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# RELATIVE WAGE VARIABILITY IN THE UNITED STATES, 1860-1983

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## ABSTRACT

This paper examines the magnitude of changes in relative wages across industries between 1860 and 1983 and analyzes the macroeconomic determinants of such changes at different intervals during this period. The variance across industries in wage growth was at least four times larger before 1948 than afterward. Except for smaller year-to-year variability in output growth across industries after 1948, the macroeconomic factors examined cannot account for this increased rigidity of relative wages. Increases in average establishment size and improved communication of wage trends are probably partially responsible for the observed increase in relative wage rigidity. No single macroeconomic model was consistent with the year-to-year fluctuations in relative wage rigidity in every historical period examined.

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## I. INTRODUCTION

This paper examines the magnitude of changes in relative wages across industries between 1860 and 1983 and analyzes the macroeconomic determinants of such changes at different intervals during this period. By studying the magnitude of relative wage changes over such a long period, new light can be shed on the old question of whether the wage structure has become more rigid in the post-World War II period (or, using the terminology currently popular, whether there has been a gradual shift away from spot markets toward long-term contracts in the labor market--a subject pursued in more depth in Kniesner and Goldsmith (1986)).

The macroeconomic determinants of changes in relative wages and prices have received considerable attention over the last 10 years, but all previous studies have focused on the post-World War II period and have ignored the question of whether structural changes have taken place. A key factor in any period should be the magnitude of sectoral shifts within the economy. Hamermesh (1986) has shown how increased dispersion of changes in output across industries should be positively correlated to changes in relative wages. In addition he, Fischer (1981), and Cukierman (1984) have pointed out how data on changes in relative wages and prices can be used to test a variety of models of aggregate behavior. This paper extends this work by testing these models in different periods and examining whether structural changes in wage setting behavior have taken place.

## II. DATA

This study examines five different data sources to trace the long-run changes in relative wage variability between 1860 and 1983. Clarence Long (1960) compiled series of daily wage rates in January and July for thirteen manufacturing industries and building for 1860 to 1890 from the Aldrich report. Only the January to January changes are examined below because all other series available for this period are annual. He also compiled separate series by state for seven of the manufacturing industries, with two to seven states per industry.

Paul Douglas' (1930) wage series for "payroll" (nonunion) and "union" manufacturing, building trades, unskilled labor, farm labor, coal mining, transportation, federal employees, teachers, and ministers are used for the 1890-1926 period. This sample covers a wider range of industries, allowing for separate estimates of relative wage rigidity in different sectors such as manufacturing and nonmanufacturing industries and union and nonunion manufacturing industries.

The Conference Board published wage data for twenty-one manufacturing industries for July between 1920 and 1936. This information is of limited usefulness for regression analysis because of the small number of observations. Nonetheless, this data set is an extremely interesting one for the obvious reason that it documents relative wage changes during most of the Great Depression.

The Bureau of Labor Statistics (BLS) did not begin to publish industry data in detail sufficient to gauge changes in relative wages until 1947. Although Hamermesh has examined this period with considerable care, some new results are reported below for 20 two-digit manufacturing industries for 1947-1983 to facilitate comparisons with the earlier periods. The data come from CITIBASE.

The final data set examined here is the National Income and Product Accounts (NIPA) series of wages and salaries per full-time equivalent employee.

Although not a wage series, it is examined here because it covers the period between the end of the Conference Board series and the beginning of the BLS series. Data for 55 two-digit industries in all sectors are used for 1929-1948; 57 industries, for 1949-1982.

## III. COMPARISONS ACROSS PERIODS

Changes in relative wages are defined here in terms of the variance in the rate of change of wages across industries. A percentage change in the wage in industry i in period t ($dw_{it}$), which is greater (less) than the percentage change in the mean wage across all industries in period t ($dw_t$), is defined as a relative wage increase (decrease). The variance of $dw_{it}$ ($VW_t$) is used to measure the overall magnitude of relative wage changes, where

$$VW_t = \sum_i \frac{E_{it}}{E_t} (dw_{it} - dw_t)^2$$

and $E_{it}$ equals employment in industry i in period t and $E_t = \sum_i E_{it}$.

The mean value of $VW_t$ for each of the samples containing wage data are reported in Figure 1. They show that, on average, relative wages are much more rigid in the post-war period than in earlier periods. Between 1860 and 1890 relative wages changed 10 times as much each year as they did after 1947. Annual relative wage changes were 16 times greater between 1890 and 1926 and 12 times greater between 1920 and 1936 than they were after 1947.

These results are reported in further detail in Table 1. In the 1860-1890 period, the changes in relative wages become even greater once interstate variation within a subset of industries is taken into account. The mean change in relative wages across states and industries in line 3 is 25 percent larger than the mean change reported over a larger set of industries in line 2.

Differences in the magnitude of relative wage changes across sectors in the 1890-1926 period are reported in lines 4 through 7. Relative wages in manufacturing changed by roughly the same extent as they did in the nonmanufacturing sector, as can be seen by comparing lines 4 and 5. Relative wages changed much more within the nonunion sector of manufacturing than in the union sector, well before the advent of the three-year agreement. The changes in relative wages between 1920 and 1936 in line 8 are comparable to those between 1860 and 1926.

The smaller changes in relative wages in the post-war period are documented in more detail in lines 9 and 10. Weighting clearly has little effect on the overall trend in relative wages. One possible source (in a statistical sense) of the greater rigidity of relative wages in this period can be seen by comparing the minimum and maximum changes in relative wages in the postwar period to those of earlier periods. Between 1890 and 1936, the maximum changes in relative wages (which occur in periods when there are severe shocks to the economy) are 20 to over 100 times greater than the minimum changes. Since 1947, the maximum changes are only about 10 times larger than the minimum changes. This shows that the swings in relative wage change behavior have become much less extreme. This may be attributable to smaller shocks (in terms of amplitude or duration), stabilization policies, or changes in wage-setting mechanisms.

Even though relative wages changed much less since 1947, the average year-to-year change in the average wage tended to be greater in the most recent period. Wages rose by 5.6 percent per year between 1947 and 1983, whereas the absolute value of the annual rate of change of manufacturing wages in earlier periods ranged between 3.4 and 4.3 percent between 1890 and 1936. Despite the greater mean rate of change, there was much less fluctuation around the mean after 1947. The standard deviation of the rate of change of wages is .022 for 1947-1983, whereas it ranges between .048 and .098 in the earlier periods. This suggests that there actually may have been less uncertainty since 1947 about changes in average wages, which may be partially responsible for the smaller changes in relative wages.

The heterogeneity of these data sets raises the question of whether relative wages really have become more rigid, with the alternative hypothesis being that there is less noise in the BLS data. One reason to doubt the latter is that the Conference Board data were collected with methods quite comparable to those used by BLS. A more convincing reason to discount this argument comes from the NIPA data. The longer span of this data set provides the opportunity to examine whether there was a noticeable downward shift in relative full-time income variability after 1936. This would be consistent with a decline in relative wage variability (unless year-to-year variability in full-time hours declined over this period, a highly unlikely condition). Such a shift seems to have taken place around 1948, as shown in lines 12 and 13. Mean relative full-time income variability before 1948 was nine times greater than after 1948.

Another problem in interpreting the means in Table 1 is differences in the level of aggregation across the four data sets. For instance, Long reports separate series for two different types of metals and two different types of textile products. In the two-digit SIC code used for manufacturing by BLS, there is but one series for each of these major sectors. Similar problems arise in Douglas' series and, to a lesser extent, in the Conference Board series. This aggregation reduces the total variation in the rate of change in wages. To examine how much of the lower variation in the post-war period is attributable to aggregation, the post-war series are re-examined at the three-digit level. The results in line 14 show a slight increase in relative wage variability results when more disaggregated data are used, but the basic finding of lower relative wage variability in the post-war period is unaffected.

A further difficulty is measurement error in the Douglas data. Douglas had to impute values for seven of the nonunion manufacturing industries for every other year after 1914. To the extent Douglas' imputations were erroneous, the variance in the rate of change of wages in his series is overstated during this period. The magnitude of this bias cannot be ascertained readily through pre-and post-1914 comparisons because the variability of changes in output across sectors is greatest after 1914. One reason to doubt that this bias is very large is that the ratio of relative wage variability in nonunion industries to that of union industries actually fell after 1914.

A final problem in making comparisons across the four data sets is differences in which sectors are included. For instance, Long includes brewing, agricultural implements, and carriages and wagons but excludes baking and knit goods. Douglas does the opposite. A related difficulty is that the Conference Board and BLS series cover a larger proportion of the manufacturing sector than the Long and Douglas series. The differences in coverage need not bias the estimates, but they make comparisons across periods potentially misleading.

To standardize for industry mix, a relative wage variability measure was constructed for four industries from each data set: textile products, printing, lumber, and primary metal products. Wage data for textiles, printing, and primary metals in the Douglas and Conference Board samples were obtained by aggregating wage series within each category (e.g., knits, woolens, and cotton were used to create the textiles series in the Douglas data). The following results were obtained for annual changes in relative wages (x 100):

| | Mean (S.D.) | Minimum | Maximum |
|---|---|---|---|
| 1860-1890 | .062 (.076) | .002 | .292 |
| 1890-1926 | .115 (.224) | .001 | 1.205 |
| 1920-1936 | .103 (.188) | .004 | .756 |
| 1947-1983 | .017 (.017) | .000 | .080 |

Standardizing for industrial mix substantially lowers the estimates of relative wage variability in the prewar period and slightly raises the estimate for the post-war period. Nonetheless, relative wage variability remains four to seven times larger in the prewar period.

