Jorgenson's initial study confirmed the importance of this accelerator effect.[28] More recent studies have, however, reaffirmed that relative factor prices, and, in particular, the user cost of capital, play an important role in determining investment behavior—especially in Germany.[29]

ESTIMATION

Our first step in modeling investment is to analyze the time series properties of the data. This is necessary in order to test if any of the time series in our data set are nonstationary (contain a unit root). Stationary time series have a constant mean and variance. The covariance between two periods depends only on the length of the gap between them but not on the time when it is examined. If one of these conditions is not met, a variable is said to contain a unit root.[30] Nonstationarity invalidates most statistical tests. All previous contributions have ignored the issue of unit roots.[31] It may therefore be that some of the highly significant t-statistics presented in the literature owe more to the nonstationary character of the time series used than to actual causation—a typical case of "spurious

[24] On the debate surrounding the correct specification of a true neoclassical investment demand equation, see Coen, "Tax Policy"; Gould, "Use"; and Duharcourt, *La fonction*. Artus and Muet, *Investment*, pp. 46–48.

[25] Artus and Muet, *Investment*, p. 47.

[26] Jorgenson, "Capital Theory," p. 248.

[27] Artus and Muet, *Investment*, p. 47; see also Jorgenson, "Capital Theory," p. 249.

[28] Ibid., p. 253. But see Kennedy, "Economy," p. 21, who, on the basis of the endogeneity of variables, doubts that even very high correlations of investment and changes in output lend empirical support to the accelerator theory.

[29] Gerfin, "Gewinne," table 2, p. 614; and Landmann and Jerger, "Unemployment."

[30] Banerjee, "Testing."

[31] Voth, "Zinsen"; Ritschl and Borchardt, "Could Brüning?"; Voth, "Investitionen"; Ritschl, "Goldene Jahre?"; and Voth, "Wages."

regressions."[32] The following estimates are the first attempt to remedy this problem, taking into consideration the time series properties of the data. The tests I employ are the Dickey-Fuller and the Augmented Dickey-Fuller test of the hypothesis that a time series possesses a unit root.[33] This is equivalent to examining the hypothesis that the coefficient β is smaller than zero in the following regression:

$$\Delta x_t = \beta x_{t-1} + \sum_{i=1}^{n} \gamma_i \Delta x_{t-i} + \epsilon_t \qquad (7)$$

If the coefficient β is smaller than zero, then a time series is stationary (integrated of order zero $-I(0)$). A process is $I(d)$ if it needs to be differenced d times to become stationary. Critical values for β come from J. G. MacKinnon.[34] In the case of the Dickey-Fuller test, no additional lags of the dependent variable are used ($n = 0$). In the following, in addition to the results of Dickey-Fuller tests, I also report the Augmented Dickey-Fuller statistic. It uses additional lags of the dependent variable. This is sometimes necessary to ensure that the error term ϵ_t is not autocorrelated—with an autocorrelated error term, OLS would yield inefficient estimates of β.

We now test the time series properties of the variables in our dataset. *I / K*, the rate of expansion of capital stock, and *INV*, the level of net investment, are used as alternative measures of investment (for details, see the appendix). *UNIT* is a variable for unit labor cost, *GIN* is the real interest rate on long-term gold bonds, and *RW* is a measure of real wages. Table 2 reports results for the Dickey-Fuller and the Augmented Dickey-Fuller test.

TABLE 2
INTEGRATION DIAGNOSTICS

	Dickey-Fuller Test		Augmented Dickey-Fuller Test	
	Level	ΔLevel	Level	ΔLevel
I / K	−0.162	−8.9**	−0.65	−1.96*
INV	−0.648	−8.85**	−0.337	−1.82
UNIT	0.14	−8.96**	−0.285	−2.19*
GIN	−1.05	−7.7**	−1.14	−2.52*
DEM	1.026	−6.49**	0.952	−3.36**
RW	1.42	−8.49**	0.367	−2.37*

* = Significant at the 5 percent level.
** = Significant at the 1 percent level.
Sources: See the Appendix.

[32] Granger and Newbold, "Spurious Regressions"; and Deadman and Charemtzka, *New Directions*, pp. 14, 29.
[33] Dickey and Fuller, "Distributions."
[34] If x is an $I(1)$ process, we are regressing a stationary series on an $I(1)$ variable. Therefore, normal t-tables do not apply. Critical values used come from MacKinnon, "Critical Values."

As the results in Table 2 demonstrate, critical levels for the Dickey-Fuller and Augmented Dickey-Fuller test are only surpassed after first differencing. In the case of the Dickey-Fuller test, all variables in first differences reject the null of a unit root at less than the 1 percent level. For the Augmented Dickey-Fuller test, a lag length of 12 was chosen. All variables in difference form are stationary at the 5 percent level of confidence. The only exception is *INV* with a statistic of -1.82. The insignificant Augmented Dickey-Fuller statistic after first differencing should not be interpreted as a sign of an $I(2)$ process since the original error term in a regression without additional lags shows no sign of autocorrelation.[35] The unaugmented Dickey-Fuller test is clearly superior in this case.[36] It therefore emerges that all the variables in our data set are $I(1)$.[37]

