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BOARD OF GOVERNORS
OF THE
FEDERAL RESERVE SYSTEM

Office Correspondence

Date February 2, 1990

To Federal Open Market Committee

Subject:

From Michael J. Prell

MJP

As I indicated at the time of the December FOMC, the staff has undertaken an analysis of the forecast performance of the conventional expectations-augmented Phillips curve during the 1980s. The attached report, prepared by David Stockton and Sandy Struckmeyer, examines the predictive accuracy of the conventional wage equation and explores a variety of additional hypotheses about wage behavior in the 1980s. Their work supports the central thesis that there is an important link between wage inflation and the unemployment rate.

Attachment

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A Report to the FOMC

The Predictive Accuracy of the Wage Equation in the 1980s

by

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Division of Research and Statistics
Board of Governors of the Federal Reserve System

February 2, 1990

THE PREDICTIVE ACCURACY OF THE WAGE EQUATION IN THE 1980s

by David J. Stockton and Charles S. Struckmeyer[1]

I. Introduction

The outlook for labor costs, which constitute about two-thirds of the value of production, plays an important role in the staff's assessment of the medium-term prospects for aggregate price inflation. Although a variety of models are monitored by the staff when assembling the projection for labor costs, the expectations-augmented Phillips curve model embodies the basic underlying logic of the staff wage projection. That model hypothesizes that wage inflation is negatively related to the level of the unemployment rate and positively related to price inflation.

The large number of apparent changes in the economic environment over the course of the 1980s and the relatively modest degree of wage acceleration that has occurred over the past two years have raised questions about the reliability of conventional specifications of the wage equation. For example, the declining strength of unions and increasing global competition have been cited as possible reasons to have expected the performance of the wage equation to have faltered in recent years. Some criticisms of the conventional wage equation potentially could be addressed by adding new variables to capture the suspected omitted influences. But other criticisms are in a sense more fundamental and raise the question whether the underlying

1. We wish to thank Flint Brayton, David Lebow, Catherine Mann, Ellen Meade, Michael Prell, Peter Tinsley, and Joyce Zickler for many constructive comments. David Potter provided excellent research assistance.

paradigm that relates wage inflation to the unemployment rate and price inflation is appropriate--the thought being that only entirely different models of wage determination can truly explain the events of the 1980s.

This report addresses some of these questions, in an exploration of just how robust the Phillips curve model has proven as a predictor of wage inflation in recent years. We perform a variety of tests of the conventional specification of the wage equation and explore its out-of-sample forecast performance. In addition, we examine several key hypotheses about the behavior of wages in the 1980s and present some results from alternative models of wage determination. These are our principal findings:

- There is little evidence of statistically significant structural instability of the wage equation. Nevertheless, the model fits better in sample than out of sample. This was most pronounced in the early 1980s. In recent years, in-sample and out-of-sample performance have been similar.

- Declining union strength does not appear to have played a major role in determining the behavior of aggregate wage inflation in the 1980s.

- The results for open economy variables are mixed; we find some evidence of a role for changes in import prices, but other equally plausible measures of openness and competition are insignificant or of the wrong sign. In any event, there is little evidence that the variables we examined improve significantly the out-of-sample prediction of wages.

- The unemployment rate and past price inflation are highly correlated with wage inflation. Specifications of wage determination that ignore these variables uniformly perform worse than the conventional model in out-of-sample forecasting exercises.

We should stress at the outset that our findings do not justify complacency about current specifications of the wage equation. The design of a reliable model of aggregate wage determination--one that is capable of capturing the complexities of the wide variation in labor markets and their interactions with the rest of the economy--is still unfinished business. In that regard, we do not report here on many significant efforts at the Board and elsewhere to improve the empirical representation of wage determination. Nonetheless, the results of our work suggest that the conventional model has provided a reasonably reliable guide to wage determination in recent years. And, although we find variables that have additional explanatory power with respect to wage inflation, there is little evidence that the structure of product markets or of labor markets has changed sufficiently to have significantly attenuated the link between wage inflation, the unemployment rate, and price inflation.

In the next section, we review recent wage and compensation developments and discuss the possible sources of discrepancy in two key measures of hourly compensation. The specification and predictive accuracy of a conventional model of wage determination are examined in the third section. A number of modifications to the specification of the expectations-augmented Phillips curve are presented in the fourth section. In the fifth section, the fit and forecast performance of several alternative representations of the wage-setting process are explored. A sixth section presents our conclusions.

II. Measuring wage and compensation inflation[2]

Interpretation of recent developments has been complicated by differences in the behavior of available measures of wage and compensation inflation. The staff reports routinely on two measures of hourly compensation in the private sector of the economy--hourly

2. This section draws directly on the work of our colleague William Wascher, now on loan to the Council of Economic Advisers.

compensation in the nonfarm business sector reported in the Productivity and Cost release and the Employment Cost Index (ECI) for private industry workers. As seen in chart 1, the general contours of these compensation measures have been in rough conformity for most of the 1980s. Nevertheless, there have been instances when the two measures diverged significantly, such as during 1983 and 1986. Both measures of compensation have accelerated since early 1987. However, compensation per hour, as reported in the Productivity and Cost release, has risen about 5-1/2 percent over the four quarters ending in the third quarter of 1989; in contrast, the change in the ECI over the same period (as well as for the four quarters ending in the fourth quarter of 1989) was about 4-3/4 percent. The recent divergence, while not exceptional by historical standards, does yield a somewhat different interpretation of the current intensity of labor cost pressures.

The conceptual difference between hourly compensation in the nonfarm business sector and the ECI compensation measure is relatively straightforward. Hourly compensation is defined as the total wages and benefits received by all persons in the nonfarm business sector divided by total hours worked. In contrast, the ECI is a fixed-weight index, with the weights computed over an occupation-by-industry matrix using information from the the 1980 Census. As a result, the only conceptual reason for differences in the pace of compensation inflation implied by the two series would be compositional shifts in the mix of employment across industries and occupations. Both concepts contain information about the inflation outlook. The fixed-weight ECI concept provides the best estimate of underlying compensation trends, while hourly compensation provides a measure of changes in labor costs based on the current composition of the workforce.

In addition to the conceptual distinctions, however, differences in measurement techniques and in the sources of the data may induce distortions in the two series. The ECI is based directly on a rotating sample of employers and reflects employers' responses to questions about compensation changes for particular jobs. As a result, the ECI directly measures changes in wage and benefit costs but is subject to the errors associated with the use of a probability sample. Hourly compensation in the nonfarm business sector is derived from the data on total compensation estimated in the National Income and Product Accounts coupled with estimates of aggregate employee hours from the Bureau of Labor Statistics. Although BEA's historical estimates of compensation reflect extensive payroll information from unemployment insurance tax records and corporate tax returns, complete data only are available with a lag of several years.