## IV. PATTERNS WITHIN PERIODS

Before turning to a more formal analysis of the determinants of changes in relative wages, it will be useful to look carefully at the patterns of relative wage changes within each of the samples under consideration (Figures 2 through 8). In Long's sample for 1860-1890 (see Figure 2), changes in relative wages were most pronounced during the Civil War. After the war the variance in the rate of change of wages was considerably smaller. The relatively large change in 1878 took place during a contraction in the business cycle, whereas those in 1871 and 1880 took place in the initial stages of expansions. However, relative wages changed very little during the contraction of 1870.

The pattern of relative wage changes in Douglas' series between 1890 and 1926 in Figure 3 shows that relative wages changed very little, on average, between 1890 and 1915. The large changes shown for 1916 to 1918 probably are attributable to wartime conditions. The biggest changes took place in 1920 and 1921, a period that coincides with a sizable contraction in output.

The Douglas and Conference Board (see Figure 4) series overlap between 1920 and 1926. In this period they show the same pattern--large changes in relative wages during the contraction of 1923-1924 followed by smaller changes through 1926. The trend toward greater wage rigidity continued until the beginning of the depression, which first becomes manifest in relative wage changes in 1930. As the contraction continued, relative wages changed at an accelerating rate. Even after 1934, the changes in relative wages were greater than just before the depression.

Annual changes in relative wages since 1947 are reported in Figure 5. The largest changes took place in the late 1940s and 1950s. In the first half of the 1960s, relative wages hardly changed at all. Over the last twenty years the largest changes in relative wages took place in 1967, 1971-1972, 1975, and 1983. These periods coincide with either contractions or changes in the aggregate growth rate. The double-digit inflation rates observed in 1973-1974 and 1979 are associated with relatively small changes in relative wages.

The year-to-year fluctuations in the NIPA relative full-time income series are reported in Figure 6 for 1929-1982, with values for 1929-1948 and 1948-1982 reported in Figures 7 and 8. Figure 6 shows the dramatic drop in relative wage variability in the last half of the 1940s. The patterns in the NIPA series during the depression and in the post-war period are similar to those observed in the Conference Board and NIPA data. Relative wage variability increased considerably at the beginning of World War II and again at the end of the war.

## V. DETERMINANTS OF CHANGES IN RELATIVE WAGES

Hamermesh (1986) shows the implications of two different models of wage adjustment for changes in relative wages. In Keynesian models, wages are assumed to be either downwardly rigid in nominal terms (i.e., nominal wages don't fall, real wages can fall) or downwardly rigid with respect to the expected rate of price inflation (i.e., nominal and real wages don't fall). In the former case, inflation allows firms to cut real wages without cutting nominal wages. In periods of low inflation, a relatively small proportion of workers receive wage increases and there is relatively little variation in the rate of increase among those receiving increases. As the inflation rate rises, more workers receive wage increases and the range of observed increases becomes larger. In essence, higher inflation allows employers to avoid the constraint nominal wage rigidity imposes on real wage cuts. In this model there should be a positive correlation between inflation (both anticipated and unanticipated) and changes in relative wages. If the minimum rate of wage increase is the expected rate of inflation instead of zero, expected inflation has no effect on changes in relative wages. In this case, only unanticipated inflation leads to larger changes in relative wages.

Hamermesh also shows that the variance across sectors in the rate of growth of nominal output ($VQ_t$) should be positively related to changes in relative wages. The intuition behind this result is fairly clear. When there is greater variation in the rate of excess demand across sectors, there should be more variation in labor demand. Unless workers anticipate these shifts and move accordingly across sectors, this results in changes in relative wages.

Hamermesh tested these propositions for the U.S. after World War II and found that the data contradict the "Keynesian" propositions -- the variance of the rate of growth of wages decreases with inflation, especially with unanticipated inflation ($p^u$). One possible explanation, Hamermesh argues, is that workers demand more indexing (formal and informal) when there is uncertainty about inflation. If wage-setting mechanisms throughout the economy adjust so that more weight is placed on preserving real wages through partial or complete indexing and less weight is placed on reacting to excess demand for labor, then one would expect a smaller variance in the growth rate of wages simply because the CPI is the same for everybody. This rationale can be further tested by determining whether unexpected inflation reduces $VW_t$ in other periods.

If one admits the possibility of heterogeneity of indexing schemes across markets, then $VW_t$ can actually increase with $p^u$. To see this, rewrite Hamermesh's equation (1) as

$$dw_{it} = p^e + \gamma_i p^u + \alpha y_{it},$$

where $\gamma_i$ is now interpreted as an indexing parameter and $p^e$ = anticipated inflation and $y_{it}$ = excess demand in market i at time t. In this model,

$$VW_t = (p^u)^2 \text{ Var } \gamma_i + \alpha^2 \text{ Var } y_{it} + 2\alpha p^u \text{ Cov } (y_{it}, \gamma_i),$$

which means that $\partial VW_t/\partial p^u \gtrless 0$, depending on the signs of $\alpha$, $p^u$, and Cov ($y_{it}$, $\gamma_i$).

Hamermesh's empirical model did not contain a measure of uncertainty about inflation. Conceptually, uncertainty about inflation can be interpreted as variation of $p^e$ across individuals. The measure which will be used below is the variance in the rate of change of the CPI over the previous 10 years, denoted $PIUNC_t$ below.

Fischer's analysis of the linkages between relative price variability and inflation points out two other possible rationales for empirical relationships between inflation and changes in relative wages. The market clearing with imperfect information approach, developed by Barro (1976) and tested by Hercowitz (1981, 1982), examines the effect of changes in the money supply on relative prices in an "islands" model where agents do not know whether observed price changes are due to inflation or to shifts in relative excess demand. If supply and demand elasticities vary across markets, misperceptions about changes in the money supply are translated into actual relative wage changes. This argument applies equally to unanticipated inflation and deflation--the absolute value of the unexpected change in the price level matters, not the direction of the change. Anticipated inflation and deflation have no effect on relative wages in this model.

The adjustment cost approach emphasizes the lump-sum costs of changing wages and prices. Under both inflation and deflation, these costs (e.g., paperwork involved with changing wage rates, costs of reporting worker performance) call for making changes in wages at discrete intervals. As long as all firms don't make these changes at the same time, this results in changes in relative wages. Both expected and unexpected changes in the price level cause changes in relative wages in this model.

The empirical implications of each of these models for the effects of expected and unexpected inflation on relative wage variability are summarized below:

| | Impact on changes in relative wages of: | | | |
|---|---|---|---|---|
| Model | $p^e$ | $p^u$ | $\lvert p^e \rvert$ | $\lvert p^u \rvert$ |
| I. Simple Keynesian | | | | |
| A. Nominal wage rigidity | + | + | 0 | 0 |
| B. Wage rigidity with respect to expected inflation | 0 | + | 0 | 0 |
| II. Indexing | | | | |
| A. Homogeneous $\lambda$ | 0 | - | 0 | 0 |
| B. Heterogeneous $\lambda$ | 0 | ? | 0 | 0 |
| III. Market clearing with imperfect information | 0 | 0 | 0 | + |
| IV. Adjustment cost | 0 | 0 | + | + |

## VI. EMPIRICAL SPECIFICATION

The results reported below are obtained from two general nonnested specifications:

(1) $$\ln(VW_t) = \alpha_o + \alpha_1 p_t^e + \alpha_2 p_t^u + \alpha_3 \ln(VQ_t) + \alpha_4 \ln(PIUNC_t) + e_t$$

(2) $$\ln(VW_t) = \beta_o + \beta_1 \lvert p_t^e \rvert + \beta_2 \lvert p_t^u \rvert + \beta_3 \ln(VQ_t) + \beta_4 \ln(PIUNC_t) + e_t' ,$$

where $e_t$ and $e_t'$ are normally distributed error terms and $\alpha_i$ and $\beta_i$ are parameters to be estimated. Models I and II are estimated with (1); models III and IV with (2). Model II is distinguished from model I by the restriction

$\alpha_1=0$; model III from model IV, by the restriction $\beta_1=0$. These restrictions are tested below with likelihood ratio tests and information criteria. The equations are estimated by maximum likelihood to allow for first-order serial correlation without dropping the first year in each sample. The logarithmic form of the equation was chosen to make the results directly comparable to Hamermesh's.

Definitions, means, and standard deviations for each of the variables used in the regression analysis are reported in Table 2. Expected inflation rates were generated from rolling AR(3) models estimated over the previous thirty years. This specification was chosen because of its relatively stable lag structure and its ability to track changes in the price level throughout each sample period.