Normal regression analysis will yield biased and inefficient estimates when time series are $I(1)$. In order to examine if a long-run relationship between two variables exists, we test for cointegration. If two variables, y and x, are $I(1)$ and there exists a linear combination of the two ($z_t = y_t - \beta x_t$) that is $I(0)$, they are said to be cointegrated. A regression of y on x will then yield residuals that are stationary, and any deviation from the long-run path will be transitory.[38] To estimate the long-run cointegrating relationships, we first employ an autoregressive distributed lag (ADL) model. Since investment decisions are normally elements of a long-term business strategy, we have to take into account the possibility of considerable time-lags.[39] The advantage of ADL-modeling is that, instead of having to choose a limited set of lagged variables at varying lag lengths, we can employ a closed lag structure. The latter can then be used to estimate the long-run coefficients of the exogenous variables, using the full information available.[40] The unrestricted ADL (m, n, o) model for the variables x, y, and z can be formulated as:

$$y_t = \sum_{i=1}^{m} \alpha_i y_{t-i} + \sum_{i=0}^{n} \beta_i x_{t-i} + \sum_{i=0}^{0} \gamma_i z_{t-i} + \epsilon_t \tag{8}$$

In the long run, $y_t = y_{t-1}$, $x_t = x_{t-1}$, and $z_t = z_{t-1}$. Equation 8 under OLS yields estimates for the coefficients $\hat{\alpha}$, $\hat{\beta}$, and $\hat{\gamma}$. The long-run coefficients (β^*) can now be inferred from the ADL estimates:[41]

[35] The Durbin-Watson statistic is 1.99.

[36] Deadman and Charemtzka, *New Directions*, pp. 135–36.

[37] It is not necessary to impose stricter than 5 percent thresholds for both test statistics—the Dickey-Fuller statistic is always significant at the less than 1 percent level, and none of the error terms shows signs of autocorrelation.

[38] Deadman and Charemtzka, *New Directions*, pp. 143–48.

[39] Some of the literature (for example, Ritschl, "Goldene Jahre?") on the Borchardt thesis fails to take into account the possibility of time lags.

[40] All estimation was carried out using PC-Give. See Hendry, *PC-GIVE*.

[41] For the derivation of a static long-run solution from an ADL model, see Hendry, *PC-GIVE*, p. 40.

TABLE 3
STATIC LONG-RUN SOLUTIONS

Exogenous Variables	(1) *I / K*	(2) *INV*	(3) Dependent Variable *I / K*	(4) *INV*	(5) *INV*
GIN	−0.1065	−246.4	−0.11	−278.1	−144
	(0.0317)	(89.9)	(0.028)	(71.5)	(96.9)
UNIT	0.051	105.1			251
	(0.0234)	(80.2)			(93.4)
RW			0.03577	97.54	
			(0.0198)	(51.28)	
Constant	−2.37	−3924	0.56	546.4	−20,520
	(2.498)	(8,585)	(1.447)	(3,768)	(1,044)
Wald − χ^2	11.92**	7.51*	17.847**	17.917**	13.5**
Dickey-Fuller	−7.06**	−7.001**	−6.873**	−6.873**	−6.969**
Augmented Dickey-Fuller	−2.618**	−2.511*	−2.321*	−2.321*	−2.975**

* = Significant at the 5 percent level.
** = Significant at the 1 percent level.
Notes: Static long-run solutions from autoregressive distributed lag models [ADL (6, 12, 6)], estimated under ordinary least squares. For details, see the text. Sample period in regression 1–4 is 1925–1930; in regression 5 it is 1925–1929. The figures in parentheses are standard errors.
Sources: See the Appendix.

$$\beta^* = \frac{\sum_{i=0}^{n} \hat{\beta}_i}{1 - \sum_{i=1}^{m} \hat{\alpha}_i} \tag{9}$$

Experimentation with the data showed that a maximum lag of 12 months yields the most consistent results. As dependent variables, we use two variables measuring investment in the economy as a whole during the Weimar period. *I / K* refers to the rate of expansion of the capital stock, while *INV* gives the absolute (net) investment in prices of 1913 (for details see the data appendix). Table 3 presents an overview of results for the "neoclassical" specification. The χ^2 statistic is the result of a Wald test found by Gunnar Bardsen to be valid for testing the significance of cointegrating equations.[42] It emerges that the null hypothesis of all coefficients being jointly zero is strongly rejected—at the 99 percent confidence level for all regressions except regression 2, which was significant at the 95 percent confidence level. This result is independent of the measure of investment used as the dependent variable. Table 3 also reports Dickey-Fuller and Augmented Dickey-Fuller tests for the residuals of the estimated equations. The strongly negative test statistics allow us to reject the null that the found solutions are not cointegrating vectors. This

[42] Bardsen, "Estimation," pp. 345–50.

