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Wage Flexibility and Economic Performance: Evidence Across Industrial Countries

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Wage Flexibility and Economic Performance: Evidence Across Industrial Countries

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Abstract

This paper provides new empirical evidence on the degree of nominal wage flexibility in a sample of nineteen industrial countries. Across countries, aggregate uncertainty increases the degree of wage flexibility in the face of various shocks. Wage flexibility stabilizes fluctuations in real output and guarantees workers a higher real standard of living in response to aggregate demand shocks. Wage flexibility in response to energy price shocks guarantees workers higher real wages without exacerbating price inflation or output contraction. Nominal wage inflation decreases in response to productivity shocks, reinforcing output expansion.

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I. Introduction

Business-cycle theory has focused on cyclical fluctuations among economic variables. Theoretical models have focused on the explanation of the real and inflationary effects of aggregate demand shocks. In the equilibrium explanation of business cycles, e.g., Lucas (1973), imperfect information plays a key role in explaining the output-inflation tradeoff in the face of aggregate demand shifts. In contrast, nominal rigidity is a key factor in the context of new Keynesian explanation of business cycles. This rigidity interferes with market forces in labor and/or product markets. In sticky-price models of business cycles (see, e.g., Ball, Mankiw, and Romer (1988)), "menu costs" determine the frequency of price adjustment and, in turn, the output-inflation tradeoff. Alternatively, in sticky-wage models (see, e.g., Gray (1978)), the presence of implicit or explicit agreements in the labor market determines the frequency of wage and salary negotiations. Wage flexibility determines the allocation of cyclical shifts among nominal and real magnitudes in labor and product markets.

The primary difference between the contractual wage-rigidity explanation and contending explanations of business cycles is in the detailed connection between cyclical conditions in the labor market and economic fluctuations. Given cyclical fluctuations in wages and labor employment, the theory explains cyclical fluctuations in output and price in the product market. This is in contrast to competing explanations of business cycles that do not account for a detailed treatment of cyclical conditions in the labor market. Specifically, the Lucas imperfect-information model eliminates the need for an explicit treatment of cyclical fluctuations of wages by assuming that agents are self-employed for simplicity. In the context of the sticky-price new Keynesian models, wages are determined by equilibrium conditions in the labor market or in the form of "installment payments" that do not vary with the cycle.

The apparent differences between the various explanations of business cycles have stimulated the interest of macro-economic researchers to differentiate their empirical validity. The focus of the empirical research has been on testable hypotheses that differentiate the alternative explanations.[2] The current investigation seeks to contribute to these efforts. Specifically, the analysis of the paper will evaluate the validity of the unique implications of the sticky-wage explanation of business cycles concerning the relevance of labor-market conditions to the output-inflation tradeoff.

Towards this objective, the paper's theoretical background studies the implications of several measures of nominal wage rigidity depending on the type of shock impinging on the economic system. Hence, the theoretical model incorporates a broad measure of aggregate demand shocks and two specific measures of supply-side disturbances: a shock to the energy price and a productivity shock. The empirical investigation provides new evidence that measures the degree of nominal wage flexibility in the face of these shocks in a sample of

[2] Examples are Kormendi and Meguire (1984); Ahmed (1987); Bils (1987); Ball, Mankiw, and Romer (1988); Kandil (1991a), (1991b); Gray, Kandil, and Spencer (1992); Kandil and Woods (1995), (1997); and Kandil (1995a), (1995b), (1996), (1997), (1999), and (2000).

nineteen industrial countries. These measures are likely to be affected by the duration of contractual wage agreements, as well as the degree of nominal wage indexation, to each of the shocks in the economy. In the absence of wage indexation, longer contracts increase the rigidity of the nominal wage and, in turn, the cyclical response of the real wage to various shocks. This channel is hypothesized to be important in differentiating the effects of demand and supply shocks across countries.

The paper's evidence is based on the estimation of empirical models of real output, the price level, and the real and nominal wage. Empirical proxies are established for the three shocks under investigation. Cross-sectional variation is evaluated for the possible endogeneity of nominal flexibility with respect to a broad measure of stochastic uncertainty impinging on the economic system. To summarize, aggregate uncertainty appears particularly important in differentiating the degree of nominal wage flexibility in the face of aggregate demand shocks across countries. Nominal wage flexibility is correlated with an increase in price inflation and a decrease in real output expansion. Aggregate uncertainty is also significant in increasing the flexibility of the nominal wage in the face of each of the energy price shock and the productivity shock across countries. Nominal wage flexibility does not differentiate, however, the real and inflationary effects of energy price shocks across countries. In contrast, the downward flexibility of nominal wage inflation in response to productivity shocks increases real output growth across countries.

The remainder of the paper is organized as follows. Section II provides a theoretical background for the present investigation. Section III describes the empirical model. Estimation results are presented in Section IV. Cross-sectional analysis of the time-series estimates is provided in Section V. A summary and conclusion are offered in Section VI.

II. Theoretical Background

To motivate the empirical investigation of this paper, this section presents an example of a contractual wage rigidity model in which conditions in the labor market determine cyclical fluctuations in nominal and real variables. For more details, see Kandil and Woods (1997).

In brief, the supply side of the model consists of a number of sectors (industries) that comprise the aggregate output supplied. Each sector, in turn, consists of a continuum of identical firms that are distributed uniformly between zero and one. Only one commodity is produced in each sector. There are no relative prices or quantities. The only thing that distinguishes between firms is the time elapsed since they negotiated their last contract. The signing dates of contracts are assumed to be uniformly staggered. That is, at any instant of time an equal number of firms negotiate a new contract.

All contracts are of equal length. The contract sets a path of non-contingent nominal wage rates for the duration of the contract. After contracts are negotiated, the employment decision is entirely at the discretion of the firm. Employment by each firm depends on the nature of contracts as well as the labor market conditions. Each contract specifies a contract length and a path of non-contingent nominal wages for the contract duration. The contract wage is assumed to be set at the value that is expected to clear the labor market in each period of the contract using available information at the time contracts are drawn up. Firms set contract length at the value that minimizes the expected cost resulting from output deviations from its desired level that would prevail in the absence of contractual wage rigidities, i.e., the output produced by the level of employment corresponding to the intersection of the labor supply and demand schedules.

The theoretical model incorporates three types of shocks: aggregate demand shocks and two specific supply-side shocks: productivity shocks and energy price shocks. Based on the model's solution, each variable is decomposed into a natural rate component and a cyclical component. The natural rate component is a function of anticipated shifts at the time of contract negotiation. The natural components of all variables are functions of anticipated supply-side shifts that enter the production function for the specific firm. In addition, anticipated aggregate demand shifts determine the full-equilibrium values of the price level and the nominal wage.

The cyclical component expresses the variables' deviation from its natural rate (full-equilibrium level) in terms of unanticipated shifts. These are unit innovations in the output price, the demand shift, the productivity shift, and the energy price shift from the signing date of contracts up to the most recent time. Cyclical effects diminish over time. Further, a shock that occurred before the signing date of the oldest contract in the economy has no cyclical impact today. That is, longer contracts increase the size of the cyclical movements.