A different data set had to be used in each sample period to construct $VQ_t$. For 1860-1890 I use the five output series in Frickey (1947) which extend throughout the period: food and kindred products, textile fabrics and materials, articles from textile fabrics, iron and steel and their products, and metals and metal products other than iron and steel. For 1890-1926 I use Shaw's estimates of the implicit price index and the value of output for five major sectors: perishable goods, semidurable goods, consumer durables, producer durables, and construction materials. For 1920-1936 I use the seven Federal Reserve Board industry indexes which are available for the entire period (food, tobacco, textiles, lumber, leather, iron and steel, and stone, clay and glass). For 1929-1982 and 1947-1983 the national income accounts provide much more comprehensive coverage than any of these other sources. The variance in the rate of change of output is calculated over one-digit industries. The variances for 1890-1926, 1929-1982, and 1947-1983 are Divisia weighted by the share of real output in each industry; the variances for the other two periods are unweighted because dollar values are not reported.

The across-industry variance of the rate of change of output is a function of a number of factors, including the dispersion of industry-specific excess demand shocks and the magnitude of economy-wide shocks. The impact of economy-wide shocks on wages will vary by industry unless demand and supply elasticities are the same everywhere. To the extent that wage shocks have an immediate impact on excess demand in product markets, it is plausible that $VQ_t$ is a function of $VW_t$. Ideally, one would like to purge $VQ_t$ of this influence. Instrumental variables are available for economy-wide shocks, but not for industry-specific shocks. Without a good set of instruments, it makes little sense to replace $VQ_t$ with predicted $VQ_t$. Another alternative is to drop $VQ_t$ altogether, but this creates omitted variable bias. In my judgment it is preferable to include $VQ_t$ because the magnitude of the within-year impact of $VW_t$ on $VQ_t$ is likely to be quite small even if the same industry definitions are used for each variable. Because the industries used to construct $VQ_t$ never coincide with those used to construct $VW_t$, there is even less reason to believe simultaneity bias is a severe problem. The estimates of (1) and (2) are reported in Tables 3 and 4.

## VII. RESULTS

The Keynesian model with nominal wage rigidity implies $\alpha_1 > 0$, whereas $\alpha_1=0$ in the Keynesian model with real wage rigidity and Hamermesh's indexing rationale. Likelihood-ratio tests of the restriction $\alpha_1=0$ are distributed $\chi^2$ with one-degree of freedom:

| | |
|---|---|
| 1860-1890 | 4.26 |
| 1890-1926 | 4.22 |

| | |
|---|---|
| 1920-1936 | 2.31 |
| 1947-1983 | .34 |
| 1929-1982 | .29 |

The restriction is rejected at the 95 percent confidence level for the 1860-1890 and the 1890-1926 samples, but cannot be rejected for the other three samples. Judge et al (1980) and Chow (1983) note that the choice of any significance level is arbitrary and can be avoided by using information criteria. The values of Akaike's information criterion (AIC) and the Schwartz-Bayes information criterion (SBC) in Tables 3 and 4 are multiplied by -2, so the relevant test is to see which specification gives the smallest value in the tables. The information criteria point to essentially the same conclusion as the likelihood-ratio tests in this case. The $\alpha_1=0$ restriction is rejected for 1947-1983 and 1929-1982, but cannot be rejected for 1860-1890 and 1890-1926. The information criteria deliver a split verdict for 1920-1936.

These results show that both anticipated and unanticipated inflation are positively correlated with changes in relative wages between 1860 and 1926. This relationship vanishes in the two later samples, where I obtain the same results as Hamermesh: a negative correlation between unanticipated inflation and changes in relative wages (albeit at only a 20 percent confidence level). The notion that inflation lubricates the labor market to permit larger changes in relative wages seems to hold through 1936, but not afterward. The evidence is consistent with the indexing rationale in the 1929-1982 and 1947-1983 samples. The difference in the results before and after 1936 is most likely a response to the sustained inflation of the 1960's and 1970's.

The market clearing with imperfect information model implies $\beta_1=0$, whereas the adjustment cost model requires $\beta_1>0$. Likelihood-ratio tests of the restriction $\beta_1=0$ are:

| | |
|---|---|
| 1860-1890 | 3.01 |
| 1890-1926 | 5.96 |
| 1920-1936 | 2.98 |
| | |
| 1947-1983 | .38 |
| 1929-1982 | .05 |

The restriction can be rejected only for the 1890-1926 sample at conventional levels of significance. Both information criteria indicate that $\beta_1=0$ can be rejected for 1890-1926 and 1920-1936. It is also rejected for 1860-1890 under the AIC but not the SBC. However, $\beta_1$ is negative in this period, which is not consistent with the adjustment cost model. The restriction cannot be rejected for the 1947-1983 and 1929-1982 samples under either AIC or SBC. In summary, the adjustment cost model is consistent with the evidence for the 1890-1926 and 1920-1936 samples, but otherwise it has little explanatory power.

The evidence for the market clearing with imperfect information model is fairly weak. Although the estimated values of $\beta_2$ are positive in every period except 1947-1983, the hypothesis that $\beta_2=0$ can be rejected only for 1860-1890. It is probably no coincidence that this is the sample period where the assumption of no current information about prices in other markets is most likely to hold.

In summary, the evidence is consistent with the Keynesian model with nominal wage rigidity for 1860 through 1936, the adjustment cost model for 1890 through 1936, and the market clearing model for 1860 through 1890. The Keynesian model model does not fare as well as its competitors in terms of goodness of fit criteria (root MSE, $R^2$ and log likelihood values). One way to test these models against each other within each of these three sample periods is to estimate a composite equation containing all explanatory variables and then test whether $\alpha_1=\alpha_2=0$ or $\beta_1=\beta_2=0$. The former set of restrictions can be rejected for 1920-1936; the latter set can be rejected for all three periods.

The obvious problem with such "tests" is that the composite model makes little theoretical sense. Nonetheless, the data seem to be saying that more explanatory power is lost by dropping the absolute values of $p^e$ and $p^u$ from the equation than is lost by dropping $p^e$ and $p^u$. This evidence, along with the goodness of fit statistics, is more favorable toward the market clearing and adjustment costs models than the Keynesian models.

Except for the indexing rationale, none of the models examined here are entirely consistent with the evidence for the 1929-1982 and 1947-1983 samples. In these samples $VQ_t$ and $PIUNC_t$ are the only variables which are strongly correlated with relative wage variability. These variables are also generally positively correlated with $VW_t$ in the other three samples. Although the negative correlation between $p^u$ and $VW_t$ reported here is fairly weak, these results cannot be viewed in isolation from Hamermesh's findings which are based on a wide variety of measures of $p^u$.

## VIII. WHY HAVE RELATIVE WAGES BECOME MORE RIGID ?

The macroeconomic sources of increased wage variability can be identified for the regression model $y_t = \beta_t x_t$, t = 0,1 from the identity

$$\Delta y = \Delta\beta x_o + \Delta x \beta_o + \Delta\beta \, \Delta x.$$

The unrestricted specifications in Tables 3 and 4 are used for the decomposition of the sources of decreased relative wage variability between the 1890-1926 and the 1947-1983 samples. The 1890-1926 sample is used in the comparison because the wage data seem more reliable than those for 1860-1890 and the sample period is considerably longer than that in the Conference Board data. The results of this decomposition are reported in Table 5.

There is only one economically meaningful factor in the decomposition based on (1) that can account for any of the decline in relative wage variability between 1890-1926 and 1947-1983: a reduction in the variability of output growth. By itself this accounts for 22 percent of the decline. Changes in all other independent variables either had little effect on the decline in relative wage variability (less unexpected inflation and less variability of past inflation in 1947-1983) or worked to increase relative wage variability (higher expected inflation in 1947-1983). Changes in the coefficients and interactions between changes in the independent variables and changes in the coefficients exactly offset the impact of reduced variability of output growth. Statistically speaking, the change in relative wage variability can be "explained" fully by the change in the intercept between the two samples.

The conclusions from the decomposition based on (2) seem different at first glance. In this specification, the change in each of the coefficients has a large impact on the decline in relative wage variability. The biggest contributor is the growth in the PIUNC coefficient between 1890-1926 and 1947-1983; by itself this accounts for 75 percent of the observed decline in relative wage variability. The growth in the VQ coefficient and the shrinkage of the inflation coefficients each account for an additional eleven to fifteen percent. Yet there is little intuition behind these results; all they say is that for given values of each independent variable, VQ is smaller in 1947-1983 than in 1890-1926. In fact, these results are more mystifying than those based on (1) because changes in the means of the independent variables account for a negligible proportion of the change in the dependent variable.

What other factors can account for the increasing rigidity of relative wages? Based on the discussion in Section III, it is clear that some of the decline in $VW_t$ can be attributed to more accurate measurement of wages and changes in the industrial mix. Yet it is equally clear from that discussion that factors such as measurement error, aggregation, and industrial mix are not the entire story.