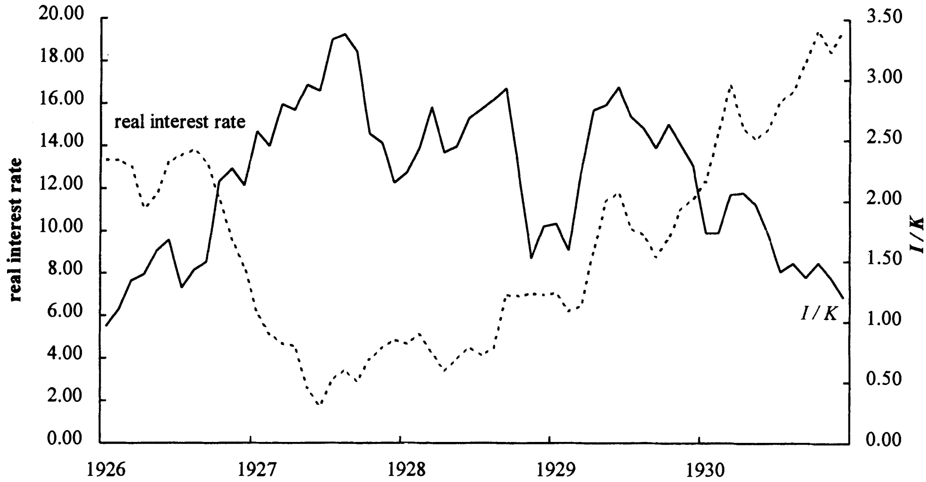

FIGURE 3

GROWTH OF CAPITAL STOCK AND REAL INTEREST RATES IN GERMANY, 1925–1930

Source: See the Appendix.

is true at the 95 percent confidence level for all equations, with 99 percent confidence in some cases.

Turning to the coefficients of the explanatory variables themselves, we first note that there is a strong and negative effect of long-term interest rates on investment. Independent of the specification used, the coefficient on *GIN* is significant at the 95 percent confidence level in all equations except regression 5, where it is significant at the 90 percent level. Equally strong and significant is the estimated coefficient on the proxies for wage pressure, *UNIT* and *RW*. When the rate of expansion of the capital stock is used as a dependent variable, both variables are strongly positively signed and significant at the 95 percent level. The sign remains the same when we use absolute net investment instead in specifications 2 and 4, but the coefficient is insignificant. Only when the sample period is reduced to 1925 to 1929 (regression 5) does unit labor cost again appear as a positive and significant factor boosting investment. We therefore conclude that *I / K*, the rate of expansion of capital stock, is a more appropriate measure of investment then simply the (net) value spent on capital goods. These results suggest that there were strong substitution effects between labor and capital, with employers strongly substituting away from the factor of production that became relatively more expensive. This interpretation is reinforced by the fact that the coefficient on *UNIT* is consistently larger than the coefficient on *RW*; if wages rose faster than productivity, increasing unit labor cost, firms were particularly likely to shift resources into investment. Our result that higher interest rates exerted a strong negative effect on investment is also corroborated by a simple time series plot of the data (Figure 3).

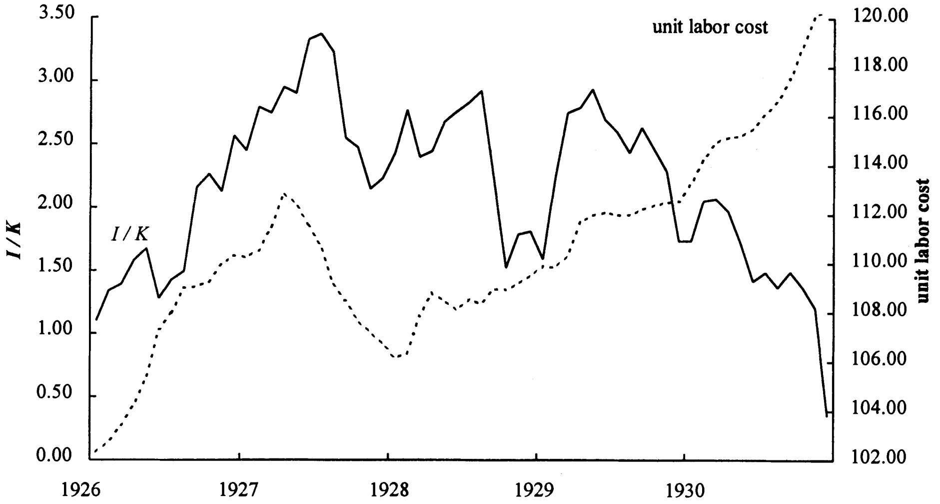

FIGURE 4

GROWTH OF CAPITAL STOCK AND UNIT LABOR COST IN GERMANY, 1925–1930

Source: See the Appendix.

The evidence for unit labor cost is less clear-cut when the data is presented in this more conventional way—although both the investment and the unit labor cost series show a striking degree of co-movement for most of the period, there is significant divergence during 1930 (Figure 4). As the ADL-solutions demonstrate, however, the orthogonalized component of investment (investment corrected for the effect of interest rates) is positively related to both unit labor cost and real wages.

Next, consider the consequences if a Jorgenson-type specification is used. Table 4 gives an overview of the results. The demand proxy used is based on the monthly output series of consumption goods (see the appendix for details). From the estimates (with 12 lags on the demand proxy) in Table 4, the influence of output on investment is ambiguous. Depending on the endogenous variable used, the coefficient is either positive or negative. Again, interest rates emerge as highly significant and strongly negative, with wages entering the equation with a positive sign. The sign on the latter, however, is now insignificant. The conclusion must therefore be that the "neoclassical" specifications give a more adequate description of the data and that we should use one of the well-specified regressions with tightly and consistently estimated coefficients for further estimation.