Chart 2 shows changes in compensation growth for each series broken into their wage and benefit components.[3] As seen in the upper panel, the recent gap between the two measures of compensation growth has reflected the net effect of a difference in wages and salaries that has been partially offset by a difference in the measure of benefits. More detailed data reveal that changes in wages and salaries for comparable groups of production and nonsupervisory workers in the two measures are quite similar. Thus, the principal differences are to be

3. For the nonfarm business sector, benefits are measured by the BEA as the sum of "other labor income" and employer contributions for social insurance programs.

found in the measures of wages for supervisory workers. The BLS has no explanation for this current divergence, and there are no compelling reasons for the discrepancy to persist. We would expect to see some convergence of the two series over time or in subsequent annual revisions. The divergence in benefits reflects differences in methodology in the construction of the two series. The ECI is based on an actual sample of employers, while for the past few years, the BEA measure largely is extrapolated using related indicator series.

In terms of econometric modeling, the results reported below employ the Productivity and Cost measure of compensation per hour in the nonfarm business sector. Although the ECI compensation per hour measure is of interest as well, the series only begins in 1980, and in essence, only would encompass one episode of decelerating wages. As a consequence, the ECI data do not provide enough variation to obtain reliable estimates of the important underlying parameters.

III. Evidence on the predictive accuracy of a conventional model of wage determination

There are many possible specifications of a "conventional" model of aggregate wage determination.[4] We present results from a class of models that is representative of those used routinely by the staff as an aid in formulating our wage and price projections. The basic elements of the conventional wage equation are shown in column 1 of table 1. In this specification, quarterly percent changes in nonfarm business compensation per hour are a function of twelve lagged values of the quarterly percent change in the consumer price index (CPI), a

4. For convenience in the remainder of this memo, we shall use the terms "wages" and "compensation" interchangeably. However, all empirical work employs hourly compensation.

demographically weighted unemployment rate (RU), variables to measure the influence of changes in the minimum wage (MinW) and social security taxes (FICA), and a dummy variable to capture the effect of the Nixon-era wage and price controls (Controls).[5] The coefficients on the lagged price inflation variables are constrained to sum to one, but otherwise are unrestricted; the constraint implies the existence of a "natural" rate of unemployment and prevents a long-run tradeoff between inflation and unemployment. This restriction is not rejected by the data. The numbers in parentheses are t-statistics.

The model explains about 73 percent of the variation in quarterly compensation inflation. The standard error of the regression is 1.63 percent. The model suggests that a one percentage point rise in the demographically weighted unemployment rate, maintained for one year, reduces the rate of compensation inflation by 0.9 percentage point, all else equal. The implicit natural rate of unemployment (assuming trend productivity grows about 1.4 percent annually) currently is 5.9 percent.[6] Increases in the minimum wage and social security taxes have statistically significant effects on the growth in hourly compensation. The Durbin-Watson statistic, at 1.37, suggests the residuals are serially correlated, an indication that relevant variables likely have

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5. MinW is the deviation between the growth in the minimum wage and the trend rate of increase in compensation per hour. FICA is the deviation between the growth in employers contributions' for social insurance and the trend rate of increase in compensation per hour. CONTROLS is a dummy variable for the 1971 wage and price controls; it is -1 in 1971:Q4 and 1 in 1972:Q1.

6. The current 5.9 percent natural rate is down over a percentage point from its peak in the mid-1970s, reflecting favorable demographic changes as well as a pickup in trend labor productivity growth.

been omitted from the model.[7]

The actual growth in hourly compensation and the fitted values from the model are plotted in the upper panel of chart 3. The residuals of the equation are plotted in the lower panel. The equation has captured the basic contours of wage inflation reasonably well over most of the postwar period. As can be seen in the lower panel, the errors of the 1980s do not appear to have deviated in magnitude or direction from those of earlier periods. Over the past 6 years, the mean error of the equation indicates an underprediction of wage inflation of less than 0.1 percentage point and the root mean square error is 1.51 percentage points--less than for the sample period as a whole.[8] We test more formally the casual observation that there has been no structural instability of the wage equation; a Chow test with a break at the midpoint of the sample (1971:Q2) yields an F-statistic, which is not significant at the 5 percent level.

Of course, these test statistics tend to place the equation in its most favorable light. The current version of the model has the benefit of the most recent data, as well as changes in the specification of the equation that were made in response to the forecast performance of the model. At the opposite extreme, a more demanding test would be

7. We present regression and simulation results from models without correction for serial correlation in order to present a clearer picture of the performance of the model without the introduction of a lagged dependent variable. When necessary, we reestimated each model with a correction for serial correlation, and we note in the text cases where the correction for serial correlation affects importantly the tests of the hypotheses.

8. The mean errors and root mean square errors reported in table 1, table 2, and table 3 are calculated by estimating the respective regressions up to 1983:Q4 and then dynamically simulating the equation from 1984:Q1 to 1989:Q3.

to use the model as it existed at the beginning of the 1980s and examine how well it would have explained the events of the past decade. We carry out this experiment by retrieving the wage and price equations from the Board staff's quarterly econometric model as they existed in the fall of 1980.[9] We employ not just the specifications, but also the actual parameter estimates as they resided in the model. The equations then are simulated over the 1980s, and the results from the wage equation are shown in chart 4. The model overpredicted the wage inflation of the 1980s by an average of 1.39 percentage points. The most pronounced feature of the simulation is the degree to which the wage equation missed the timing and the speed of the deceleration of wage inflation in the 1981-82 recession. After 1983, the wage equation gradually gets back on track. Since 1987, both actual compensation inflation and the simulated compensation inflation picked up, and by the third quarter of 1989 the equation was nearly on the mark.

A less stringent test of the wage equation, and one that more closely approximates the conditions under which it is used, would allow the equation to be reestimated and simulated period by period. In this exercise, the equation in column 1 of table 1 is estimated from the first quarter of 1953 to the first quarter of 1976 and dynamically simulated over the subsequent eight quarters, about the normal projection interval presented in the Greenbook. The sample period then is extended an additional period, and the equation is reestimated and simulated over the next eight quarters. This procedure is carried out 47 times, up to the third quarter of 1987. The root mean square error

9. We wish to thank Flint Brayton for providing us with the quarterly model results.

and mean error for each simulation period is plotted in chart 5.[10] The average root mean square error from these 47 simulations is 1.91 percent, somewhat above the average standard error of the estimated equation of 1.63 percent.

The most notable feature of the simulation results is the poor performance of the equation in the late 1970s and early 1980s. In part, this reflects the fact that compensation gains did not capture all of the rapid acceleration of price inflation that followed in the wake of the oil shock of 1979. In addition, wages tended to slow earlier and more rapidly in response to the exceptionally severe recession than was anticipated by the equation. It seems quite possible that inflation expectations adjusted more rapidly than is implied by the adaptive expectations mechanism employed by the model. However, since about mid-1982, the equation has posted both modest over <u>and</u> underpredictions, and the root mean square error has been at the lower end of the range observed over the past fifteen years. During the past two years, the equation has tracked compensation inflation closely.