In the absence of contractual wage rigidity, the model predicts that wage and price will be fully flexible, and hence the realized real output will remain at its natural (full equilibrium value) over time. Anticipated demand shifts at the time of contract negotiation will be fully absorbed in wage and price inflation with no response of real activity to these shocks. By contrast, anticipated supply-side shifts determine the full-equilibrium values of real output and the price level. An anticipated increase in labor productivity increases the natural rate of real output and, therefore, decreases the full-equilibrium value of the price level. Higher productivity stimulates the demand for labor and, therefore, increases the nominal wage. Concurrently, lower prices prompt workers to accept lower wages. The combined effect of the two channels is inconclusive. The steeper the demand curve is, the larger the reduction in price and the higher the probability of lower nominal wages in response to the increased productivity. In contrast, an anticipated increase in the energy price is contractionary for the natural rate of real output and, therefore, accelerates the full-equilibrium value of price inflation. Higher energy prices decrease the demand for labor and decrease the nominal wage.[3] Concurrently, higher prices prompt workers to negotiate higher wages. The combined effect is also inconclusive. The steeper the demand curve is, the larger the increase in price and the higher the probability of a rise in the nominal wage in response to an increase in energy prices.

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[3] The theoretical model assumes complementary labor and energy in the production process.

The presence of a fixed nominal wage leads, however, to different results. A positive aggregate demand shock that is realized after contracts are negotiated raises the price level and lowers the real wage. Consequently, the realized real wage is smaller than its market clearing value, leading to a positive response of output to aggregate demand shocks and to a reduction in the price and nominal wage responses to these shocks. When this occurs, real output is above its full-equilibrium value. Consistent with the sticky-wage new Keynesian explanation of business cycles, wage and price inflation fall below the full-equilibrium values. As contract length increases, these cyclical deviations become larger and more protracted.

The presence of contractual wage rigidities also creates cyclical deviations in the response of output, wages, and prices to productivity and energy price shocks. A positive productivity shock that is realized after contracts are negotiated increases the marginal product of the labor input and decreases the output price. Consequently, the realized real wage is larger than its market-clearing value, which moderates output expansion and price deflation in the face of a positive productivity shock. This is likely to moderate the effect of the productivity shock (positive or negative) on the nominal wage. Similarly, a positive energy price shock that is realized after contracts are negotiated decreases the marginal product of the labor input and increases the output price. Consequently, the realized real wage is smaller than its market-clearing value, which moderates the contractionary effect of a positive energy price shock on real output and its inflationary effect on the price level. Consequently, the effect of the energy price shock on the nominal wage (positive or negative) becomes more moderate. Cyclical deviations in response to unanticipated changes in supply-side shifts increase as contract length increases.

The model's solution clearly demonstrates that contract length is an important determinant of the size and duration of macro-economic fluctuations. Contract length is endogenously determined within the model. Contract length increases as the cost of negotiating contracts increases and decreases with an increase in the amount of uncertainty.[4] An increase in uncertainty increases losses attributed to output deviations from its desired level, following contract negotiation.[5]

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[4] For a theoretical illustration of these results, see Gray (1978), Canzoneri (1980) and Gray and Kandil (1991).

[5] The theoretical model does not incorporate an explicit indexing parameter. The implications of this modification remain consistent concerning the effects of demand uncertainty in determining wage rigidity and subsequent effects. Demand uncertainty increases the optimal degree of wage indexation, increasing nominal wage flexibility while moderating fluctuations in the real wage (see, e.g., Gray (1978)).

III. Empirical Model

The empirical investigation analyzes annual data for nineteen industrial countries: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Ireland, Italy, Japan, the Netherlands, New Zealand, Norway, Spain, Sweden, Switzerland, the United Kingdom, and the United States.[6] The data are annual over the sample period 1958 to 1998.[7]

Approximating wage flexibility is crucial for the empirical investigation of the paper's theoretical hypotheses. Wage flexibility is likely to vary in response to the length of implicit or explicit contracts and the degree of wage indexation. Rather than relying on ad hoc measures, wage flexibility is determined by estimating the time-series response of the nominal wage to aggregate demand and supply shocks.[8]

In the first step of the empirical investigation, four time-series regressions will be estimated for each country. The regressions approximate the effects of changes in aggregate demand, the energy price and productivity on real output, price, the nominal wage, and the real wage.[9] The time-series parameter estimates will approximate cyclical fluctuations in response to the shocks employed in the empirical model. Theory predicts that these fluctuations are likely to vary with nominal wage flexibility. In the second step of empirical investigation, cross-sectional analysis will test predictions concerning variation in the time-series parameter estimates.

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[6] This sample comprises all industrial countries according to the United Nations' classification, except for Iceland, which is excluded due to data limitation.

[7] Quarterly data are not available for all series in various countries. Description and sources of data are described in Appendix 2.

[8] The empirical literature on the cyclical behavior of wages includes aggregate and disaggregated studies. Examples of aggregate studies are Wachter (1976), Sachs (1980), and Allen (1992). Disaggregated studies include Chirinko (1980) and Kim (1989). Some of the ad hoc measures of wage flexibility, e.g., unionization rates, are not available for all countries under investigation.

[9] Nominal GNP or GDP approximates aggregate demand. It is possible, however, that this proxy is affected by supply variables in the economy. Accordingly, the empirical model accounts for two major sources of supply-side shifts: changes in the energy price and in the output produced per worker. By accounting for major supply-side shifts, shocks to nominal GNP/GDP capture the effects of demand-side shocks. Assuming rational expectations, each demand and supply variable is decomposed into anticipated and unanticipated components. This decomposition is also intended to separate the permanent component of the process, anticipated, from the transitory component, unanticipated.

The stationarity of the variables under investigation is tested following the suggestions of Nelson and Plosser (1982). Based on the results of Fuller (1976), and Dickey and Fuller (1981), stationarity of variables is rejected.[10] Given these results, the empirical models are specified in first-difference form as follows:

$$\begin{aligned} Dy_t = a_0 + a_1 E_{t-1} Dq_t + a_2 E_{t-1} D\tau_t + a_3 Dy_{t-1} \\ + a_4 Dns_t + a_5 Dqs_t + a_6 D\tau s_t + v_{yt} \end{aligned} \quad (1)$$

$D(.)$ is the first-difference operator and y_t is the logarithm of real output. The logarithm of the energy price is denoted by q_t where $E_{t-1}Dq_t$ denotes agents' forecast of the change in energy price given information at time $(t-1)$. The logarithm of productivity is denoted by τ_t where $E_{t-1}D\tau_t$ denotes agents' forecast of the change in productivity. The lagged value of output is added to account for possible persistence in output over time.[11] Unanticipated demand shifts, Dns_t, are measured by the difference between the growth of nominal GNP/GDP at time t and its forecast.[12] Unanticipated change in the energy price is measured by the difference between Dq_t and its forecast and denoted by Dqs_t. The difference between $D\tau_t$ and its forecast measures the unanticipated component of the productivity change which is denoted by $D\tau s_t$.[13] Finally, the term v_{yt} is a stochastic error at time t with mean zero and constant variance.[14]

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[10] Detailed results are available upon request.

[11] One lag has proven to be adequate to capture all the dynamics in output. Additional lags are statistically insignificant.