To estimate a model of short-term investment behavior, we employ an error-correction model (ECM). The argument with ECM models is that the economy will not adjust instantly to shifting relative prices and that it takes time for it to reach the static long-run equilibrium. For the purpose of further estimation, I use the static long-run solution from specification

TABLE 4
STATIC LONG-RUN SOLUTIONS

	(6)	Dependent Variable	(7)
Exogenous Variables	*INV*		*I / K*
GIN	−131.7		−0.055
	(46.04)		(0.0201)
UNIT	23.15		0.0057
	(46.12)		(0.019)
DEM	0.0055		−6.96 e − 6
	(0.133)		(5.876 e − 5)
Constant	3,697		0.57
	(2333)		(1.447)
Wald − χ^2	85.22**		77.863**
Dickey-Fuller	−8.226**		−8.044**
Augmented Dickey-Fuller	−2.424*		−2.381*

* = Significant at the 5 percent level.
** = Significant at the 1 percent level.
Notes: Static long-run solutions from autoregressive distributed lag models [ADL (6, 12, 6, 12)], estimated under ordinary least squares. Sample period is 1925–1930. The figures in parentheses are standard errors.
Sources: See the Appendix.

3, Table 3. It has one of the largest Wald-statistics of all the "neoclassical" specifications, Dickey-Fuller and Augmented Dickey-Fuller tests strongly suggest a cointegrating vector, and all the coefficients are highly significant. The cointegrating vector thus found ($I / K + 0.11GIN - 0.03577RW - 0.56$) can now be used to estimate an error correction model of investment. In addition to the long-run path from ADL modeling, we add the same variables in first differences to describe investment behavior in the short run ($\Delta(I / K)$). Following Hendry's general-to-specific approach to econometric modeling, we arrive at the following model for the sample period 1925:1 to 1930:12, where seasonals are included but not reported:[43]

$$\Delta(I / K) = \underset{(0.0982)}{0.30433ECM} - \underset{(-0.0226)}{0.031659\Delta GIN_{-15}} - \underset{(-0.0615)}{0.0595\Delta RW_{-10}} \quad (10)$$

$R^2 = 0.42$; F (15, 94) = 2.18; Durbin-Watson = 1.87; Lagrange-Multiplier − F (7, 37) = 0.428; autoregressive conditional heteroscedasticity − F (7, 33) = 0.336; Normality Chi^2 (2) = 0.83; Dickey-Fuller = 10.71**; Augmented Dickey-Fuller = −7.959**; **means significant at the 1 percent level; standard errors are in parentheses

Equation 10 describes the factors underlying short-term developments of investment. The ECM-variable is equivalent to the long-run relationship found in regression 3, Table 3. The regression residuals from equation 10 are stationary, as indicated by the high Dickey-Fuller and Augmented Dickey-Fuller test statistics (significant at the 1 percent level). This shows

[43] Hendry, *PC-GIVE*, pp. 89, 164–66.

that equation 10 represents a cointegrating relationship between the static long-run solution, short-term fluctuations of interest rates, and short-term changes in wages.[44]

Unsurprisingly, the ECM is highly significant with a *t*-statistic of 3.1. Short-term variations in interest rates only exercised a weak and nonsignificant negative effect on investment (significant at the 86 percent confidence level). There is also a weakly positive effect of real wages, but this effect is not significant. The conclusion from equation 10 can therefore only be that investment during Weimar's "golden years" was never very far away from the static long-run equilibrium. Since rigorous "testing down" showed that only the ECM was highly significant, short-term disturbances had little impact on investment behavior.[45] This in itself is eloquent testimony to the flexibility of Weimar's factor markets.

THE DIRECTION OF CAUSATION

Before we can proceed to simulations of investment behavior during Weimar's "golden years," we first have to address the issue of causality. It is conceivable that interest rates, real wages, and investment were indeed closely linked but that causality ran from investment to one (or both) of the regressors rather than the other way around. Interest rates might have been determined by investment projects that were carried out independently of the level of interest. Perhaps more likely, real wages may have been influenced by the rate of expansion of capital stock, since high growth rates of the latter should ceteris paribus boost the capital-labor ratio and lead to higher productivity. Since we used lagged variables (in addition to the unlagged one) as elements of our ADL models, this danger is small. It is nonetheless necessary to present the results of a more formal test.

A standard way of addressing the issue of causality is re-estimation of the equation using instrumental variables.[46] In statistical terms, the problem is that the covariance between the error term and one of the independent variables is not zero. The two-stage least squares procedure (2SLS) therefore first estimates a new set of values for the exogenous variable in question so as to "purge" it from the element that causes the covariance.[47] This new variable is then used as a regressor in the equation formerly estimated under OLS. Table 5 presents the results of re-estimating regression 3, using 2SLS.

[44] Since all the variables in equation 10 are $I(0)$, the normal tests of significance apply. We first note that neither the Durbin-Watson statistic nor the Lagrange-Multiplier tests give any evidence of serial correlation. The Normality Chi^2 (2) is the statistic proposed by Jarque and Bera ("Efficient Tests"), adjusted for the number of degrees of freedom. The low value demonstrates that the residuals of equation 10 do not violate the assumption of normality. Furthermore, there is no evidence of autoregressive conditional heteroscedasticity (ARCH).

[45] Hendry, *PC-GIVE*, pp. 22–23.

[46] Berndt, *Practice*, p. 319.

[47] Kelejian and Oates, *Introduction*, p. 228.