IV. Some alternative specifications of the conventional wage equation

<u>The change in the unemployment rate</u>

In addition to the conventional wage equation, we follow a number of variations on this basic specification. It often is hypothesized that, in addition to the level of the unemployment rate, the change in the unemployment rate may influence wage inflation. For example, even if the unemployment rate is low, a rise may lead to some restraint in wage setting. The result of adding the change in the

10. The observations are plotted at the initial period of the eight-quarter out-of-sample simulation.

unemployment rate to the conventional wage equation is shown in column 2 in table 1. It appears that the direction of movement in the unemployment rate does play some role. However, the result and its interpretation are tenuous at best. As noted above, this measure of hourly compensation is affected by the mix of employment and also includes changes in overtime pay that might be associated with changes in the unemployment rate. In cyclical downturns, there typically are disproportionate layoffs among high-paid durable goods workers, which tend to push down average hourly compensation in the nonfarm business economy even though wages may not have changed. Thus, the change in the unemployment rate could be capturing the effect of the changing mix of employment on average compensation. Equations using the fixed-weight hourly earnings index fail to find a significant role for the change in the unemployment rate and, consequently, tend to support the mix-shift story. A second reason to be skeptical of the result is that if the equation is corrected for serial correlation, the change in the unemployment rate is not statistically significant at the 5 percent level. In any event, inclusion of the change in the unemployment rate does not improve the out-of-sample forecast performance of the wage equation over the past six years.

Alternative inflation measures

The equations presented thus far assume that consumer prices are the only price measure relevant to the wage-setting process; the underlying assumption is that workers care about their standard of living and thus the real wage of significance to the labor supply decision is the nominal wage relative to consumer prices. However, theory suggests that labor demand is dictated by wages measured against product prices; in essence, product prices measure the capacity of firms to grant wage increases. In theory, both consumer and product prices should figure in the wage-setting process. The results of adding the difference between the percent change in product prices, as measured by the GNP fixed-weight price measure, and the percent change in the consumer price index (PGNP - CPI) are presented in column 3 of table 1. The sum of the coefficients on this variable suggest that about two-thirds of the gap between product and expenditure prices is translated into compensation inflation; in other words, when product prices rise more rapidly than consumption prices, wages receive an extra boost. By the same token, when product prices rise less rapidly than consumer prices--as may happen, for example, when import prices are rising more rapidly than prices of domestically produced products--then wages will not reflect the full extent of the rise in consumer prices. However, as seen in the bottom row of column 3, the addition of this variable does not improve the recent forecast performance of the wage equation.

The lagged price terms in the wage equation represent an adaptive formation of inflation expectations. Another approach to the specification of inflation expectations in the wage equation is to replace the lagged price terms with survey expectations of price inflation. In column 4 of table 1, the lagged price inflation terms are replaced with twelve lags of the Michigan survey of one-year-ahead inflation expectations (MICHIGAN). The substitution has little effect on the in-sample fit of the equation, and the out-of-sample forecast performance of the wage equation in recent years deteriorates when the Michigan survey results are employed.[11]

Declining union strength in the 1980s

The decline in the extent of unionization and the ebbing power of the nation's major labor unions during the 1980s stand out clearly as possible causes of the structural shifts in the conventional wage equation. Under this hypothesis, union labor was less successful in capturing part of producers' surplus than in earlier decades, and the resultant slowdown in union wages had a significant "spillover" effect on other sectors of the economy. In a Board study, David Neumark examined this thesis by adding measures of union strength to the conventional wage equation; the variables considered were union membership, union certifications and decertifications, and work stoppages.[12] He finds that these variables do not have a statistically significant effect on the growth of aggregate hourly compensation, but they do have joint explanatory power in an equation that uses median first-year collective bargaining settlements as the dependent variable. Neumark concludes that while declining union strength did influence union settlements in the 1980s, there were no important spillovers to other sectors of the economy. Ultimately, declining union strength was not found to have been an appreciable factor affecting aggregate wage determination in the 1980s.

11. The use of lagged survey results likely introduces a moving-average error into the residuals of the wage equation for which we make no correction here.
12. David Neumark, "Declining Union Strength and Wage Inflation in the 1980s," Economic Activity Section Working Paper Series, Number 96, April 1989.

Increased domestic and foreign competition in product markets

A second feature of the 1980s was an increase in competition in U.S. markets owing to the deregulation of several key domestic industries and the appreciation of the foreign exchange value of the dollar. On the domestic side, there were significant changes in the market structure of a number of industries, including the railroad, airline, trucking, and telephone industries. The resultant increase in competition drove down the prices of these services, and wage concessions were necessary in order for many firms to remain in business. Quantifying the effects of such shifts in the structure of markets is very difficult in firm-level data, and it is next to impossible in aggregate time-series data. Nonetheless, one would expect wage concessions during periods of deregulation to produce a tendency in the conventional wage equation towards overprediction. In that regard, deregulation may provide another partial explanation for the overprediction of the wage equation in the early 1980s. However, for such errors to persist, deregulation would have to continue at a constant rate. Such a requirement does not appear to have been satisfied by the pattern of deregulation in the 1980s, which occurred at discrete intervals and was concentrated in the early part of the decade.

Increased international competition also may have played an important role in moderating wage demands in the 1980s. As the dollar appreciated early in the decade, domestic companies were forced to cut costs in order to remain competitive at home and on foreign markets. The accompanying downward pressure on product prices reduced the demand for labor at any given nominal wage. In addition, to the extent that affected workers recognized that a moderation of their wage demands was necessary to preserve their jobs, labor supply would have increased at any given nominal wage.

Although economic theory suggests the channels through which such competitive influences might affect wages, it offers only rough guidance on the choice of variables to proxy for these influences in the wage equation. As a result, a number of different amendments to the conventional wage equation are tested. The first variant adds a measure of the change in import penetration to the conventional wage equation. In such a specification, the change in the ratio of imports to goods GNP might be expected to pick up the effects of international competition on both labor demand and labor supply. However, as is illustrated in column 2 of table 2, this variable is not statistically significant at the 5 percent level and, in out-of sample forecasting experiments, the resultant equation has a larger mean error and root mean square error than the conventional wage equation.

A second possible way to allow for the effects of international competition on wage determination is to add a distributed lag on the real exchange rate[13] (real FX) to the conventional wage equation (column 3 of table 2). This variable should enter the equation with a negative sign because a real appreciation of the currency is associated with more intense competition from products produced abroad. Although the real exchange rate is marginally significant,[14] it has the wrong sign. Such

13. The real exchange rate is defined as the product of the FRB index of the foreign exchange value of the dollar against 18 currencies and the ratio of the U.S. CPI to foreign CPIs.
14. The real exchange rate was not statistically significant over the 1965:Q3 to 1983:Q4 period.

a result suggests that this variable is not picking up the intended effect and, most likely, is just capturing spurious correlations between variables. In addition, in out-of-sample forecasting experiments, this equation has a higher root mean square error than the conventional wage equation.