Two possible historical factors behind the drop in $VW_t$ over time are the growth of unions and the increase in the average size of establishments. The impact of these changes in economic structure on relative wage variability is examined in Allen (1987) by regressing the wage growth rate in each industry on the average wage growth rate, a labor market counterpart to the beta used in stock market analysis. This measure is called w-beta. The mean value of VW over any period is directly related to the dispersion of w-betas around one. In Douglas's "union" manufacturing industries, w-beta tends to be less than or equal to one; in other manufacturing industries, it is generally greater than one. For unions to reduce $VW_t$, the w-beta estimates for industries which are unionized or become unionized must converge toward one without any similar adjustment in nonunion industries. No such pattern is evident in the data; the estimates of w-beta converge toward one in practically every industry. The hypothesis that w-beta equals one can be rejected in only two cases in the BLS data. Thus, union growth does not seem to be a key factor.

The impact of the growth of average establishment size can be evaluated in an analogous fashion. In the Long data, the mean value of w-beta for industries with average establishment size of 50 or smaller is .736; whereas it is 1.146 in all other industries. In the Conference Board data, the mean value of w-beta is .694 in industries where average establishment size is 100 or below. In industries with 101 to 500 employees, the mean value of w-beta is .969; 501 or more, 1.084. A reduction in the employment share of smaller establishments would reduce the variation of w-beta around one, but because of the extreme difficulties in comparing average establishment size across these different data sets it is by no means certain that this has occurred.

A final possible explanation of the drop in $VW_t$ is improved communication of wage information. Today BLS does monthly surveys of large samples of establishments to gauge wage trends. This information is released with a relatively short lag and is widely disseminated. In contrast wage studies done in earlier periods were usually limited to particular industries or geographic areas and were not released in enough time to be of more than academic interest. Better information should reduce the odds that wages will be set at levels where markets do not clear.

## IX. CONCLUSION

This paper has documented a large decline since World War II in the magnitude of changes in relative wages across industries. The reasons for this increase in wage rigidity are not yet clear. Except for greater variability in output, the macroeconomic factors examined here do not seem to have had much effect on the rise in relative wage rigidity. Increases in average establishment size and improved communication of wage trends are probably partially responsible for the observed drop in relative wage variability.

Across all periods examined, no single macroeconomic model explained year-to-year fluctuations in the rate at which relative wages change. Rational expectations models are consistent with the evidence for 1860-1890 and the adjustment cost model is consistent with the results for 1890-1926 and 1920-1936. The Keynesian model with nominal wage rigidity is also consistent with the results for these three samples, but it has less explanatory power.

In the post-war samples, the results are consistent only with the indexing rationale developed by Hamermesh.

## DATA APPENDIX

In addition to the sources cited in the text, data were obtained from the following:

U.S. Bureau of Economic Analysis (1973): Federal Reserve Board indexes of industry output for 1920-1936, series C299, C301-C303, and C310-C312; Consumer Price Index for 1860-1970, series B69.

U.S. Bureau of the Census (1975): Shaw's series of value of output of finished commodities and construction materials for 1890-1926, series 319, 327, 334, 353, 367, and 370-374.

U.S. Council of Economic Advisors (1985): Consumer Price Index for 1970-1983, Table B-52.

U.S. Department of Labor (1975): Consumer Price Index for 1830-1859, Table 122.

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able 1. Changes in average and relative wages, 1860-1983

| Period | Coverage | Weighting | Mean (S.D.) annual change in average wage | Mean (S.D.) absolute value of change in average wage | Mean (S.D) annual change in relative wages (X 100) | Minimum change in relative wages (X 100) | Maximum change in relative wages (X 100) |
|---|---|---|---|---|---|---|---|
| 1860-1890 | 13 mfg. industries | yes | .016 (.048) | .034 (.037) | .138 (.091) | .029 | .431 |
| 1860-1890 | 13 mfg. industries and building | no | .016 (.048) | .034 (.037) | .318 (.396) | .065 | 2.253 |
| 1860-1890 | 7 mfg. industries by state | no | .016 (.048) | .034 (.037) | .397 (.396) | .084 | 1.134 |
| 1890-1926 | 24 industries or occupations | yes | .034 (.058) | .043 (.052) | .226 (.521) | .024 | 3.030 |
| 1890-1926 | 14 mfg. industries | yes | .032 (.062) | .043 (.055) | .212 (.399) | .012 | 2.214 |
| 1890-1926 | 6 union mfg. industries | yes | .031 (.054) | .037 (.051) | .082 (.173) | .001 | .730 |
| 1890-1926 | 8 nonunion mfg. industries | yes | .033 (.082) | .058 (.066) | .202 (.335) | .013 | 1.632 |
| 1920-1936 | 21 mfg. industries | yes | .001 (.098) | .061 (.075) | .157 (.146) | .025 | .513 |
| 1947-1983 | 20 mfg. industries | yes | .056 (.022) | .056 (.022) | .013 (.008) | .002 | .033 |
| 1947-1983 | 20 mfg. industries | no | .055 (.022) | .055 (.022) | .015 (.008) | .003 | .028 |
| 1929-1982 | 55 or 57 industries | yes | .047 (.047) | .060 (.028) | .102 (.145) | .008 | .640 |
| 1929-1948 | 55 industries | yes | .034 (.075) | .070 (.040) | .239 (.171) | .069 | .640 |
| 1948-1982 | 57 industries | yes | .055 (.018) | .055 (.018) | .026 (.015) | .008 | .074 |
| 1958-1979 | 90 mfg. industries | yes | .053 (.021) | .053 (.021) | .031 (.018) | .013 | .084 |

Table 2. Definitions and summary statistics for variables used in regression analysis

| Variable | Definition | Mean and standard deviation (S.D.) 1860-1890 | 1890-1926 | 1920-1936 | 1929-1982 | 1947-1983 |
|---|---|---|---|---|---|---|
| PI | Log $(CPI_t)$ - Log $(CPI_{t-1})$ | .001 | .019 | -.023 | .033 | .042 |
| | | (.072) | (.057) | (.049) | (.047) | (.034) |
| PIHAT | Predicted value of PI from AR(3) model estimated over previous 30 years | .004 | .008 | .002 | .030 | .039 |
| | | (.048) | (.050) | (.057) | (.034) | (.031) |
| UNEXPI | PI - PIHAT | -.002 | .011 | -.024 | .003 | .003 |
| | | (.078) | (.058) | (.076) | (.030) | (.020) |
| ABS(UNEXPI) | Absolute value of UNEXPI | .045 | .034 | .050 | .022 | .016 |
| | | (.063) | (.048) | (.062) | (.021) | (.013) |
| ABS(PIHAT) | Absolute value of PIHAT | .022 | .030 | .040 | .036 | .041 |
| | | (.042) | (.040) | (.040) | (.027) | (.028) |
| Log(VQ) | Logarithm of the variance in the rate of change of output | -5.237 | -5.363 | -4.770 | -6.022 | -7.140 |
| | | (1.002) | (1.033) | (1.282) | (1.507) | (.903) |
| Log(PIUNC) | Logarithm of the variance of PI over previous 10 years | -6.240 | -7.336 | -5.497 | -7.219 | -7.698 |
| | | (1.361) | (1.349) | (.742) | (1.164) | (1.172) |
| Log(VW) | Logarithm of the variance in the rate of change of wages | -6.770 | -6.917 | -6.852 | -7.620 | -9.192 |
| | | (.613) | (1.128) | (.949) | (1.175) | (.769) |

Table 3. Estimates of equation (1)

| | Sample Period | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1860-1890 | | 1890-1926 | | 1920-1936 | | 1947-1983 | | 1929-1982 | |
| $\alpha_0$ | -4.868 | -5.390 | -3.051 | -3.019 | -4.473 | -.888 | -5.349 | -5.214 | -3.323 | -3.274 |
| | (.658) | (.677) | (1.577) | (1.192) | (3.342) | (3.084) | (1.094) | (1.163) | (.826) | (.788) |
| $\alpha_1$ | | 4.289 | | 8.123 | | 9.513 | | -2.091 | | -1.531 |
| | | (2.271) | | (3.557) | | (7.305) | | (3.840) | | (2.868) |
| $\alpha_2$ | 1.153 | 2.093 | -3.282 | .232 | 2.225 | 11.303 | -5.179 | -6.259 | -3.081 | -3.508 |
| | (1.310) | (1.337) | (2.021) | (2.563) | (3.163) | (6.150) | (4.155) | (4.630) | (2.644) | (2.749) |
| $\alpha_3$ | .160 | .085 | .201 | .277 | .500 | .907 | .168 | .171 | .450 | .460 |
| | (.100) | (.102) | (.133) | (.132) | (.259) | (.290) | (.108) | (.109) | (.087) | (.089) |
| $\alpha_4$ | .169 | .151 | .381 | .340 | -.012 | .250 | .340 | .344 | .220 | .212 |
| | (.064) | (.060) | (.184) | (.133) | (.434) | (.342) | (.130) | (.134) | (.125) | (.122) |
| AR(1) | .280 | .300 | -.515 | -.308 | -.128 | -.209 | -.397 | -.415 | -.446 | -.410 |
| | (.197) | (.205) | (.168) | (.184) | (.322) | (.344) | (.168) | (.170) | (.145) | (.149) |
| Root MSE | .582 | .553 | .761 | .732 | .818 | .798 | .549 | .555 | .555 | .559 |
| -2*AIC | 57.237 | 54.977 | 87.464 | 85.239 | 43.012 | 42.698 | 63.750 | 65.406 | 92.923 | 94.637 |
| -2*SBC | 64.243 | 63.384 | 95.381 | 94.740 | 46.875 | 47.334 | 71.667 | 74.908 | 102.774 | 106.459 |
| $R^2$ | .223 | .326 | .596 | .639 | .455 | .529 | .549 | .554 | .794 | .795 |

Note: Standard errors in parentheses. AIC is Akaike's information criterion and SBC is the Schwartz-Bayes information criterion.