[12] This is a broad measure that accounts for a variety of shocks that underlie aggregate demand: domestic shocks to consumption, investment, government spending, velocity and the money supply as well as foreign shocks to net exports and capital mobility. As explained in Appendix 1, the estimation technique accounts for the endogeneity of aggregate demand. In addition, the equation of aggregate demand growth accounts for variables that determine its endogeneity. Accordingly, aggregate demand shocks (the difference between the endogenous proxy and the fitted value from the forecast equation) are exogenous, by construction, i.e., purely random and uncorrelated with the right-hand side variables in the estimated equations.

[13] Based on data availability, productivity is measured by the ratio of total output to employment. This is a broad measure that captures the change in the output produced per worker in response to changes in the marginal product of labor or other factors in the production function that relate to advances in capital and technological innovations. By construction, productivity changes are endogenous. As explained in Appendix 1, the estimation technique accounts for this endogeneity in two ways: (i) First, instrumental variables are used to proxy the endogenous productivity variable. (ii) Second, the equation for agents' forecast of productivity accounts for variables that are likely to determine its

(continued...)

Similarly, the equation approximating the change in the output price is specified as follows:

$$\begin{aligned} Dp_t = b_0 + b_1 E_{t-1} Dq_t + b_2 E_{t-1} D\tau_t + b_3 E_{t-1} Dn_t \\ + b_4 Dns_t + b_5 Dqs_t + b_6 D\tau s_t + v_{pt} \end{aligned} \tag{2}$$

where, Dp_t measures the change in the logarithm of the industrial output price. In contrast to the output equation, changes in the output price are determined by anticipated and unanticipated shifts in aggregate demand. The term v_{pt} is a stochastic error at time t with mean zero and constant variance.

To test the implications of the contractual wage rigidity model on conditions in the labor markets, empirical models for nominal and real wages are specified as follows:

$$\begin{aligned} Dnw_t = c_0 + c_1 E_{t-1} Dq_t + c_2 E_{t-1} D\tau_t + c_3 E_{t-1} Dn_t \\ + c_4 Dns_t + c_5 Dqs_t + c_6 D\tau s_t + v_{nwt}; \end{aligned} \tag{3}$$

$$\begin{aligned} Drw_t = d_0 + d_1 E_{t-1} Dq_t + d_2 E_{t-1} D\tau_t + d_3 E_{t-1} Dn_t \\ + d_4 Dns_t + d_5 Dqs_t + d_6 D\tau s_t + v_{rwt} \end{aligned} \tag{4}$$

where Dnw_t and Drw_t measure the change in the logarithm of nominal and real wages, respectively. Anticipated demand shifts are fully perceived by workers. Thus, workers are assumed to be able to secure changes in their nominal wage equal to the expected rate of change of the aggregate price level. This is consistent with a zero net impact on the real wage.[15] Contractual wage rigidity determines the responses of the nominal wage and the real

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endogeneity. Accordingly, productivity shocks (the difference between the endogenous proxy and the fitted value from the forecast equation) are exogenous, i.e., purely random and uncorrelated with right-hand side variables in the estimated equations.

[14] Anticipated demand shifts are fully perceived by agents and, in turn, they are not likely to have any positive effect on real output. For contracts longer than one year, nominal wages may not adjust fully to anticipated demand shifts at time t-1. Accordingly, anticipated demand shifts may prove non-neutral. Testing the validity of this hypothesis is beyond the scope of this paper. Further, anticipated demand shifts are orthogonal, by construction, to unanticipated shifts. Accounting for anticipated demand shifts in the output equation does not determine, therefore, the response of output to aggregate demand shocks, which is the primary focus of this paper.

[15] The validity of this prediction is dependent, however, on the institutional structure that determines the speed of wage adjustment to anticipated demand shifts. For example, contracts of duration longer than one year may prevent the wage adjustment despite the fact that demand shifts are anticipated.

wage to various shocks. More rigidity is consistent with a smaller response of the nominal wage to aggregate demand and energy price shocks and, therefore, a bigger reduction in the real wage. Further, the increased rigidity moderates the effect of unanticipated productivity shifts on the nominal wage and exacerbates the increase in the real wage.[16]

IV. Estimation Results

Appendix 1 outlines the details of forming the proxies for agents' forecast of aggregate demand, the energy price and productivity. Once empirical proxies are constructed, the empirical models are estimated following the details outlined in Appendix 1.

The focus of this investigation concerns wage flexibility and the real and inflationary effects of aggregate demand and supply shocks.[17] To conserve space, Table 1 summarizes the variables' responses to aggregate demand shocks, energy price shocks, and productivity shocks in models (1) through (4). The evidence is evaluated based on statistical significance at the five or ten percent levels.

Fourteen countries (Australia, Austria, Belgium, Canada, Denmark, France, Germany, Japan, the Netherlands, Norway, Spain, Sweden, Switzerland, and the United States) indicate statistically significant increases in output growth resulting from unanticipated rise in nominal GNP/GDP. For these countries, demand shocks induce cyclical fluctuations in real output growth. Across countries, the average response of output growth to aggregate demand shocks is 0.45 with a standard deviation 0.28. Countries that are characterized by a steep supply curve, i.e., a small response of output growth to aggregate demand shocks include Italy, New Zealand, and Ireland. Countries that are characterized by a flat supply curve, i.e., a large response of output growth to aggregate demand shocks, include Austria, Switzerland, and the United States.

Nine countries (Australia, Canada, Denmark, Italy, Japan, the Netherlands, New Zealand, Switzerland, and the United States) show negative and statistically significant change in output growth resulting from unexpected energy price increases. For these countries, energy is an important input in the production process. Across countries, the average response of output growth to energy price shocks is -0.019 with a standard deviation 0.024. Countries that demonstrate the largest output contraction in the face of energy price shocks include the Netherlands, Italy, and Denmark. In contrast, output growth appears the least affected by the

[16] Unlike the output equation, equations (2) through (4) do not account for a lagged dependent variable. By construction, anticipated demand shifts account for the lagged values of wage and price.

[17] The investigation focuses on the contemporaneous response of variables to demand and supply shocks within a year period. These parameters approximate wage flexibility and accompanying fluctuations in the short-run. The average economy-wide contract length and the stipulation of wage indexation determine wage flexibility.

contractionary effects of energy price shocks in New Zealand, Ireland, Sweden, Norway, and France.

Eight countries (Australia, Finland, Ireland, Italy, Japan, New Zealand, Sweden, and the United States) indicate significant output increases in response to an unexpected increase in productivity. In these countries, workers' productivity contributes to fluctuations in output growth. Across countries, the average response of output growth to productivity shocks is 0.42 with a standard deviation 0.51. Countries that demonstrate the largest expansion in the face of productivity shocks include New Zealand, Sweden, Ireland, and Belgium. In other countries (Canada, Denmark, and Germany), there is evidence of a negative response of output growth to productivity shocks. That is, output growth appears to be decreasing, on average over time, despite an increase in productivity growth. Other determinants of output growth dominate over time.

Twelve countries (Australia, Belgium, France, Ireland, Italy, Japan, the Netherlands, New Zealand, Norway, Spain, Sweden, and the United Kingdom) show statistically significant increases in price inflation in response to aggregate demand shocks. In these countries, price inflation adjusts flexibly in the face of demand shocks. Across countries, the average response of price inflation to aggregate demand shocks is 0.52 with a standard deviation, 0.39. The highest inflationary effects are evident for Italy, New Zealand, Ireland, and the United Kingdom, indicating a steep supply curve. In contrast, the evidence of price rigidity in the face of aggregate demand shocks includes Canada, Denmark, Switzerland, and the United States, indicating a flat supply curve.