Another specification we employed for testing the influence of foreign competition on wage determination adds to the conventional wage equation a distributed lag on the ratio of U.S. unit labor costs to foreign unit labor costs (Rel. ULC). Higher relative unit labor costs should result in a deterioration in a country's competitive position, and with a lag, induce a deceleration in the rate of growth of domestic wages. As was the case with the real exchange rate, relative unit labor costs are marginally significant but have the wrong sign (column 4 of table 2). In addition, the out-of-sample performance of this equation is considerably worse than the conventional wage equation.

Our final test for the influence of international competition on wage determination adds a distributed lag on the rate of change in nonpetroleum import prices (PM) to the conventional wage equation.[15] Import prices should enter with a positive sign as falling import prices put downward pressure on wages. One way in which this might occur is by influencing workers' expectations about inflation. But beyond this channel, the theoretical rationale for the inclusion of the change in import prices, as opposed to the real exchange rate or the <u>relative</u> price of imports, is less straightforward. In this equation, we impose the restriction that wages are homogeneous with respect to all nominal

15. Ellen Meade and Catherine Mann of the International Finance Division suggested this approach to us.

variables. As is illustrated in column 5 of table 2, a distributed lag on import prices is significant at the 5 percent level. The standard error of this equation is below that of the conventional wage equation, and the fit improves. However, the addition of the rate of change of import prices causes a marginal deterioration in the out-of-sample forecasting performance, which probably is related to the estimated 8 percent natural rate of unemployment in this specification.

We conclude from this exercise that changes in international competition probably did play a role in the variation in wage inflation over the past few years, as is illustrated by the wage equation that includes the rate of change in import prices. However, we are somewhat troubled by the sensitivity of estimated international effects to changes in specification. In addition, the implausibly high natural rate in the equation that included the change in import prices suggests to us that, while there is additional information in these variables, we still have not found the best formal specification for the influence of international competition on wage determination.

A broadly similar result emerges in a recent study by Vroman and Vroman[16] that uses a large micro dataset on collective bargaining settlements in manufacturing sector over the 1959-1984 period. Using a similar theoretical framework and econometric methods, they conclude that the effect of measures of international competitiveness on wages is statistically significant but economically small. Moreover, their principal conclusion is that high levels of unemployment and declining price inflation explain most of the slowdown in wage inflation in the

16. Susan Vroman and Wayne Vroman, "International Trade and Money Wage Growth in the 1980s," mimeo, Georgetown University, 1989.

mid-1980s. In this regard, one cautionary note is important here. It is possible that the more traditional parts of the wage equation already are capturing international effects. For example, if a sharp appreciation of the dollar boosts the unemployment rate, then one might wrongly conclude that international considerations do not affect wages.

V. Alternative Paradigms of Wage Determination

The wage-price Phillips curve is not the only model of the wage determination process. In this section, we consider five alternative models: (1) the wage-wage Phillips curve, (2) an augmented wage-price equation suggested by Blanchard,[17] (3) an M2 variant of the wage equation, (4) a velocity-gap version of the conventional wage-price Phillips curve, and (5) wage equations that key off of movements in spot commodity prices.

The wage-wage Phillips curve

In the wage-wage Phillips curve, also known as a wage-norm equation, compensation demands are based only on recent trends in compensation growth and the level of slack (as measured by the demographically adjusted unemployment rate). The theoretical motivation for this approach is that workers and firms are, in effect, concerned only with relative wages; as long as pay increases match other recent agreements, workers are satisfied. In the estimation of this equation, we impose the restriction that the coefficients on lagged growth in compensation (W) sum to one; this ensures that the equation has a reasonable steady state. The results of estimating a wage-wage specification are shown in column 1 of table 3. Generally, this

17. Olivier J. Blanchard, "Aggregate and Individual Price Adjustment," Brookings Papers on Economic Activity, 1987:1.

specification fits the data well; it has a bit lower standard error than the wage-price Phillips curve. The coefficient on the unemployment rate is well below that of conventional model and implies that an additional percentage point of unemployment reduces compensation inflation by only 1/4 percentage point over a year. In out-of-sample forecasting experiments, this specification does very poorly. It underpredicts compensation inflation over the past 6 years by almost 4 percentage points. It also has the highest root mean square error of any of the alternative models considered in this memo.[18]

Augmented wage-price model

In the augmented wage-price model, wages are a function of lagged wage inflation, lagged price inflation, and the unemployment rate. This is a more general specification than the wage-price Phillips curve, and in addition, we do not impose restrictions on the data that are suggested by economic theory; in particular, we do not force first-degree homogeneity of wages with respect to nominal variables. As a result, this model can be expected to capture more of the pure time-series properties of compensation inflation.

As shown in column 2 of table 3, lagged prices in this specification are statistically significant at the 5 percent level, while lagged wages are not. As might be expected, the coefficient on the unemployment rate falls between those of the wage-price and wage-wage models. The overall fit of this equation is better than that of

18. We also performed a static simulation of the wage-wage model, and it had a RMSE of 1.68. For comparison with the other models, particularly the conventional wage equation, the dynamic simulations probably overstate the inadequacies of the wage-wage model in out-of-sample forecasting experiments owing to the presence of the lagged dependent variable in this specification.

the wage-price Phillips curve, a result that is not surprising, given that we are using more explanatory variables and imposing no restrictions on the data. Such a result carries over to the out-of-sample experiments, where this equation has a root mean square error of 1.32 versus 1.51 in the conventional model. The chief weakness of this equation from the perspective of forecasting wages is that it implies a long-run tradeoff between inflation and unemployment, a dubious theoretical proposition. Thus, this specification may be preferred for very near-term forecasting, but the conventional wage equation probably is better suited for longer horizons over which the economic properties of the model are important.

The wage-M2 and velocity gap equation

In the wage-M2 equation (column 3 of table 3), we assume that hourly compensation growth depends only on lagged M2 growth because the rate of growth of the money supply determines the rate of inflation in the long run. Thus, M2 in this specification is viewed as a sufficient statistic for workers and firms that summarizes all relevant information. The standard error of this equation is well above those of the traditional Phillips curve specifications and it does poorly in out-of-sample simulations.