Table 4. Estimates of equation (2).

| | Sample Period | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1860-1890 | | 1890-1926 | | 1920-1936 | | 1947-1983 | | 1929-1982 | |
| $\beta_0$ | -6.200 | -5.913 | -3.599 | -5.961 | -7.994 | -10.815 | -5.096 | -5.332 | -3.661 | -3.605 |
| | (.688) | (.691) | (1.433) | (1.619) | (3.406) | (3.785) | (1.139) | (1.237) | (.915) | (.924) |
| $\beta_1$ | | -4.354 | | 13.789 | | 14.330 | | 2.452 | | -.761 |
| | | (2.738) | | (5.786) | | (8.171) | | (4.524) | | (3.479) |
| $\beta_2$ | 4.851 | 6.479 | 5.415 | 4.304 | 4.968 | 1.126 | -4.264 | -5.006 | 6.033 | 5.970 |
| | (1.465) | (1.752) | (3.022) | (3.010) | (3.389) | (4.184) | (8.300) | (8.493) | (4.239) | (4.311) |
| $\beta_3$ | .044 | .074 | .146 | .095 | .130 | -.010 | .152 | .143 | .369 | .373 |
| | (.092) | (.091) | (.139) | (.136) | (.236) | (.287) | (.111) | (.113) | (.091) | (.092) |
| $\beta_4$ | .089 | .106 | .374 | .137 | -.276 | -.598 | .380 | .370 | .261 | .261 |
| | (.058) | (.057) | (.159) | (.161) | (.484) | (.442) | (.133) | (.137) | (.129) | (.129) |
| AR(1) | .280 | .300 | -.453 | -.297 | -.433 | -.127 | -.406 | -.407 | -.502 | -.489 |
| | (.193) | (.198) | (.178) | (.199) | (.278) | (.326) | (.168) | (.179) | (.139) | (.142) |
| Root MSE | .492 | .478 | .751 | .704 | .752 | .723 | .560 | .566 | .550 | .556 |
| -2*AIC | 47.252 | 46.243 | 86.370 | 82.410 | 40.512 | 39.536 | 65.224 | 66.840 | 92.169 | 94.122 |
| -2*SBC | 54.258 | 54.650 | 94.287 | 91.911 | 44.375 | 44.172 | 73.142 | 76.341 | 102.020 | 105.944 |
| $R^2$ | .443 | .496 | .608 | .666 | .539 | .613 | .531 | .536 | .798 | .798 |

Table 5. Decomposition of the sources of the decline in relative wage variability between 1890-1926 and 1947-1983

| | Equation (1) | | Equation (2) | |
|---|---|---|---|---|
| | Absolute Change | Percentage Explained | Absolute Change | Percentage Explained |
| Change in mean log of relative wage variability | -2.275 | 100.0 | -2.275 | 100.0 |
| Change in intercept | -2.195 | 96.5 | .629 | -27.6 |
| Change in other coefficients | .386 | -17.0 | -2.622 | 115.2 |
| $p^e$ | -.082 | 3.6 | | |
| $p^u$ | -.071 | 3.1 | | |
| $\lvert p^e \rvert$ | | | -.340 | 14.9 |
| $\lvert p^u \rvert$ | | | -.316 | 13.9 |
| VQ | .568 | -25.0 | -.257 | 11.3 |
| PIUNC | -.029 | 1.3 | -1.709 | 75.1 |
| Change in means of independent variables | -.365 | 16.0 | -.143 | 6.3 |
| $p^e$ | .252 | -11.1 | | |
| $p^u$ | -.002 | 0.1 | | |
| $\lvert p^e \rvert$ | | | .152 | -6.7 |
| $\lvert p^u \rvert$ | | | -.077 | 3.4 |
| VQ | -.492 | 21.6 | -.169 | 7.4 |
| PIUNC | -.123 | 5.4 | -.049 | 2.2 |
| Interaction terms | -.078 | 3.4 | -.125 | 5.5 |
| $p^e$ | -.317 | 14.1 | | |
| $p^u$ | .052 | -2.3 | | |
| $\lvert p^e \rvert$ | | | -.124 | 5.4 |
| $\lvert p^u \rvert$ | | | .168 | -7.4 |
| VQ | .188 | -8.4 | -.085 | 3.7 |
| PIUNC | -.001 | * | -.084 | 3.7 |
| Rounding error and serial correlation | -.023 | 1.0 | -.014 | 0.6 |