Ten countries (Australia, Austria, Belgium, Denmark, Finland, Germany, Italy, Norway, Spain, and the United States) show a statistically significant increase in price inflation in response to energy price shocks. Price inflation is dependent on the energy price in these countries. Across countries, the average response of price inflation to energy price shocks is 0.025 with a standard deviation 0.029. The highest inflationary effects are evident for Italy and Finland. In contrast, the evidence of price rigidity in the face of energy price shocks includes Ireland, Switzerland, the Netherlands, Sweden, and France.

In addition, fourteen countries (Australia, Austria, Belgium, Canada, Finland, Ireland, Italy, Japan, New Zealand, Norway, Spain, Sweden, Switzerland, and the United States) indicate statistically significant decline in price inflation resulting from productivity shocks. An increase in labor productivity relaxes capacity constraints and moderates price inflation. Price deflation in the face of unanticipated changes in productivity appears more pervasive compared to output expansion. Across countries, the average response of price inflation to productivity shocks is -0.70 with a standard deviation 0.69. Price deflation is evident for New Zealand, Canada, Norway, and Switzerland. In contrast, price rigidity in the face of productivity shocks is evident in the Netherlands, Denmark, and France. That is, price inflation is increasing, on average over time, despite an increase in productivity growth. Other determinants of price inflation dominate over time.

Ten countries (Belgium, Finland, France, Ireland, Italy, Japan, the Netherlands, New Zealand, Sweden, and the United Kingdom) indicate statistically significant nominal wage inflation in response to aggregate demand shocks. In these countries, workers are able to adjust nominal wages and keep up with demand inflation. Across countries, the average response of nominal wage inflation to aggregate demand shocks is 0.49 with a standard deviation 0.38. The inflationary effects are evident in Italy, New Zealand, the United Kingdom, and Ireland. Nominal wage rigidity in the face of aggregate demand shocks is evident in Canada, the United States, Austria, Norway, and Switzerland.

The inflationary effects of the energy price on the nominal wage appear also pervasive. Eleven countries (Australia, Austria, Belgium, Canada, Denmark, Germany, Ireland, Italy, New Zealand, Sweden, and Switzerland) indicate significant nominal wage inflation in response to energy price shocks. In these countries, workers are able to adjust nominal wages and keep up with energy price inflation. Across countries, the average response of the nominal wage to energy price shocks is 0.045 with a standard deviation 0.033. The highest inflationary effects are evident for Italy, New Zealand, Belgium, and Australia. In contrast, rigidity of the nominal wage in the face of energy price shocks is evident for France, the United States, the Netherlands, and Japan.

In addition, three countries (Austria, France, and Switzerland) indicate significant increase in nominal wage inflation in the face of productivity shocks. In these countries, workers are compensated for higher productivity. Nonetheless, two countries (Ireland and Spain) indicate significant decline in nominal wage inflation in the face of productivity shocks. In these countries, higher productivity relaxes capacity constraints and moderates nominal inflation. Across countries, the average response of the nominal wage to productivity shocks is positive, 0.22, with a standard deviation 0.58. The increase in the nominal wage in the face of productivity shocks is particularly evident in France, Canada, the Netherlands, Italy, and Germany. The reduction in the nominal wage in the face of productivity shocks is evident in Spain, Ireland, Australia, the United States, the United Kingdom, Sweden, and Japan.

The signs are consistent with a counter-cyclical response of the real wage to aggregate demand shocks for eleven countries (Australia, Austria, Belgium, Canada, Denmark, Germany, Ireland, Italy, New Zealand, Sweden, and Switzerland). In these countries, workers are not able to adjust nominal wages and keep up with demand inflation. The counter-cyclical response remains, however, statistically insignificant. Only two countries (Japan and Norway) show significant real wage decline in response to aggregate demand shocks. In these countries, nominal wage adjustment is not adequate to compensate workers fully for price inflation. Across countries, the average response of the real wage to demand shocks is negative, -0.024, with a standard deviation 0.25. The majority of the countries exhibit a counter-cyclical response of the real wage to aggregate demand shocks. The largest reduction of the real wage is evident in Norway, Sweden, Spain, and Japan. Six countries demonstrate an increase in the real wage in the face of aggregate demand shocks. The largest increase is evident in Denmark and France.

For most countries, nominal wage inflation must be sufficiently strong to keep real wages from significantly declining in the face of energy price shocks. The decline in the real wage in response to energy price shocks is statistically insignificant. However, for five countries (Austria, Belgium, Ireland, New Zealand, and Sweden) nominal wage inflation must be sufficiently strong to ensure a statistically significant positive growth in real wages in response to unexpected rise in energy prices. Across countries, the average response of the real wage to energy price shocks is positive, 0.024, with a standard deviation 0.037. The majority of countries demonstrate a pro-cyclical response of the real wage to energy price shocks. The largest increase is evident in New Zealand, Ireland, Belgium, and Sweden. The reduction in the real wage in the face of energy price shocks is particularly evident in Finland, Canada, Germany, and Norway.

As predicted by theory, the downward flexibility of price inflation dominates the decline in wage inflation in response to productivity shocks for many countries. Indeed, eleven countries (Austria, Belgium, Finland, France, Germany, Italy, New Zealand, Norway, Sweden, Switzerland, and the United States) show significant real wage growth in the face of productivity shocks. That is, higher productivity facilitates an increase in workers' real standard of living in these countries. Across countries, the average response of the real wage to productivity shocks is positive, 0.83, with a standard deviation 0.67. Except for Ireland and Denmark, the real wage increases in the face of productivity shocks. The largest increase is evident in New Zealand, Norway, and Belgium.

Overall, the rigidity of the nominal wage relative to price is consistent with a counter-cyclical response of the real wage to demand shocks and a pro-cyclical response of the real wage to productivity shocks in many countries. In contrast, the flexibility of the nominal wage appears to have exceeded that of price in response to energy price shocks. As a result, the real wage adjusts pro-cyclically to energy price shocks. Variation in nominal wage flexibility in response to various shocks will be further analyzed to study its determinants and implications.

V. Cross-Sectional Analysis

Theory predicts that wage rigidity exacerbates cyclical fluctuations of economic variables in response to demand and supply shocks. Wage flexibility may be, however, an endogenous response to the level of uncertainty impinging on the stochastic structure for a given country.

A. Aggregate Uncertainty and Variation in Cyclical Fluctuations Across Countries

The contracting theory predicts the degree of wage flexibility may be an endogenous response to the level of uncertainty, which varies directly with the variability of disturbances impinging on the stochastic structure of the economy. Aggregate uncertainty increases losses attributed to output deviations from their desired level following labor contract negotiations. Accordingly, a ceteris paribus increase in the level of uncertainty is likely to be associated with shorter implicit and explicit contracts as well as the presence of nominal wage indexation, i.e., a higher degree of nominal wage flexibility.

Empirically, aggregate uncertainty is approximated by the standard deviation of the change in unanticipated nominal GNP/GDP shocks.[18] The largest variability is evident for Ireland, Italy, New Zealand, and Japan. The lowest variability is evident for Austria, France, Denmark, Belgium, and the United States.