To get at the idea that workers might use the information contained in lagged money growth in forming their expectations about inflation, we have estimated an alternative specification that adds the velocity gap (VGAP), calculated from the P-star model, to the conventional wage-price Phillips curve;[19] the results are shown in column 4 of table 3. An increase in the velocity gap, defined as actual minus trend velocity, puts downward pressure on prices and should induce workers to revise downward their expectations about inflation and their wage demands. This variable is statistically significant at the 5 percent level in the wage-price equation, and the root mean square error of this equation in out-of-sample forecasts is below that of the conventional wage-price model. This suggests that information on money growth (or other financial variables) may be useful in modeling price expectations.[20]

Wage-commodity price equation

The next specification that we test is a wage-commodity price equation (column 5 of table 3). Here it is assumed that auction market prices more accurately reflect fundamental shifts in supply and demand, and that wage developments mirror the signals from these markets. The sum of the distributed lag on changes in commodity prices (COMMOD) implies that a sustained 1 percentage point increase in commodity price inflation adds about 1/3 percentage point to wage inflation after 3 years. The overall performance of this equation does not match that of the conventional wage-price model; it has a standard error of 1.92 versus 1.63 in the conventional model. In out-of-sample experiments, its root mean square error is above that of the conventional model, and

19. The unemployment rate effectively captures the information contained in the output gap, the other component of the price gap in the P-star model.
20. This also was one of the conclusions in a recent study of price equations. See David J. Stockton and Charles S. Struckmeyer, "Tests of the Predictive Accuracy of Nonnested Models of Inflation." ReStat, May 1989.

the equation demonstrates a bias towards the overprediction of compensation inflation.[21]

Our final specification adds changes in commodity prices to the conventional wage equation to see whether they have explanatory power over and above the traditional elements of the Phillips curve; the results are shown in column 6 of table 3. Changes in commodity prices are statistically significant at the 5 percent level, and the standard error of the regression is marginally lower than in the conventional wage equation. However, in out-of-sample simulations, this equation does not perform as well as the conventional wage equation, with a root mean square error of 1.725.

VI. Conclusion

The principal conclusion of this report is that the conventional wage equation has provided a reasonably reliable guide to aggregate wage determination over the course of the 1980s. In that regard, we find strong evidence that wage inflation is negatively correlated with the unemployment rate and positively correlated with past price inflation. Models that fail to incorporate the unemployment rate and past price inflation uniformly perform worse than the conventional equations. Furthermore, there is no evidence that the relationship between wage inflation and the unemployment rate changed significantly during the past decade.

Nevertheless, our findings also suggest that the conventional wage equation does not tell the whole story. We find evidence that there is some information in import prices, the velocity gap, and

21. This analysis does not suggest that commodity price signals are not useful in turning-point analysis.

commodity prices that helps to explain in-sample variation in wage inflation; the results of using these variables in out-of-sample forecasting exercises are mixed. Because the channels of influence are not clear, it remains an open question as to whether these variables are exerting a direct influence on wage setting or are proxying for some other omitted variable. For some effects, such as unionization and international competition, the evidence is more favorable at the micro level than at the macro level. Although this is not surprising from an econometric perspective, work needs to be undertaken to reconcile the micro and macro results.

Finally, as was discussed in the presentation to the FOMC in December, expectations play a critical role in the evolution of wage and price inflation. The adaptive mechanisms embodied in the equations presented in this report likely fail to capture fully the process by which workers and firms form expectations of future inflation. As indicated in the December presentation, we are working on developing reliable forecasting models that incorporate alternative representations of inflation expectations.

Table 1

Alternative Price Measures in The Conventional Wage Equation
(t-statistics in parentheses)

Dependent Variable: Compensation per hour, percent change at an annual rate

	(1)	(2)	(3)	(4)
Constant	6.852 (11.43)	6.653 (11.19)	6.649 (10.82)	5.834 (9.85)
$\sum_i CPI_{t-i}$	1.000	1.000	1.000	
$\sum_i (PGNP - CPI)_{t-i}$			.682 (5.83)	
$\sum_i MICHIGAN_{t-i}$				1.000 (620.4)
RU_t	-.922 (9.21)	-.884 (8.89)	-.837 (8.00)	-.719 (7.34)
ΔRU_t		-.813 (2.44)		
$MinW_t$	.0926 (3.16)	.0859 (2.98)	.0876 (3.29)	.0651 (2.18)
$FICA_t$	1.035 (5.56)	1.012 (5.53)	1.111 (6.42)	1.149 (6.40)
$Controls_t$	1.796 (1.47)	1.780 (1.49)	1.915 (1.77)	
R^2	.728	.736	.759	.694
Standard Error	1.628	1.598	1.434	1.612
Durbin-Watson	1.368	1.384	1.726	1.318
Mean Error[1]	-.074	.196	.379	1.391
Root Mean Square Error[1]	1.506	1.622	1.505	1.832
Sample Period	1953:Q1-1989:Q3	1953:Q1-1989:Q3	1953:Q1-1989:Q3	1953:Q1-1989:Q3

1. Mean error and root mean square are calculated by estimating the regression up to 1983:Q4 and then dynamically simulating the equation from 1984:Q1 to 1989:Q3.

Table 2
International Effects on The Wage Equation
(t-statistics in parentheses)

Dependent Variable: Compensation per hour, percent change at an annual rate

	(1)	(2)	(3)	(4)	(5)
Constant	6.852 (11.43)	7.057 (7.32)	3.227 (1.62)	5.290 (2.30)	6.689 (7.10)
$\sum_i CPI_{t-i}$	1.000	1.000	1.000	1.000	.623 (8.04)
RU_t	-.922 (9.21)	-.976 (6.70)	-.822 (6.33)	-1.415 (4.35)	-.658 (3.98)
$MinW_t$	.0926 (3.16)	.137 (1.80)	.0885 (2.60)	.0836 (.68)	.184 (2.78)
$FICA_t$	1.035 (5.56)	.860 (3.27)	.909 (4.63)	.931 (2.00)	1.041 (5.30)
$Controls_t$	1.796 (1.47)	1.394 (1.05)	1.791 (1.62)		1.092 (1.09)
Import Penet.		-121.0 (.85)			
$\sum_i$ Real FX_{t-i}			.0255 (1.86)		
$\sum_i$ Rel. ULC_{t-i}				.0471 (1.82)	
$\sum PM_{t-i}$					.377 (4.87)
R^2	.728	.770	.768	.847	.857
Standard Error	1.628	1.575	1.421	1.453	1.228
Durbin-Watson	1.368	1.493	1.891	1.731	2.12
Mean Error[1]	-.074	-1.266	.0182	-.319	.286
Root Mean Square Error[1]	1.506	2.206	1.749	2.093	1.525
Sample Period	1953:Q1-1989:Q3	1953:Q1-1989:Q3	1965:Q3-1989:Q3	1976:Q3-1988:Q4	1970:Q2-1989:Q3

1. Mean error and root mean square are calculated by estimating the regression up to 1983:Q4 and then dynamically simulating the equation from 1984:Q1 to 1989:Q3.