TABLE 5
STATIC LONG-RUN SOLUTIONS

	(8)	Dependent Variable	(9)
Exogenous Variables	I/K		I/K
GIN	−0.147		−0.112
	(0.037)		(0.021)
RW	0.044		0.036
	(0.017)		(0.012)
Constant	0.026		0.5066
	(1.26)		(0.89)
Wald − χ^2	18.24**		37.89**
Dickey-Fuller	−4.8**		−2.67**
Augmented Dickey-Fuller	−1.982*		−2.324*

* = Significant at the 5 percent level.
** = Significant at the 1 percent level.
Notes: Static long-run solutions from autoregressive distributed lag models [ADL (6, 12, 6)], estimated under ordinary least squares. In column 8, *GIN* is endogenous; in column 9, *RW* is endogenous. Sample period is 1925–1930. The figures in parentheses are standard errors.
Sources: See the Appendix.

These findings strongly suggest that the relationship between interest rates, real wages, and investment is indeed causal: the prices of capital and labor determined the rate of expansion of capital stock. The difference in the estimates for the regressors is small and can be attributed to stochastic variation. None of the variables change sign, and the absolute size of the coefficients changes only to a very small degree. After having established the direction of causation—using 2SLS estimates of our ADL model—I shall simulate investment behavior during Weimar's middle years under a number of assumptions.

SIMULATIONS

In order to test for the relative importance of the two determinants of investment identified above, this section presents the results of two counterfactuals. First, the development of investment during Weimar's "golden years" is simulated under the assumption that none of the wage increases after January 1925 occurred. Even supporters of the Borchardt hypothesis have conceded that wages were hardly out of line with productivity in 1925.[48] Figure 5 presents a counterfactual under the assumption of wages having been frozen at their 1925 level.[49] The results of this simulation strongly suggest that Borchardt's profit-squeeze hypothesis has to be rejected. If wages had been frozen at their (low) 1925 level throughout the Weimar period, investment at the end of 1929 would have been almost one-third *below* historical levels. There is no evidence of

[48] Ritschl and Broadberry ("Real Wages," col. 8, table 2, p. 331) show that the cumulative real wage position was only 8.5 percent higher in 1925 than in 1913.
[49] Simulations were carried out on the basis of equation 10.

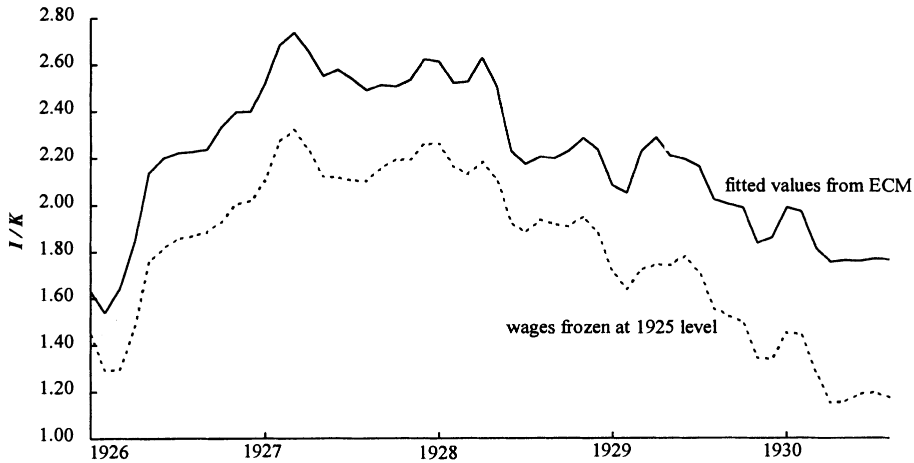

FIGURE 5

SIMULATION OF INVESTMENT UNDER THE ASSUMPTION OF A WAGE FREEZE

Note: ECM refers to error-correction model
Source: See the text.

investment being profit constrained in this period, and lower wages would have caused lower levels of investment. The reason for this seemingly paradoxical finding is, of course, that substitution effects outpaced output effects in the German economy during the 1925 to 1929 period. Firms substituted the relatively cheaper factor of production for the relatively dearer one. That the size of the output effect is smaller than the substitution effect is caused by the specific production function of the German economy during the interwar years.

The second counterfactual (Figure 6) demonstrates that investment could have been boosted significantly by lower interest rates. For the simulation, we assumed that a real interest rate of 3 percent prevailed throughout. The low volatility of the second shows that most of the short-run variation of I / K, the rate of expansion of capital stock, was due to changes in interest rates. More importantly for our argument, the difference in levels is striking. With a lower interest rate, average net investment during the second half of the 1920s would have been 20 percent higher. At the end of our estimation period, in 1930, the divergence would have grown to a staggering 40 percent.[50]

CONCLUSIONS

The causes underlying the sluggish investment performance of Weimar Germany have been a matter of debate among economic historians for

[50] Sommariva and Tullio, *German Macroeconomic History*, provide data for real short-term interest rates and the average product of capital, 1880–1979. Estimates based on their data imply that interest rates alone were responsible for 69 percent of the slowdown of capital formation during the period 1925 to 1933.