A ceteris paribus increase in the level of uncertainty will lead to a decrease in the duration of contractual agreements relative to other countries. Hence, aggregate uncertainty increases the flexibility of the nominal wage in response to various shocks.[19] Accordingly, aggregate uncertainty may provide an explanation for observed differences in wage flexibility and accompanying cyclical fluctuations across countries. Aggregate uncertainty is the independent variable in twelve cross-sectional regressions that test its effect on cyclical fluctuations in response to demand and supply shocks. Following the suggestions of Pagan (1986), the time-series estimates are weighted by the inverse of their standard error to correct for the two step procedure.[20] The evidence in Table 2 is evaluated based on statistical significance at the five or ten percent levels.

Higher uncertainty is likely to increase the upward flexibility of the nominal wage, which moderates the counter-cyclical response of the real wage in the face of aggregate demand shocks. Consequently, higher uncertainty is expected to moderate output growth while accelerating price inflation in the face of aggregate demand shocks. Given variation in the R-squared values, cross-section results will verify the direction and significance of theory's predictions.

Panel I of Table 2 summarizes the results from four cross-section regressions that verify the validity of these predictions. Higher uncertainty increases the flexibility of the nominal wage in response to aggregate demand shocks in regression I.a. This is consistent with a positive

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[18] This is a broad measure of uncertainty that captures the variability of a variety of aggregate demand shocks and, to a lesser extent, supply-side shocks. Uncertainty attributed to energy price shocks and productivity shocks are also embedded in this measure. This measure of uncertainty also captures uncertainty attributed to higher inflation, which is likely to guide negotiations for wage flexibility. It is likely that other institutional and structural factors also determine the difference in cyclical fluctuations across countries. However, by focusing on aggregate uncertainty, the cross-section analysis seeks to verify the significance of this factor in endogenizing wage flexibility and accompanying cyclical fluctuations across countries.

[19] Alternatively, higher uncertainty increases the optimal degree of wage indexation and, in turn, increases nominal wage flexibility.

[20] Observations with a relatively low standard error are weighted more heavily and hence play a greater role in the estimation process compared to observations with a relatively high standard error.

and statistically significant effect of aggregate uncertainty on the response of nominal wage inflation to unanticipated aggregate demand shifts across countries.

Further, the results in regressions I.b. and I.c. suggest that real output expansion is smaller and price inflation is larger as the level of aggregate uncertainty increases across countries. Consistently, in regression I.d., aggregate uncertainty is not statistically significant in determining the response of the real wage to demand shocks across countries.

Panel II of Table 2 provides cross-section estimation results that test the effects of uncertainty on cyclical fluctuations in response to energy price shocks. Higher uncertainty is likely to increase the upward flexibility of the nominal wage and moderate the counter-cyclical response of the real wage in response to energy price shocks. Consequently, higher uncertainty is likely to exacerbate the contractionary effects of energy price shocks on real output and their inflationary effects on prices. In general, the evidence is not consistent with a significant change in the effects of unanticipated energy price shifts on variables, as aggregate uncertainty increases across countries.

Panel III of Table 2 presents the evidence from cross-section estimation that tests the effect of uncertainty on cyclical fluctuations in response to productivity shocks across countries. Higher uncertainty is likely to accelerate the deflationary effects of productivity shocks on the nominal wage and moderate the pro-cyclical response of the real wage to these shocks. This, in turn, will exacerbate output expansion and price deflation in the face of productivity shocks. Consistent with theory's prediction, aggregate uncertainty, in regression III.a., accelerates the downward flexibility of nominal wage inflation in response to productivity shocks across countries. Furthermore, aggregate uncertainty increases output expansion in the face of productivity shocks across countries. In regression III.b., this is consistent with the positive and statistically significant effect on the response of real output growth to productivity shocks. Further, aggregate uncertainty, in regression III.c., decreases price inflation in the face of productivity shocks, which is statistically significant across countries. In regression III.d., the combined effects are not significant, however, to differentiate the real wage response to productivity shocks.

Overall, the cross-section regression results highlight the importance of aggregate uncertainty in accelerating the flexibility of the nominal wage in response to demand shocks. The increased flexibility of the nominal wage appears important to the output-inflation tradeoff. In addition, aggregate uncertainty accelerates downward wage flexibility, reinforcing output expansion in the face of productivity shocks across countries.[21] In contrast, aggregate

[21] It is worth noting that the proxy for aggregate uncertainty, the variability of nominal GNP/GDP shocks is highly correlated with inflation variability with a coefficient, 0.82, and with average inflation with a coefficient, 0.55, across countries. Indeed, average inflation is highly correlated with inflation variability with a coefficient, 0.78, across countries. Given these correlations, I experimented with the effects of inflation variability and average inflation on the coefficient estimates across countries. The qualitative evidence in Table 2

(continued...)

uncertainty does not differentiate wage flexibility and accompanying fluctuations in the face of energy price shocks.

B. The Sub-sample Evidence

It is quite plausible that aggregate uncertainty may have changed for many countries between 1958 and 1998. A classic example is the severe recession of the seventies in the wake of energy price shocks. To provide some evidence on the change in aggregate uncertainty over time, Table A1 of Appendix 1 summarizes these magnitudes across countries for three sub-samples: the fifties and sixties (1958-69), the seventies (1970-79), and the eighties and nineties (1980-98). Note that variation in aggregate uncertainty across countries is more pronounced in the seventies, and in the eighties and nineties according to the standard deviation at the bottom of Table A1. The observed changes over time stimulate interest to identify the significance of the difference in aggregate uncertainty in each sub-sample to variations in the effects of demand shocks, energy price shocks, and productivity shocks on economic variables across countries. Given the evidence in Table A1, it is possible that the effects of the various shocks may have changed over time within countries.[22] To account for this possibility, the empirical models (1) through (4) are re-estimated with a modification that includes two dummy variables that interact with each of the shocks to measure possible change in the effect of each shock between the three sub-samples in the time span under investigation.[23] The results are used to analyze variation in the effects of demand shocks, energy price shocks, and productivity shocks within each sub-sample across countries.

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remains robust in these experiments. Furthermore, I purge the shock to nominal GNP/GDP growth from any correlation with the shock to price inflation. The variability of the residual represents the component of aggregate uncertainty that varies independently of inflation variability. This proxy is not significant in differentiating the coefficient estimates across countries, as evident in Table 2. Hence, the effects of aggregate uncertainty on wage flexibility and its accompanying effects are highly dependent on inflation variability.

[22] It is possible that technology shifts, monetary and fiscal policy changes, the exchange rate system and financial innovations may have led to parameter shifts over the sample period. In addition, institutional changes that determine wage and price dynamics may have also varied over time. For example, the shortening of the average contract length over the sample period and the use of wage and price controls in a number of countries for part of the sample may also have caused shifts in the parameters of the model.

[23] The first dummy variable equals one in 1970-79 and zero otherwise. The second dummy equals one in the 1980-98 period and zero otherwise. The two dummies interact with each shock to measure possible change in its effect on economic variables in the 1970-79 and 1980-98 sub-samples. Detailed results are available upon request.