Source: Tables 2, 3, and 4

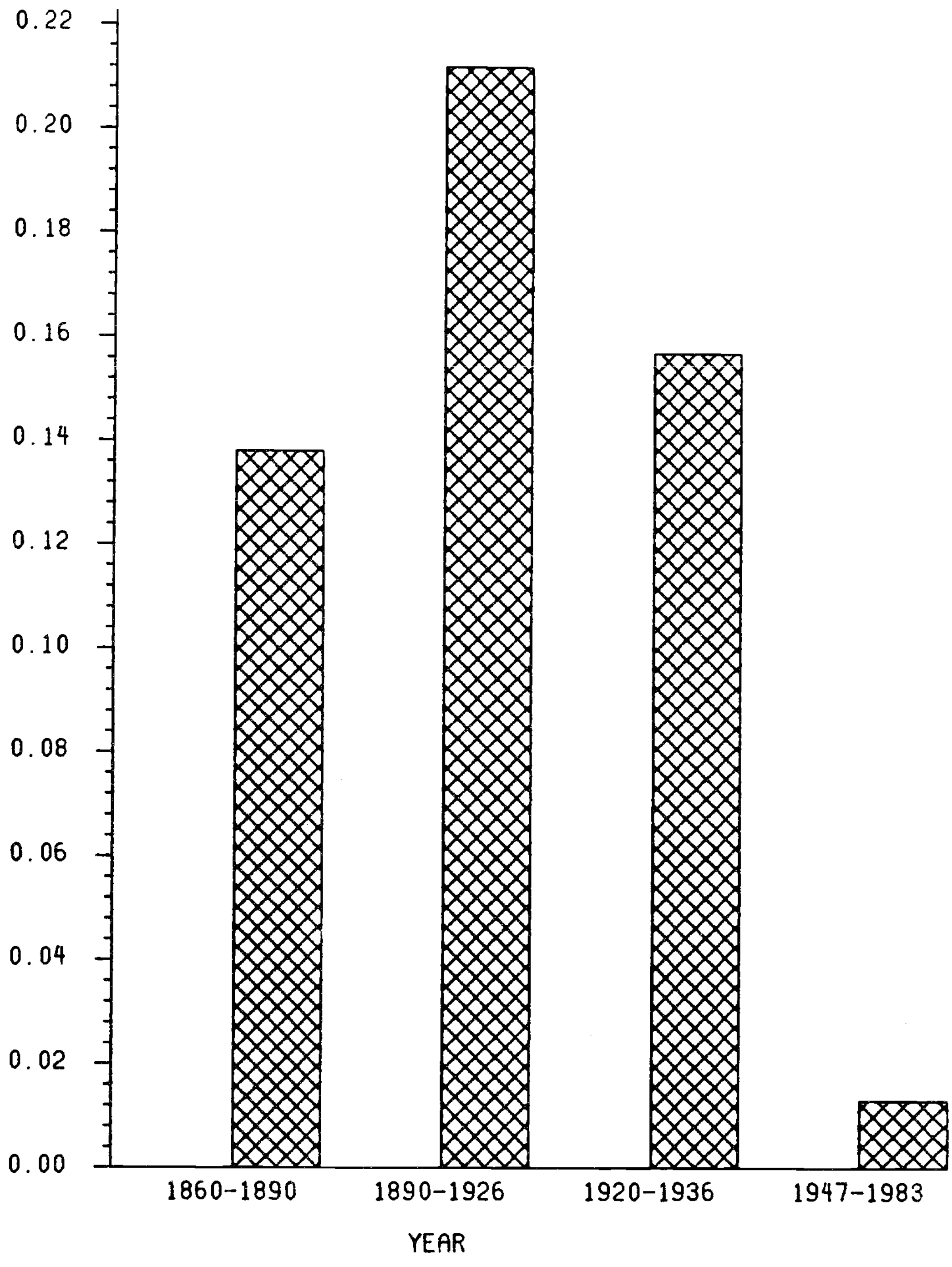


FIGURE 1: CHANGES IN RELATIVE WAGES IN MANUFACTURING, 1860-1983

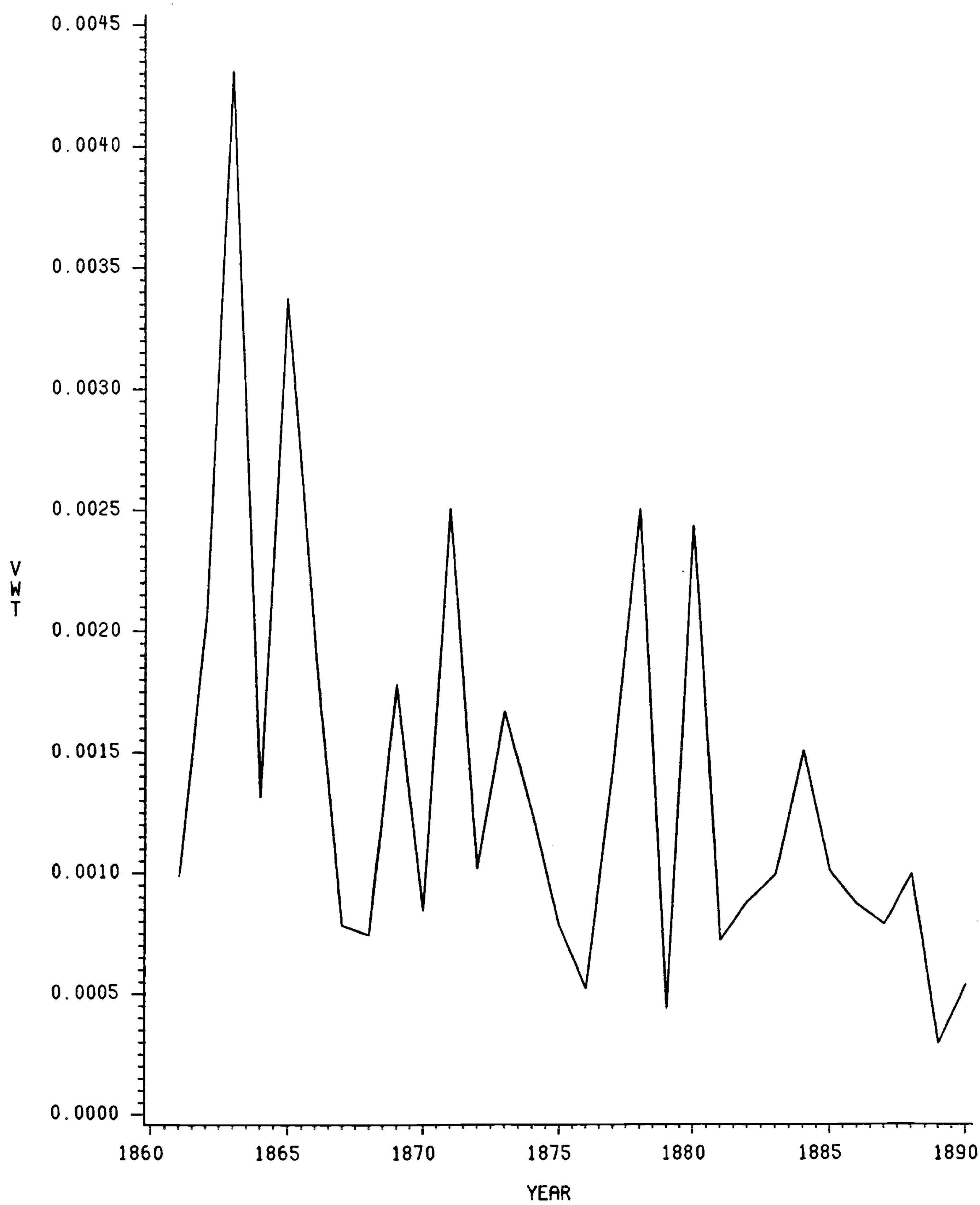


FIGURE 2: ACROSS INDUSTRY VARIANCE IN THE RATE OF CHANGE OF WAGES, 1860-1890

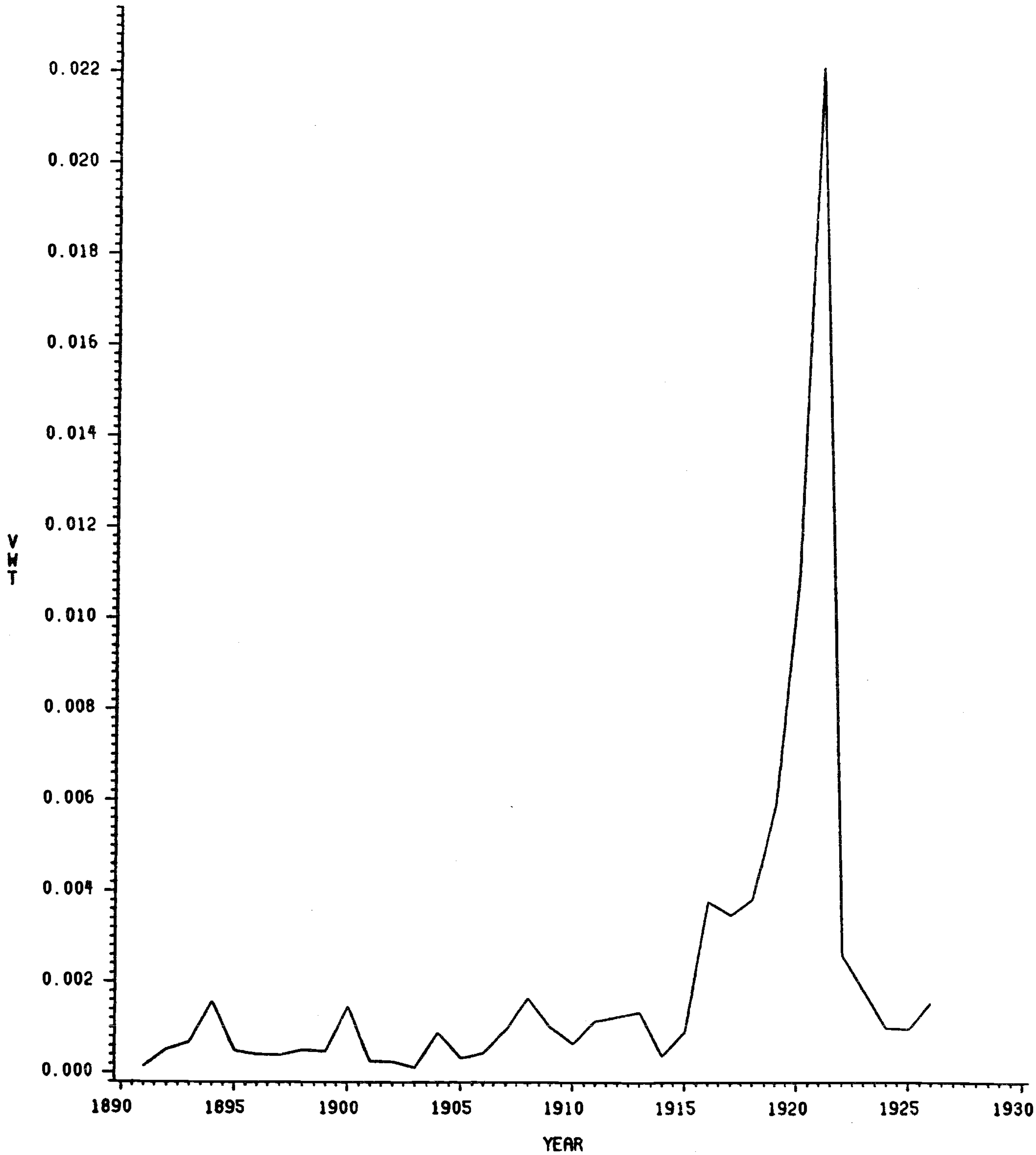