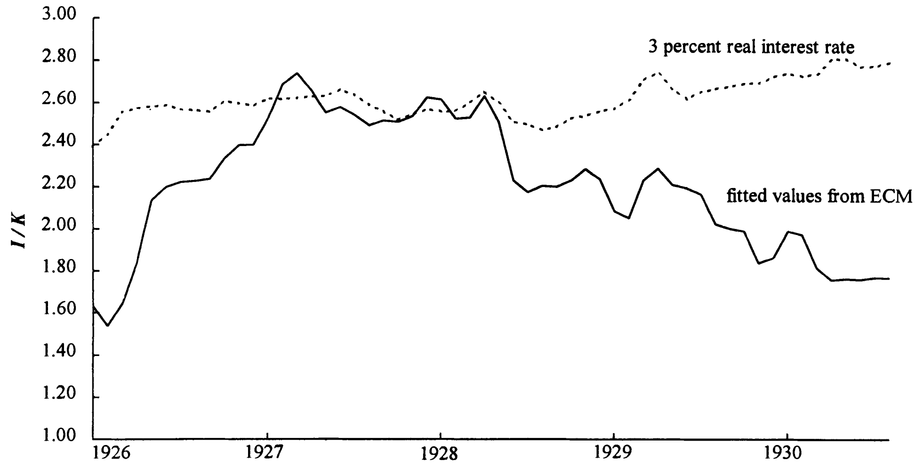

FIGURE 6

SIMULATION OF INVESTMENT UNDER THE ASSUMPTION OF A 3 PERCENT REAL INTEREST RATE

Note: ECM refers to error-correction model.
Source: See the text.

some time. This article attempts to test rigorously the two competing hypotheses in the literature. Either investment was depressed due to excessive wages that in turn reduced profits, or high interest rates undermined capital expansion.[51]

Using monthly data from official and semi-official sources, I estimated an autoregressive distributed lag model of investment in Weimar Germany. From this, I solved for the long-term cointegrating relationship and then estimated an error-correction model of investment. Cointegration analysis also proves that there was a positive long-term relationship between wages and investment: substitution effects outstripped output effects in the long run. Using an error-correction model, it emerges that even in the short run, there is no evidence of wages depressing investment. By estimating a counterfactual, I demonstrated that, on balance, lower wages would have caused significantly lower investment during Weimar's "golden years."

The econometric exercise further demonstrates that demand for capital in the German economy between 1925 and 1929 was strongly reduced by high interest rates. A simulation shows that, at the end of the 1920s, lower interest rates would have led to considerably higher investment. This directly contradicts the analysis of earlier scholars, and lends support to Holtfrerich's and Gerd Hardach's alternative interpretations of Weimar's poor economic record.[52] If, as Schumpeter suggested, domestic capital

[51] Readers who are skeptical of this form of "testing" alternative hypotheses are invited to interpret the exercise above as the atheoretical simulation of two policy alternatives. I am grateful to an anonymous referee for this suggestion.

[52] Borchardt, *Perspectives*; Borchardt and Ritschl, "Could Brüning?"; Holtfrerich, "Zu hohe Löhne," p. 132; and Hardach, *Weltmarktorientierung*.

formation was crucial in determining the overall economic performance of Weimar Germany, then interest rates and not wage pressure were at the heart of sluggish growth.[53]

Our result is not unusual by historical standards. It mirrors a similar causal relationship in the French economy between 1825 and 1886, found by Maurice Lévy-Leboyer and François Bourguignon.[54] Whatever may have been necessary to save the first German republic, the small-cake economy that—according to Borchardt—was directly responsible for its demise could hardly have been avoided through workers' sacrifices. Instead, possible remedies for Weimar's malaise of low investment could have been higher wages, or a return to the lower interest rates that had prevailed before World War I.[55]

[53] Stolper and Seidl, Introduction to Schumpeter, *Aufsätze*, pp. 40, 45; and Schumpeter, *Aufsätze*, p. 114. Former Chancellor Luther, analyzing the situation in 1930, basically came to the same conclusion. It is also in line with the perception of other contemporaries. During the 1926 crisis, for example, the Reich's finance minister Reinhold repeatedly urged the Reichsbank to cut interest rates so as to stimulate investment. See Feldman, *Great Disorder*, pp. 847, 853.

[54] Lévy-Leboyer and Bourguignon, *French Economy*, table 5.1, p. 187.

[55] Lower interest rates would also have caused firms to discount less heavily the future revenue generated by an additional worker. The consequence would have been higher employment (Phelps, *Structural Slumps*). This effect is likely to have been particularly strong in Germany, where companies—because of the apprenticeship system—habitually view their workers as a long-term asset, investing heavily in their training.

Appendix: Data Sources

The monthly data used for econometric analysis was derived from both official and semi-official publications. The German Statistical Office and the Berlin Institute of Trade-Cycle Research (Institut für Konjunkturforschung, IfK) collected a wealth of information. Only recently have economic historians begun to exploit the latter source fully (Balderston, *Origins* and Ritschl, "Goldene Jahre?"). The IfK's data in particular have been recognized as an accurate and reliable data source for the interwar period (Ritschl, "Goldene Jahre?"). The individual data series were constructed as follows:

POUT is the IfK's price index for manufactured goods (*industrielle Fertigwaren*), taken from Wagemann, *Konjunkturstatistisches Handbuch*, table 23, p. 104.

INV is Hoffmann's (*Wachstum*, p. 258) series for net investment in the whole economy. The series was interpolated with the IfK-index for the production of investment goods (Wagemann, *Konjunkturstatistisches Handbuch*, table 18, p. 52) using the Chow-Lin ("Best Linear Unbiased Interpolation") method. We estimate $Y_t^a = \alpha + \beta X_t^a + \gamma TREND + \epsilon_t$ [Y is the true annual series, X is the monthly indicator variable on an annual basis, *TREND* denotes a trend variable, α, β, and γ are coefficients, and ϵ is the disturbance term] by OLS. The derived parameter estimates are then used to construct the time series on a monthly basis. Note that, since the original series taken from Hoffmann (*Wachstum*) is net of depreciation, the same will apply to the interpolated series.