Table 3
Alternative Paradigms for Wage Determination
(t-statistics in parentheses)

Dependent Variable: Compensation per hour, percent change at an annual rate

	(1)	(2)	(3)	(4)	(5)	(6)
Constant	1.270 (2.24)	4.923 (4.59)	1.000 (1.305)	7.008 (12.32)	5.049 (27.56)	7.055 (11.50)
$\sum_i CPI_{t-i}$		.493 (3.65)				.926 (31.71)
$\sum_i W_{t-i}$	1.000	.277 (1.53)				
RU_t	-.267 (2.80)	-.500 (4.14)		-.947 (9.97)		-.925 (9.06)
$MinW_t$	.0792 (2.80)	.0764 (3.04)	.0670 (1.68)	.0912 (3.29)	.0495 (1.41)	.094 (3.21)
$FICA_t$	1.135 (6.08)	1.021 (6.41)	1.236 (4.80)	1.057 (5.99)	1.021 (4.41)	.993 (5.13)
$Controls_t$	2.550 (2.18)	2.221 (2.17)	1.856 (1.12)	1.821 (1.58)	2.309 (1.63)	1.893 (1.56)
$\sum_i M2_{t-i}$			.614 (6.46)			
$VGAP_t$				-10.227 (4.07)		
$\sum_i COMMOD_{t-i}$					.394 (10.09)	.074 (2.54)
R^2	.699	.744	.383	.738	.534	.739
Standard Error	1.544	1.397	2.211	1.540	1.921	1.605
Durbin-Watson	1.914	1.916	.819	1.516	1.071	1.451
Mean Error[1]	-3.700	-.0431	2.420	.325	1.120	.028
Root Mean Square Error[1]	4.292	1.323	3.137	1.386	1.975	1.725
Sample Period	1953:Q1-1989:Q3	1953:Q1-1989:Q3	1953:Q1-1989:Q3	1953:Q1-1989:Q3	1953:Q1-1989:Q3	1953:Q1-1989:Q3

1. Mean error and root mean square are calculated by estimating the regression up to 1983:Q4 and then dynamically simulating the equation from 1984:Q1 to 1989:Q3.