FIGURE 3: ACROSS INDUSTRY VARIANCE IN THE RATE OF CHANGE OF WAGES, 1890–1926

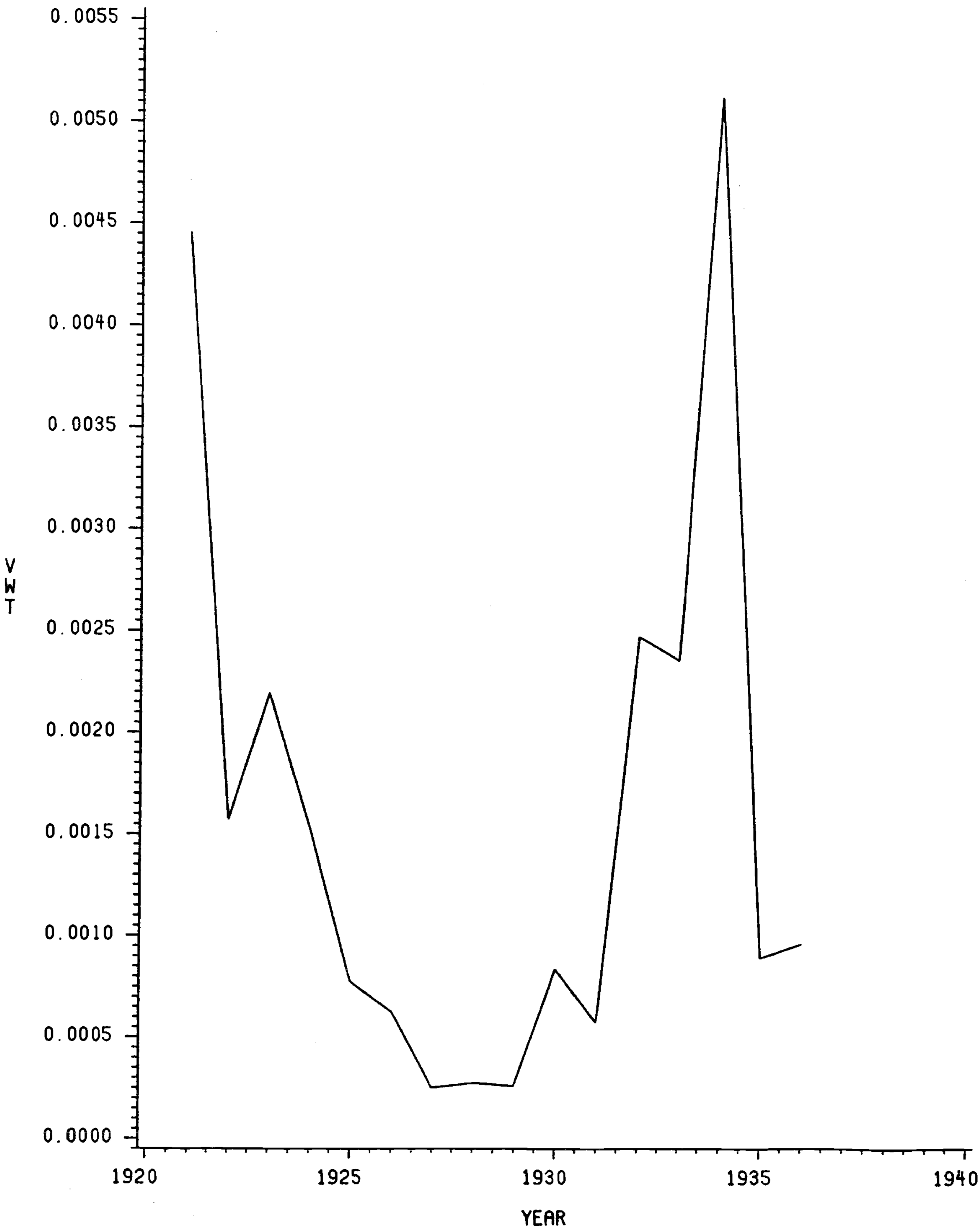


FIGURE 4: ACROSS INDUSTRY VARIANCE IN THE RATE OF CHANGE OF WAGES, 1920–1936

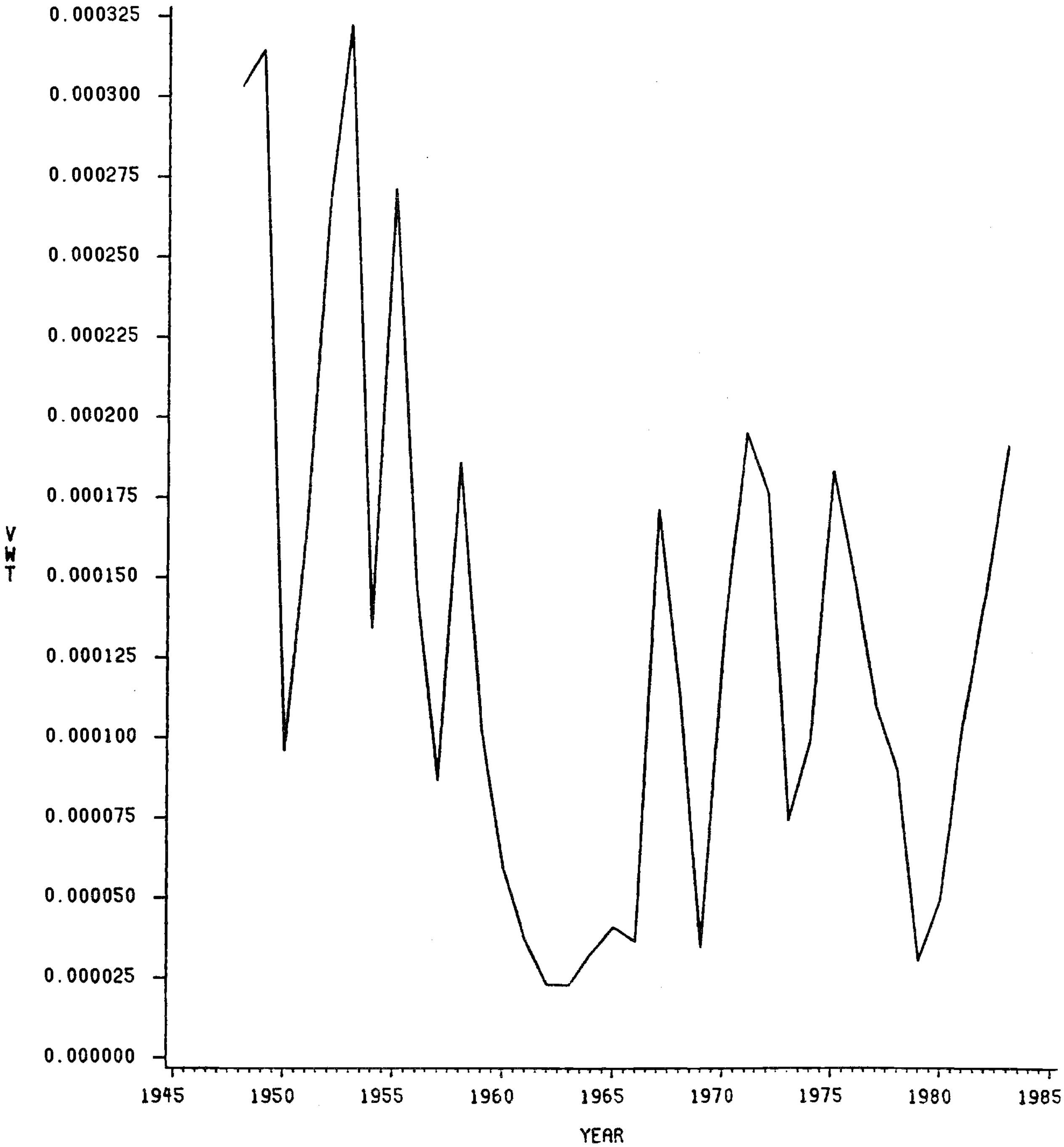


FIGURE 5: ACROSS INDUSTRY VARIANCE IN THE RATE OF CHANGE OF WAGES, 1947–1983

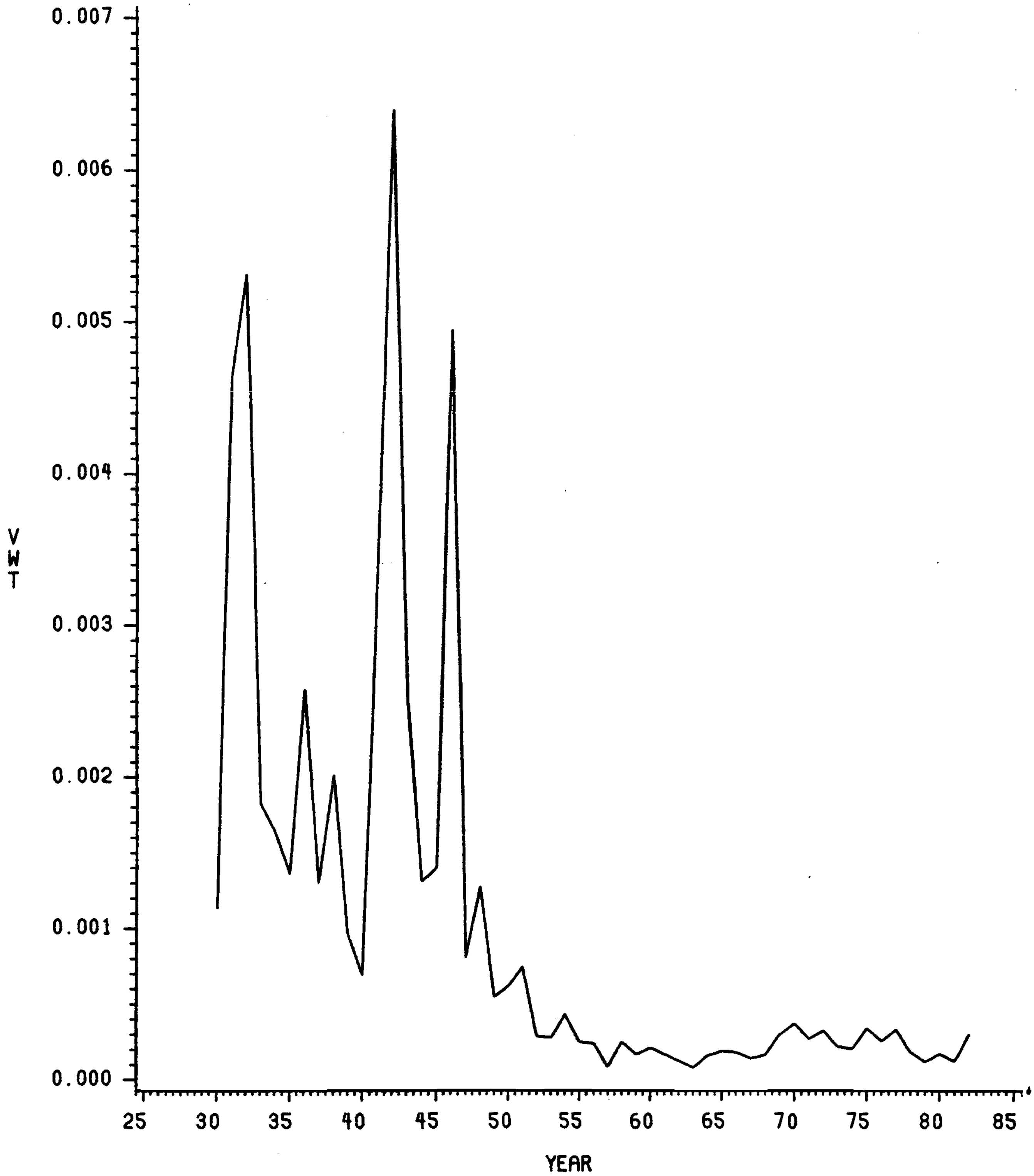