DEM uses consumption as a proxy for demand in the economy. Hoffmann's (*Wachstum*, table 249, p. 828) data on private consumption are interpolated by means of the Institut's (Wagemann, *Konjunkturstatistisches Handbuch*, table 16, p. 53) series on the output of consumption goods (*Konsumgüter des elastischen Bedarfs*) using the Chow-Lin method.

GIN is the annual rate of return on six-year gold bonds, derived from the *Konjunkturstatistisches Handbuch* (table 21, p. 114). Individual observations refer to monthly averages. For 1925, the data come from Germany, *Statistisches Jahrbuch* (1926), p. 337. For the periods when trading stopped and no official rates are available, I interpolated these data points with the interest rate on private commercial paper (*Privatdiskont*), documented in Wagemann (*Konjunkturstatistisches Handbuch*, table 16, p. 112) using the Chow-Lin method. This monthly interest-rate series was deflated with the price index *POUT*.

RW is the negotiated hourly wage of skilled workers in the highest age-group. For the period 1925 to 1927, this figure was taken from the Germany, *Statistisches Jahrbuch* (1930), p. 299. For the period 1928–30, Germany, *Statistisches Jahrbuch* (1932), p. 273 was used. Since the number of industries covered increased from 12 to 17 in 1927, the series was spliced in January 1927 and adjusted accordingly. The nominal wage series thus obtained was used to calculate a real wage series, using *POUT* as a deflator.

UNIT is the unit labor cost, which was used as an indicator of wage pressure; the data stem from Corbett, "Unemployment," table 2.1, col. 3, p. 44. His annual series was interpolated on the basis of the Chow-Lin method, using *RW* as the predictor variable.

REFERENCES

Artus, Patrick, and Pierre-Alain Muet. *Investment and Factor Demand*. Amsterdam: North-Holland, 1990.

Balderston, Theodore. "German Banking between the Wars: The Crisis of the Credit Banks." *Business History Review* 65 (1991): 554–605.

Balderston, Theodore. *The Origins and Course of the German Crisis 1923–1932*. Berlin: Haude & Spener, 1993.

Banerjee, Anindya. "Testing Integration and Cointegration: An Overview." *Oxford Bulletin of Economics and Statistics* 54 (1992): 225–55.

Bardsen, Gunnar. "The Estimation of Long-Run Coefficients from Error-Correction Models." *Oxford Bulletin of Economics and Statistics* 51 (1989): 345–50.

Berndt, Ernst. *The Practice of Econometrics*. Reading, MA: Addison-Wesley, 1991.

Borchardt, Knut. *Perspectives on Modern German Economic History and Policy*. Cambridge: Cambridge University Press, 1991.

______. and Albrecht Ritschl. "Could Brüning Have Done It? A Keynesian Model of Interwar Germany, 1925–32." *European Economic Review* 36 (1992): 695–701.

Bruno, Michael. "Aggregate Supply and Demand Factors in the OECD Economies: An Update." *Economica* 53 (1986): S35–S52.

Chow, Gregory, and An Lin. "Best Linear Unbiased Interpolation, Distribution, and Extrapolation of Time Series by Related Series." *Review of Economics and Statistics* 53 (1971): 372–75.

Clark, Peter. "Investment in the 1970s: Theory, Performance, and Prediction." *Brookings Papers on Economic Activity* (1979): 73–113.