Chart 1

Alternative Measures of Hourly Compensation

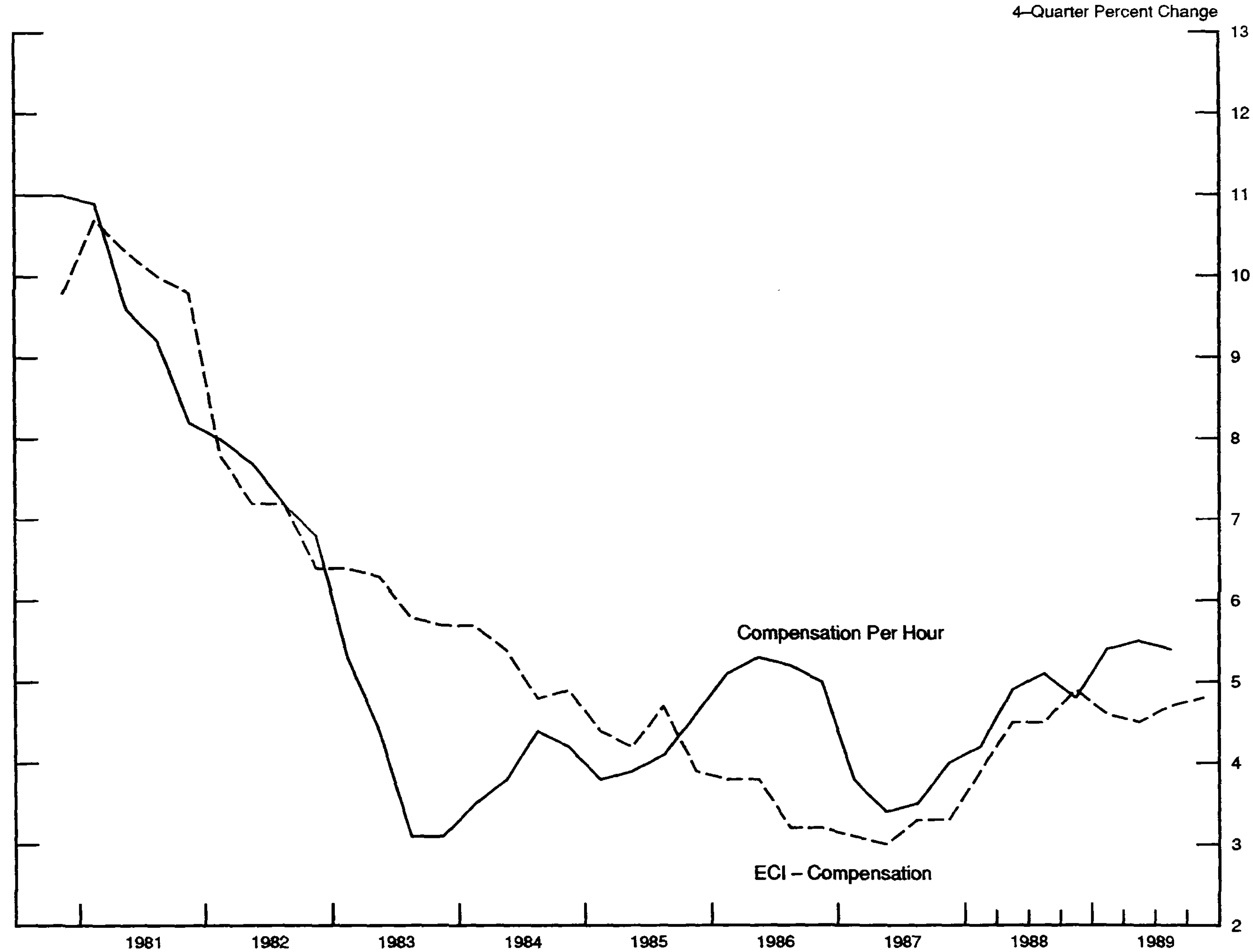


Chart 2

Components of Compensation Growth

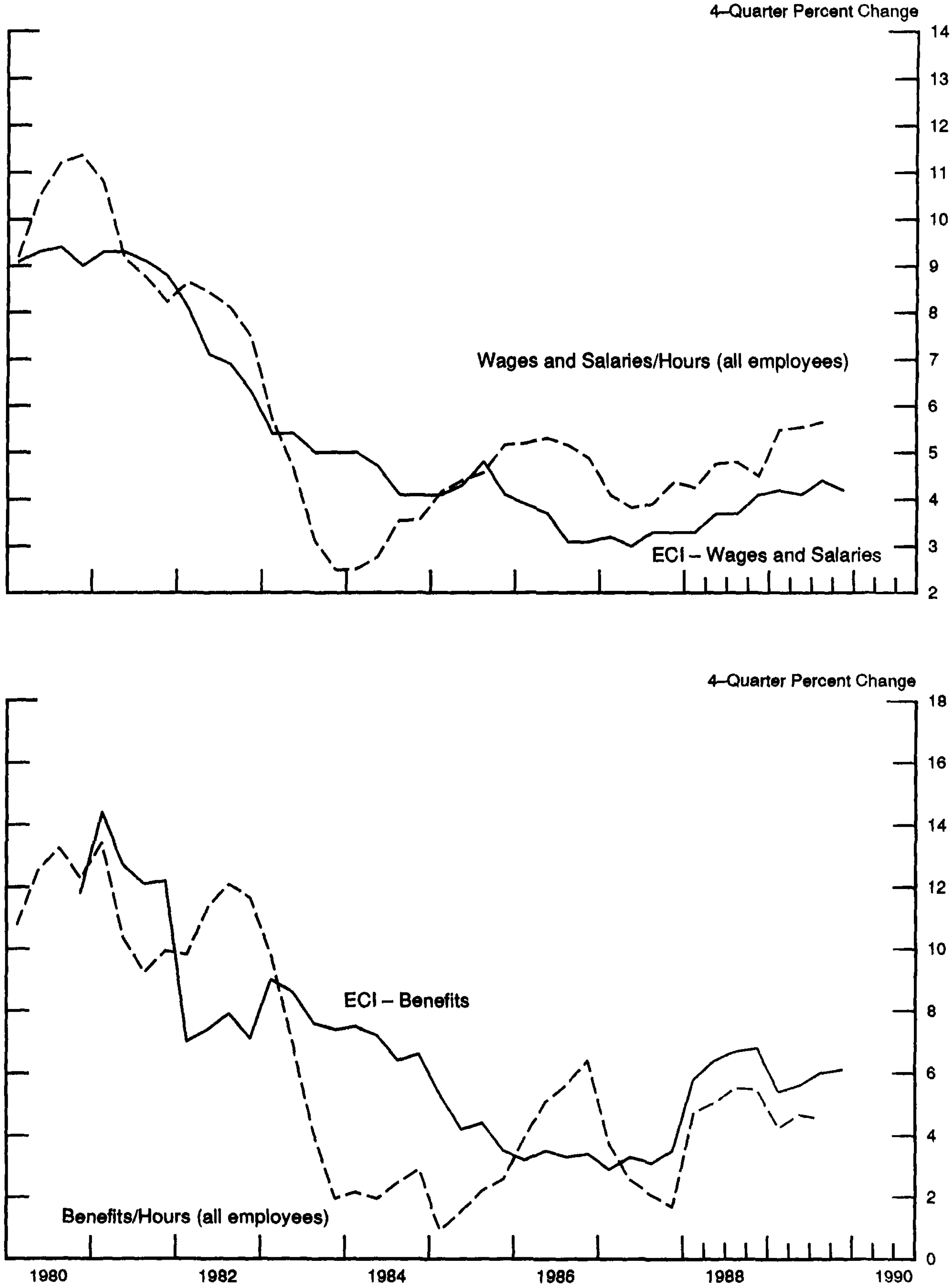


Chart 3

A Conventional Wage Equation

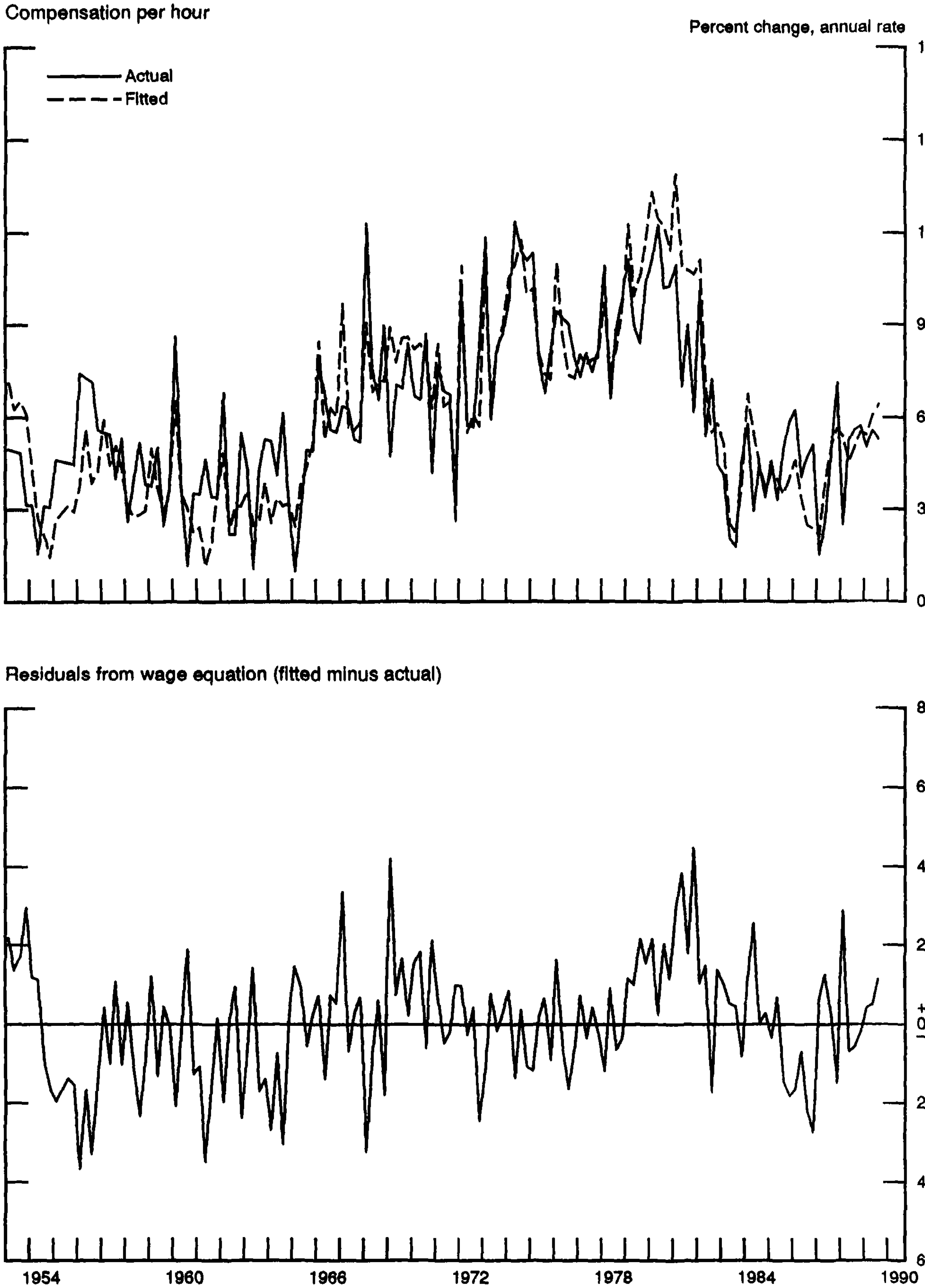


Chart 4