FIGURE 6: ACROSS INDUSTRY VARIANCE IN THE RATE OF CHANGE OF WAGES, 1929–1982

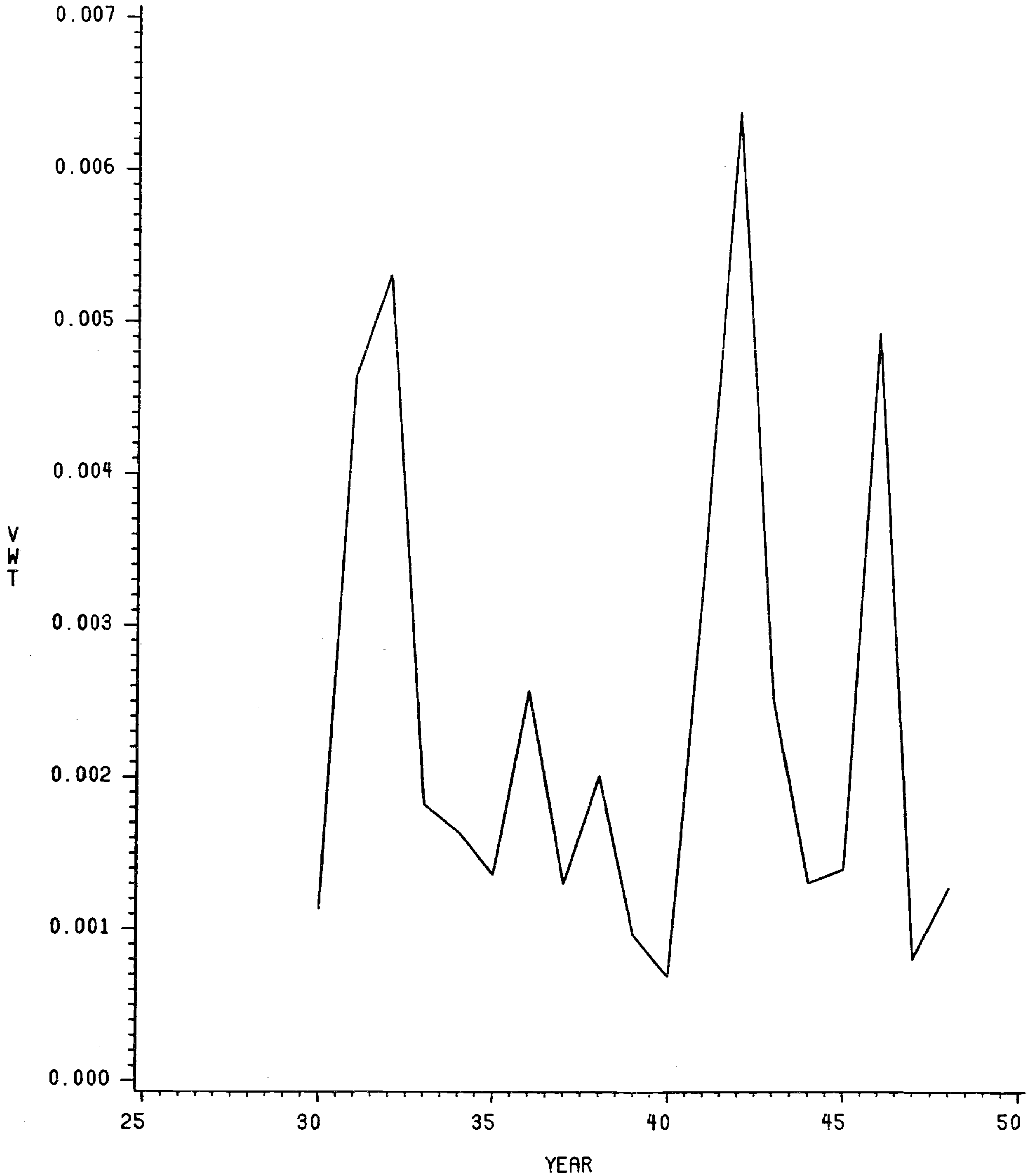


FIGURE 7: ACROSS INDUSTRY VARIANCE IN THE RATE OF CHANGE OF WAGES, 1929–1948

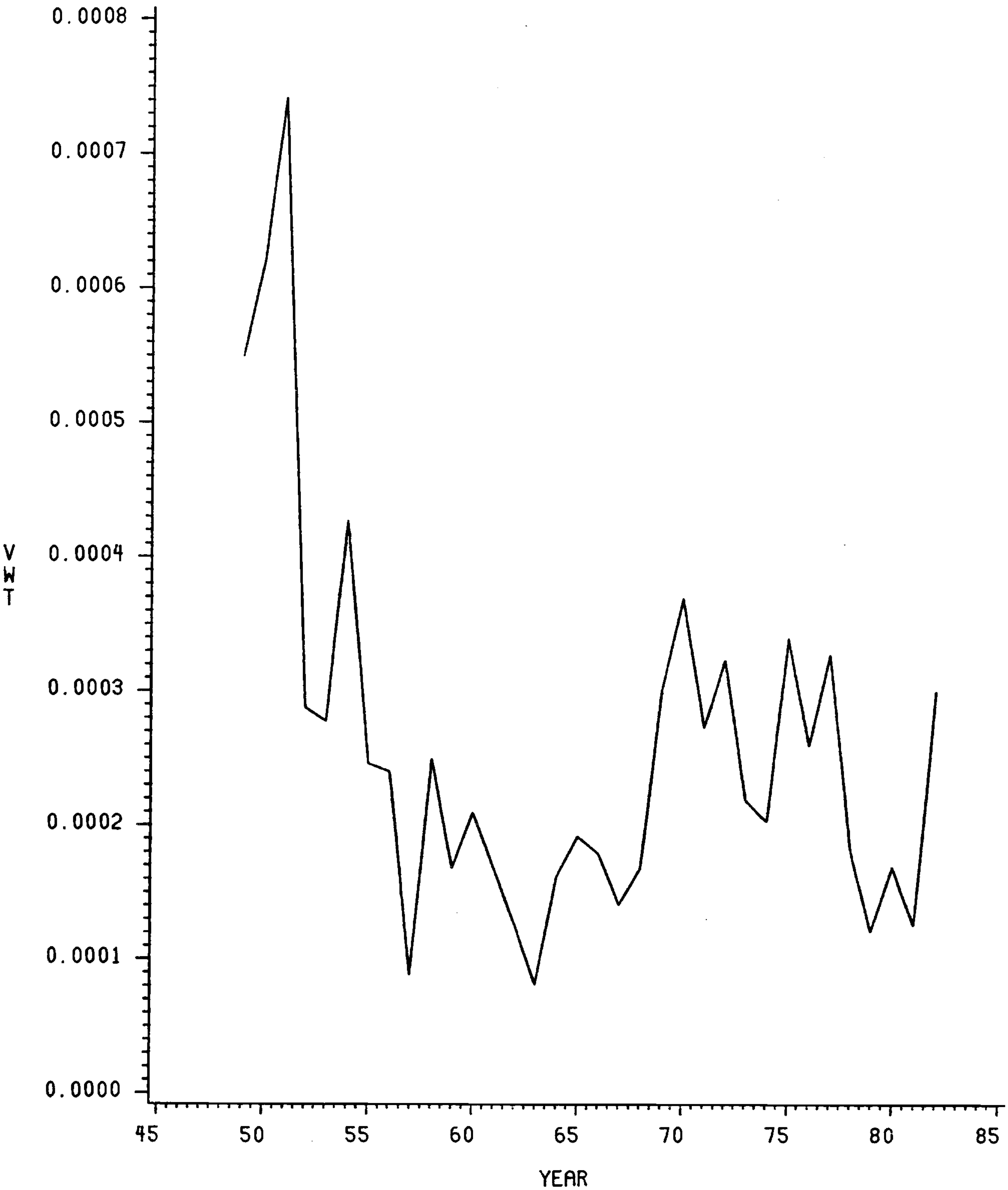


FIGURE 8: ACROSS INDUSTRY VARIANCE IN THE RATE OF CHANGE OF WAGES, 1948–1982