Table 3 summarizes the results from the cross-section regressions that measure the effects of aggregate uncertainty on variables' responses to various shocks.[24] In the left-hand side panel, aggregate uncertainty in the sub-sample 1958-60 is the independent variable in the cross-sectional regressions explaining variables' responses to the various shocks across countries. All coefficients are statistically insignificant at the five percent level.[25] Variation in aggregate uncertainty in the fifties and sixties is not important in differentiating the responses of economic variables to various shocks across countries.

In the remaining panels of Table 3, aggregate uncertainty in the sub-samples 1970-79 and 1980-98 is the independent variables in cross-section regressions that explain variables' responses to various shocks across countries. The statistical significance of coefficients highlights the importance of these episodes in differentiating the size of demand and supply-driven fluctuations across countries. The signs are consistent with the evidence in Table 2. Aggregate uncertainty across countries moderates the response of real output growth to aggregate demand shocks and increases their inflationary effects on price and the nominal wage. In addition, uncertainty appears consistent with a rise in nominal wage inflation in response to energy price shocks, although pronouncedly smaller in the eighties and nineties compared to the seventies. Higher uncertainty is also consistent with an increase in price deflation and output expansion in the face of productivity shocks.

C. Cyclical Comovements Between Variables Across Countries

The theory under investigation predicts that wage rigidity is the result of relatively longer implicit or explicit contracts and the absence of nominal wage indexation. Nominal wage rigidity exacerbates the absolute reduction of the real wage in the face of positive aggregate demand shocks. Hence, the real effects of these shocks are larger and their inflationary effects are smaller. Across countries, theory predicts that the inflationary effects of aggregate demand shocks should be positively correlated with cyclical fluctuations in both the nominal and real wage resulting from these shocks. Wage flexibility should be, however, negatively correlated with the real effects of aggregate demand shocks. To illustrate, assume that the nominal wage is more flexible in country j compared to country i in the face of aggregate demand shocks. The sticky-wage model predicts the following:

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[24] The cross-section evidence is based on estimates from the time-series model that are weighted by the inverse of their standard error to correct for the two-step procedure.

[25] Aggregate uncertainty has a negative effect that is statistically significant at the ten percent level on the nominal and real wage adjustments to demand shocks across countries in the fifties and sixties. This indicates rigidity in the wage adjustment to demand shocks in response to variation in uncertainty across countries within this sub-sample.

$c_{4i} < c_{4j} \rightarrow b_{4i} < b_{4j}$

$$d_{4i} < d_{4j} \rightarrow a_{4i} < a_{4j} \qquad (5)$$

Nominal wage rigidity in country *i* moderates the nominal wage and price inflation (c_4, b_4) in response to aggregate demand shocks and exacerbates the counter-cyclical (negative) response of the real wage (d_4) while increasing real output expansion (a_4) compared to country *j*.

Wage fluctuations in the labor market also determine the output-inflation tradeoff in response to supply-side shocks. That is, greater downward rigidity of the nominal wage (larger rise in the real wage) in response to positive productivity shocks would lead to a smaller increase in output coupled with a smaller decline in price. Thus, across countries, the theory predicts the response of the nominal and real wage to productivity shocks is positively correlated with price deflation and negatively correlated with output expansion. For example, assuming the nominal wage is rigid in country *i* compared to country *j* in response to positive productivity shocks, the sticky-wage model predicts the following:

$c_{6i} > c_{6j} \rightarrow b_{6i} > b_{6j}$

$$d_{6i} > d_{6j} \rightarrow a_{6i} < a_{6j} \qquad (6)$$

Higher nominal wage rigidity in country *i* moderates the nominal wage and price deflation in response to productivity shocks (c_6, b_6) and exacerbates the rise in the real wage (d_6), while moderating output expansion (a_6) compared to country *j*.

Similarly, greater upward nominal wage rigidity should be associated with a larger absolute reduction in the real wage in response to positive energy price shocks. This result would lead to a smaller decline in real output as well as a smaller inflationary effect of price. Hence, the inflationary effects of energy price shocks are positively correlated with cyclical fluctuations in the nominal and real wage in response to these shocks. Wage fluctuations across countries should, therefore, be negatively correlated with the real effects of energy price shocks. For example, assuming the nominal wage is more upwardly rigid in country *i* compared to country *j* in response to positive energy price shocks, the sticky-wage model predicts the following:

$c_{4i} < c_{4j} \rightarrow b_{6i} < b_{6j}$

$$d_{4i} < d_{4j} \rightarrow a_{4i} > a_{4j} \qquad (7)$$

Wage rigidity in country *i* moderates the nominal wage and price inflation in response to energy price shocks (c_4, b_4) and exacerbates the reduction in the real wage (d_4) while moderating output contraction (a_4) compared to country *j*.

To provide additional evidence on comovements between nominal wage flexibility and cyclical fluctuations in response to demand and supply shocks, Table 4 summarizes correlations between variables' responses to each of the shocks in the empirical models across the sample of nineteen countries. For example, $corr(y,p)_n$ in Table 4 measures the correlation between a_{4i} and b_{4i} in the empirical models (1) and (2), i=1,...,19. This correlation determines the direction and strength of comovements in variables' responses to aggregate demand shocks, as approximated by the parameters from the time-series regressions for each country. That is, whether the increase in the inflationary effects of aggregate demand shocks is correlated with an increase or a decrease in the effects of these shocks on real output growth and the strength of this correlation across countries.

The correlations in Table 4 are based on the parameters' estimates in Table 1 over the sample period 1958-1998. Panel I of Table 4 summarizes the correlations across countries between the variables' responses to aggregate demand shocks. The response of the nominal wage to aggregate demand shocks is positively correlated with that of price and negatively correlated with that of real output across countries. Both correlations are statistically significant. That is, wage inflation accelerates with price inflation where the real effects of aggregate demand shocks are smaller. It is also interesting to note that the response of the real wage to aggregate demand shocks, while uncorrelated with that of real output and the price level, is positively correlated with the response of the nominal wage to demand shocks. The implications of this positive correlation are two-fold. First, the larger correlation between the effects of demand shocks on the nominal wage and the price level is consistent with the evidence in the cross-section regressions. The real wage does not vary significantly with the trade-off in the inflationary and real effects of aggregate demand shocks across countries. Second, while the increased wage flexibility appears to have accelerated price inflation, workers are guaranteed a higher real standard of living in response to demand shocks compared to their counterparts in countries that experience less flexible nominal wages.[26]

Comovements between variables' responses to energy price shocks in each country are formalized by correlations across countries in Panel II of Table 4. The responses of the nominal and real wage to energy price shocks are positively and significantly correlated. Workers are able to maintain a higher real standard of living compared to their counterparts in countries where wages are less flexible in response to energy price shocks. This was accomplished without accelerating price inflation or output contraction in response to energy price shocks. Correlations between the response of the nominal wage to energy price shocks and that of price and real output are statistically insignificant.

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[26] This evidence challenges the implications of the sticky-price explanation of business cycles. In these models, price flexibility is expected to determine the real wage response to demand shocks negatively. Higher price flexibility moderates the pro-cyclical response of the real wage to demand shocks. Moreover, the time-series evidence in Table 1, in contrast to the predictions of sticky-price models, is not consistent with a pro-cyclical adjustment of the real wage to demand shocks in general.