The 1980 Version of the Quarterly Model Wage Equation

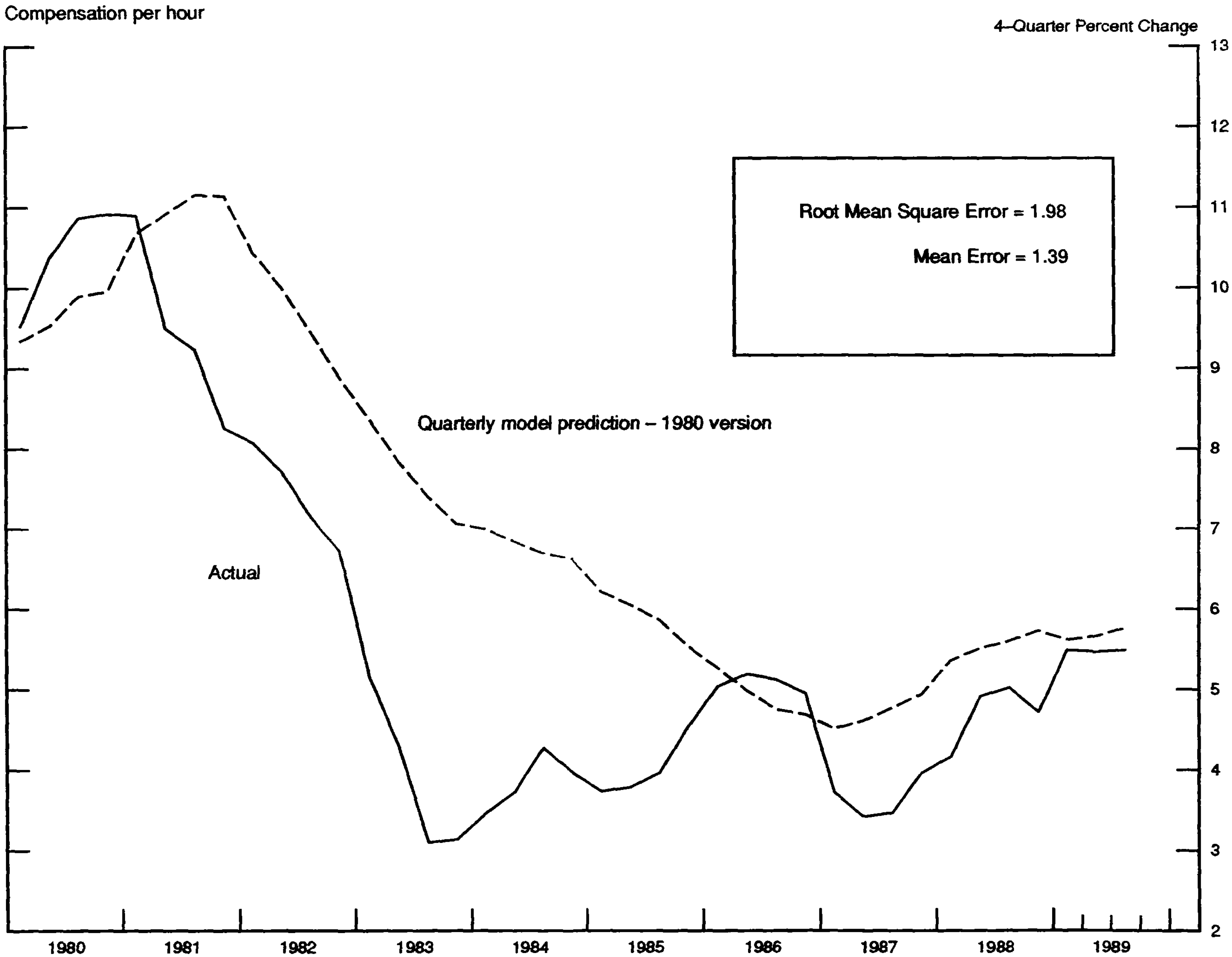
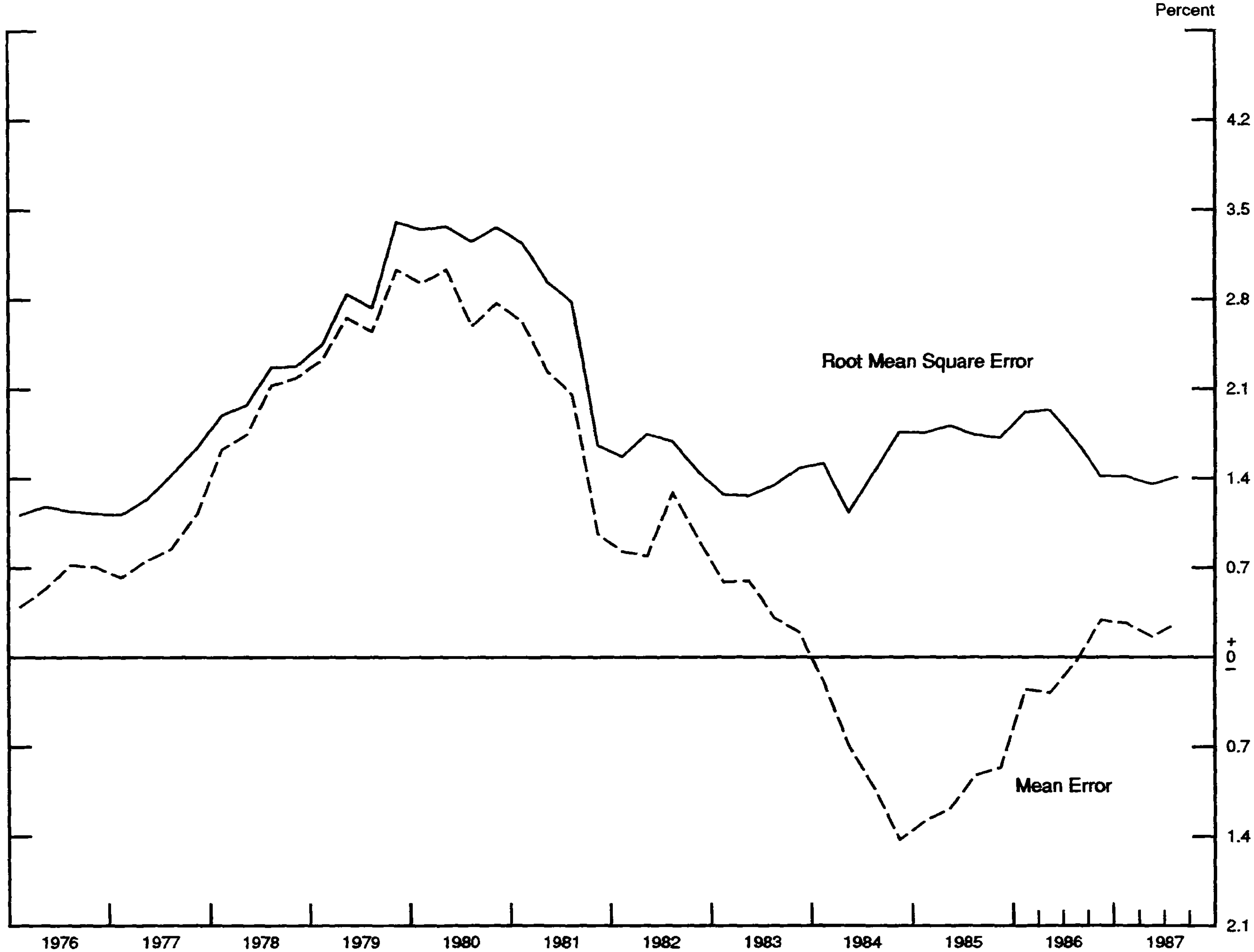


Chart 5

Mean Errors and Root Mean Square Errors from Rolling Simulations



Statistics are plotted in the first period of the eight-quarter simulation.