Coen, Robert. "Tax Policy and Investment Behaviour: A Comment." *American Economic Review* 59 (1969): 73–113.
Corbett, David. "Unemployment in Interwar Germany." Ph.D. diss., Harvard University, 1991.
Deadman, D., and W. Charemtzka. *New Directions in Econometric Practice. General to Specific Modelling, Cointegration and Vector Autoregression*. Aldershot: Edward Elgar, 1992.
DeLong, Bradford. "Productivity Growth and Machinery Investment: A Long-Run Look, 1870–1980." this JOURNAL 52 (1992): 307–24.
DeLong, Bradford, and Lawrence Summers. "Equipment Investment and Economic Growth." *Quarterly Journal of Economics* 106 (1991): 445–502.
______. "Equipment Investment and Economic Growth: How Strong is the Nexus?" *Brookings Papers on Economic Activity* (1992): 157–99.
Dickey, David, and Wayne Fuller. "Likelihood Ratio Statistics for Autoregressive Time Series with a Unit Root." *Econometrica* 49 (1981): 1057–72.
Duharcourt, P. *La fonction d'investissement*. Paris: Sirey, 1970.
Feldman, Gerald D. *The Great Disorder: Politics, Economics, and Society in the German Inflation 1914–1924*. Oxford: Oxford University Press, 1993.
Gerfin, Harald. "Gewinne, Investitionen und Beschäftigung." *Zeitschrift für Wirtschafts- und Sozialwissenschaften* 108 (1988): 593–616.
Germany. Statistisches Reichsamt. *Statistisches Jahrbuch für das Deutsche Reich*. Berlin, 1926–1935.
Gould, John. "The Use of Endogenous Variables in Dynamic Models of Investment." *Quarterly Journal of Economics* 83 (1969): 580–99.
Granger, Clive, and Paul Newbold. "Spurious Regressions in Econometrics." *Journal of Econometrics* 26 (1974): 111–20.
Hardach, Gerd. *Weltmarktorientierung und relative Stagnation: Währungspolitik in Deutschland 1924–1931*. Berlin: Duncker und Humblot, 1976.
Helfferich, Karl. *Deutschlands Volkswohlstand 1888–1913*. 6th ed. Berlin, 1915.
Hendry, David. *PC-GIVE. An Interactive Econometric Modelling System*. Oxford: Institute of Economics and Statistics, 1989.
Hoffmann, Walter. *Das Wachstum der deutschen Wirtschaft seit der Mitte des 19. Jahrhunderts*. Berlin: Springer, 1965.
Holtfrerich, Carl-Ludwig. "Zu hohe Löhne in der Weimarer Republik? Bemerkungen zur Borchardt-These." *Geschichte und Gesellschaft* 10 (1984): 122–41.
Institut für Konjunkturforschung. *Konjunkturstatistisches Handbuch*. Berlin, 1935.
James, Harold. *The Reichsbank and Public Finance in Germany*. Frankfurt am Main: Fritz Knapp, 1985.
______. *The German Slump. Politics and Economics 1924–1936*. Oxford: Oxford University Press, 1986.
______. "Economic Reasons for the Collapse of the Weimar Republic." In *Weimar: Why Did German Democracy Fail?* edited by Ian Kershaw, 30–91. London: Weidenfeld & Nicolson, 1990.
Jarque, C. M., and A. K. Bera. "Efficient Tests for Normality, Homoscedasticity and Serial Independence of Residuals." *Economics Letters* 6 (1980): 255–59.
Jorgenson, Dale W. "Capital Theory and Investment Behaviour." *American Economic Review* 53 (1963): 247–59.
Kelejian, Harry, and Wallace Oates. *Introduction to Econometrics: Principles and Applications*. New York: Harper & Row, 1974.
Kennedy, M. C. "The Economy as a Whole." In *The UK Economy: A Manual of Applied Economics*, edited by Michael Artis et al., 1–71. London: Weidenfeld and Nicholson, 1992.
Landmann, Oliver, and Jürgen Jerger. "Unemployment and the Real Wage Gap: A

Reappraisal of the German Experience." *Weltwirtschaftliches Archiv* 129 (1993): 689–717.

Lee, J. "Policy and Performance in the German Economy, 1925–35: A Comment on the Borchardt Thesis." In *The Burden of German History*, 131–50, edited by M. Laffan, 131–50. London: Goethe Institut, 1988.

Lévy-Leboyer, Maurice, and François Bourguignon. *The French Economy in the Nineteenth Century: An Essay in Econometric Analysis*. Cambridge: Cambridge University Press, 1990.

MacKinnon, J. G. "Critical Values for Cointegration Tests." In *Long-run Econometric Relationships*, edited by Robert Engle and Clive Granger, 267–76. Oxford: Oxford University Press, 1991.

Müller, Helmut. *Die Zentralbank - eine Nebenregierung. Reichsbankpräsident Schacht als Politiker der Weimarer Republik*. Opladen: Westdeutscher Verlag, 1973.

Phelps, Edmund. *Structural Slumps: The Modern Equilibrium Theory of Unemployment, Interest and Assets*. Cambridge, MA: Harvard University Press, 1994.

Ritschl, Albrecht. "Zu hohe Löhne in der Weimarer Republik?" *Geschichte und Gesellschaft* 16 (1990): 375–402.

______. "Goldene Jahre? Zu den Investitionen in der Weimarer Republik." *Zeitschrift für Wirtschafts- und Sozialwissenschaften* 114 (1994): 99–111.

Ritschl, Albrecht, and Steve Broadberry. "Real Wages, Productivity and Unemployment during the 1920s." *Explorations in Economic History* 32 (1995): 327–49.

Schumpeter, Joseph A. *Aufsätze zur Wirtschaftspolitik*. Edited by Wolfgang Stolper and Christian Seidl. Tübingen: Mohr, 1985.

Sommariva, Andrea, and Giuseppe Tullio. *German Macroeconomic History, 1880–1979*. London: Macmillan, 1987.

Stolper, Wolfgang, and Christian Seidl. Introduction to *Aufsätze zur Wirtschaftspolitik*, by Joseph A. Schumpeter. Tübingen: Mohr, 1985.

Voth, Hans-Joachim. "Investitionen in den "Goldenen Jahren" der Weimarer Republik." *Zeitschrift für Wirtschafts- und Sozialwissenschaften* 113 (1993): 629–33.

______. "Wages, Investment, and the Fate of the Weimar Republic: A Long-Term Perspective." *German History* 11 (1993): 265–92.

______. "Zinsen, Investitionen und das Ende der großen Depression in Deutschland." *Zeitschrift für Wirtschafts- und Sozialwissenschaften* 114 (1994): 267–81.

Wagemann, Ernst, ed. *Konjunkturstatistisches Handbuch 1936*. Berlin: Hanseatische Verlagsanstalt, 1935.

Winkler, Heinrich-August. *Der Schein der Normalität. Arbeiter und Arbeiterbewegung 1924–1929*. Bonn/Berlin: Dietz, 1989.