Panel III of Table 4 formalizes the evidence on comovements across countries between variables' responses to productivity shocks. The increased flexibility of the nominal wage in response to productivity shocks exacerbates price deflation. Consistent with the cross-section regression results, the flexibility of the nominal wage in response to productivity shocks exacerbates real output growth across countries. Accordingly, real output growth and nominal wage inflation show a negative and statistically significant correlation in response to productivity shocks across countries.

VI. Summary and Conclusion

This paper has attempted to provide a comprehensive evaluation of the sticky-wage contractual explanation of business cycles. The primary difference between this explanation and competing alternatives is the theoretical connection between labor and product markets. The empirical investigation provides a detailed analysis of the short-run cyclical behavior of real output, prices and wages using data for nineteen industrial countries. The analysis is conducted by estimating both time-series and cross-sectional regressions that address the theoretical implications under investigation.

The time-series results provide estimates of nominal wage flexibility and accompanying real and inflationary effects in response to demand and supply shocks. The cross-sectional analysis has focused on evaluating the degree of nominal wage flexibility in response to the level of uncertainty impinging on each country. The degree of uncertainty across countries is approximated by the variability of disturbances in nominal GNP or GDP growth. Aggregate uncertainty is expected to increase agents' incentives for wage indexation and decrease their incentives for longer contractual agreements. Both effects are likely to stimulate the flexibility of the nominal wage in response to various shocks. The increased flexibility is likely to moderate the real effects of aggregate demand shocks while exacerbating their inflationary effects. In contrast, nominal wage flexibility is likely to exacerbate both the real and inflationary or deflationary effects of supply shocks. The cross-country results shed some light on the validity of these predictions.

The important implications of the cross-sectional results are as follows. Consistent with the theoretical predictions, aggregate uncertainty is an important factor in increasing the flexibility of the nominal wage in response to demand shocks. This is consistent with an increase in the inflationary effects of demand shocks on price, while moderating their real effects on output growth. Nonetheless, the resulting higher short-run labor costs are apparently fed back more slowly to product markets across countries. Accordingly, while the increased flexibility of the nominal wage appears correlated with higher real wages, the correlation between price and real wage adjustments appears negligible in response to aggregate demand shocks across countries.

The evidence also appears consistent with an increase in the flexibility of the nominal wage in response to energy price shocks as the level of uncertainty increases across countries. This flexibility is not important, however, to the difference in the contractionary effects of energy price shocks on output growth or their inflationary effects on the price level across countries.

Downward flexibility of the nominal wage in response to productivity shocks also appears more pronounced with higher uncertainty across countries. Higher flexibility of the nominal wage is consistent with an increase in output expansion and price deflation in the face of productivity shocks.

In summary, detailed evaluation of cyclical fluctuations across nineteen industrial countries illustrates large dependency of nominal wage flexibility on the level of uncertainty impinging on the stochastic structure of the economic system. Wage flexibility stabilizes fluctuations of real output in response to aggregate demand shocks and guarantees workers a higher real standard of living. Furthermore, the flexibility of the nominal wage in response to energy price shocks guarantees workers higher real wages, without exacerbating the inflationary effects of energy price shocks on the price level or their contractionary effects on real output. Finally, nominal wage inflation decreases in response to productivity shocks, reinforcing output growth. These effects are worthy of consideration in evaluating nominal wage adjustments to aggregate demand and supply shocks.

Table 1. Wage Flexibility and the Effects of Aggregate Demand and Supply Shocks

Country	$\frac{\partial Dy}{\partial Dns}$	$\frac{\partial Dy}{\partial Dqs}$	$\frac{\partial Dy}{\partial D\tau s}$	$\frac{\partial Dp}{\partial Dns}$	$\frac{\partial Dp}{\partial Dqs}$	$\frac{\partial Dp}{\partial D\tau s}$	$\frac{\partial Dnw}{\partial Dns}$	$\frac{\partial Dnw}{\partial Dqs}$	$\frac{\partial Dnw}{\partial D\tau s}$	$\frac{\partial Drw}{\partial Dns}$	$\frac{\partial Drw}{\partial Dqs}$	$\frac{\partial Drw}{\partial D\tau s}$
Australia	0.48*	-0.04*	0.74*	0.61*	0.05*	-0.97*	0.30	0.08*	-0.21	-0.10	0.03	0.70
	(2.65)	(-2.27)	(1.76)	(3.41)	(2.10)	(-2.15)	(0.72)	(3.67)	(-0.33)	(-0.34)	(0.96)	(1.25)
Austria	0.86*	-0.01	0.26	0.23	0.02*	-0.46*	0.11	0.06*	0.57**	-0.15	0.04*	1.04*
	(4.12)	(-0.72)	(1.18)	(1.20)	(1.80)	(-2.60)	(0.34)	(2.64)	(1.40)	(-0.38)	(1.77)	(3.03)
Belgium	0.28**	-0.01	0.80	0.60*	0.03**	-0.98*	0.53*	0.09*	0.49	-0.21	0.07*	1.60*
	(1.50)	(-1.05)	(1.08)	(3.45)	(1.56)	(-2.45)	(1.70)	(2.59)	(0.83)	(-0.67)	(2.11)	(3.06)
Canada	0.73*	-0.04**	-0.34	-0.55	0.03	-1.58*	-0.17	0.03**	0.94	-0.21	-0.02	0.70
	(3.77)	(-1.69)	(-0.49)	(-1.20)	(0.66)	(-3.25)	(-0.87)	(1.68)	(1.29)	(-0.62)	(-0.48)	(1.10)
Denmark	0.78*	-0.04*	-0.32	0.05	0.05*	0.05	0.38	0.30**	0.04	0.50	0.02	-0.47
	(3.11)	(-2.74)	(-0.87)	(0.16)	(2.61)	(1.20)	(0.73)	(1.36)	(0.70)	(1.06)	(0.57)	(-0.57)
Finland	0.34	-0.02	0.69**	0.39	0.08*	-0.66*	0.60*	0.04	0.20	0.23	-0.05	0.88*
	(0.85)	(-0.47)	(1.42)	(1.24)	(2.14)	(-2.14)	(1.93)	(1.04)	(0.55)	(0.64)	(-1.19)	(1.93)
France	0.27*	0.001	0.13	0.65*	-0.002	0.17	0.61*	-0.01	1.06*	0.27	0.01	0.46*
	(2.89)	(0.11)	(0.72)	(5.70)	(-0.21)	(1.23)	(2.41)	(-0.58)	(3.22)	(1.25)	(0.92)	(1.99)
Germany	0.67*	-0.02	-0.11	0.28	0.04*	-0.43	0.22	0.03**	0.65	-0.06	-0.01	1.16*
	(2.17)	(-0.95)	(-0.16)	(1.12)	(2.68)	(-1.17)	(0.69)	(1.39)	(1.29)	(-0.27)	(-0.80)	(2.78)
Ireland	0.07	0.02	0.75*	0.95*	-0.02	-0.74*	0.91*	0.06*	-0.84*	0.01	0.07*	0.003
	(1.20)	(1.16)	(5.04)	(10.66)	(-1.21)	(-5.04)	(5.57)	(2.37)	(-2.59)	(0.06)	(3.36)	(0.01)
Italy	-0.002	-0.06*	0.59*	1.16*	0.08*	-0.49*	1.27*	0.11*	0.63	0.23	0.04	0.99**
	(-0.02)	(-2.13)	(2.01)	(6.92)	(2.29)	(-1.74)	(3.75)	(1.78)	(1.00)	(0.65)	(0.68)	(1.60)
Japan	0.42*	-0.03*	0.35*	0.71*	0.02	-0.33*	0.66*	0.02	-0.004	-0.22**	-0.004	0.06
	(4.54)	(-3.18)	(4.01)	(4.17)	(1.01)	(-2.16)	(2.85)	(0.74)	(-0.02)	(-1.42)	(-0.22)	(0.40)
Netherlands	0.73*	-0.07*	-0.03	0.66*	-0.01	0.85	0.59**	0.01	0.79	-0.006	0.03	0.66
	(2.54)	(-2.29)	(-0.14)	(1.91)	(-0.52)	(1.22)	(1.43)	(0.45)	(1.23)	(-0.01)	(0.94)	(1.05)
New Zealand	0.03	0.03**	1.87*	0.99*	0.03	-1.97*	1.09*	0.09**	0.12	0.18	0.11*	2.42**
	(0.17)	(1.44)	(2.07)	(6.75)	(1.20)	(-3.30)	(2.83)	(1.56)	(0.08)	(0.45)	(2.08)	(1.39)
Norway	0.29**	0.00	0.29	0.71*	0.03**	-1.32*	0.13	0.02	0.41	-0.50*	-0.01	1.99*
	(1.37)	(0.00)	(0.81)	(5.07)	(1.33)	(-4.38)	(0.50)	(0.50)	(0.78)	(-1.79)	(-0.22)	(3.08)
Spain	0.29*	-0.02	0.49	0.69*	0.03*	-0.68*	0.53	0.04	-1.14**	-0.27	0.02	0.62
	(1.91)	(-1.24)	(1.04)	(7.98)	(2.01)	(-2.07)	(1.24)	(1.03)	(-1.47)	(-0.75)	(0.68)	(1.17)
Sweden	0.36*	0.01	0.83*	0.63*	-0.01	-1.06*	0.43*	0.06*	0.02	-0.26	0.06**	0.99**
	(2.39)	(0.80)	(2.84)	(3.91)	(-0.72)	(-4.03)	(1.80)	(2.25)	(0.08)	(-0.65)	(1.50)	(1.61)
Switzerland	0.80*	-0.03**	-0.03	0.12	-0.02	-1.29*	0.15	0.07*	0.52*	0.002	0.02	0.56**
	(5.33)	(-1.60)	(0.00)	(0.83)	(-0.72)	(-3.11)	(0.90)	(4.30)	(1.80)	(0.02)	(1.15)	(1.62)
U.K.	0.27	-0.02	0.68	0.81**	0.03	-0.67	0.97*	0.02	-0.14	0.24	0.02	0.88
	(0.70)	(-0.83)	(0.91)	(1.50)	(0.75)	(-0.71)	(2.16)	(0.67)	(-0.20)	(0.64)	(0.74)	(1.19)
U.S.	0.80*	-0.02**	0.40**	0.19	0.03*	-1.17*	0.07	0.003	-0.36	-0.13	-0.004	0.45**
	(3.46)	(-1.69)	(1.36)	(0.95)	(2.07)	(-4.59)	(0.38)	(0.18)	(-0.95)	(-0.94)	(-0.40)	(1.59)

Notes:

- Estimates approximate the effects of the shocks to aggregate demand, the energy price and productivity on real output growth, price inflation, nominal wage inflation, and real wage growth according to the parameter estimates in (1) through (4).
- t ratios are in parentheses where * and ** denote statistical significance at the five and ten percent levels.

Table 2. OLS Cross-Sectional Regression Results

Dependent Variable	Intercept	Aggregate Uncertainty	R^2
I. The Effects of Aggregate Demand Shocks:			
a. $\frac{\partial Dnw}{\partial Dns} = c_4$	0.034 (0.05)	11.27* (2.39)	0.25
b. $\frac{\partial Dy}{\partial Dns} = a_4$	2.45* (4.81)	-1.40 (-0.89)	0.045
c. $\frac{\partial Dp}{\partial Dns} = b_4$	-1.00* (-1.82)	19.12* (9.52)	0.84
d. $\frac{\partial Drw}{\partial Dns} = d_4$	0.16 (0.42)	-2.07 (-0.99)	0.054
II. The Effects of Energy Price Shocks:			
a. $\frac{\partial Dnw}{\partial Dqs} = c_5$	0.69 (0.85)	0.64 (1.14)	0.071
b. $\frac{\partial Dy}{\partial Dqs} = a_5$	-2.26* (-2.57)	0.55** (1.49)	0.12
c. $\frac{\partial Dp}{\partial Dqs} = b_5$	1.53* (1.81)	-0.21 (-0.55)	0.017
d. $\frac{\partial Drw}{\partial Dqs} = d_5$	1.03** (1.40)	-0.19 (-0.53)	0.016
III. The Effects of Productivity Shocks:			
a. $\frac{\partial Dnw}{\partial D\tau s} = c_6$	1.00* (1.75)	-6.24 (-1.11)	0.067
b. $\frac{\partial Dy}{\partial D\tau s} = a_6$	0.005 (0.013)	10.065* (3.71)	0.45
c. $\frac{\partial Dp}{\partial D\tau s} = b_6$	-1.26** (-1.58)	-6.79** (-1.36)	0.098
d. $\frac{\partial Drw}{\partial D\tau s} = d_6$	1.92* (4.96)	-4.10 (-1.19)	0.077

Notes:

- Estimates of the time-series models are weighted by the inverse of their standard error in the cross-section regression.
- a_4, b_4, c_4, and d_4 measure the effects of aggregate demand shocks on real output growth, price inflation, and nominal and real wage inflation from the estimation of models (1) through (4).
- a_5, b_5, c_5, and d_5 measure the effects of energy price shocks on real output growth, price inflation, and nominal and real wage inflation from the estimation of models (1) through (4).
- a_6, b_6, c_6, and d_6 measure the effects of productivity shocks on real output growth, price inflation, and nominal and real wage inflation from the estimation of models (1) through (4).
- t-ratios are in parentheses.
- * and ** denote statistical significance at the five and ten percent levels.

Table 3. OLS Cross-Sectional Regression Results in Three Sub-samples

	Sample	Period	1958-69	Sample	Period	1970-79	Sample	Period	1980-98
Dependent Variable	**Intercept**	**Aggregate Uncertainty**	**R^2**	**Intercept**	**Aggregate Uncertainty**	**R^2**	**Intercept**	**Aggregate Uncertainty**	**R^2**
I. The Effects of Aggregate Demand Shocks:									
a. $\frac{\partial Dnw}{\partial Dns} = c_4$	0.85* (3.36)	-14.25** (-1.52)	0.12	-0.054 (-0.26)	16.38* (2.76)	0.31	0.19 (0.95)	11.072** (1.59)	0.13
b. $\frac{\partial Dy}{\partial Dns} = a_4$	0.39* (1.94)	2.28 (0.31)	0.0055	0.77* (4.61)	-9.81* (-2.078)	0.20	0.79* (5.88)	-12.81* (-2.80)	0.32
c. $\frac{\partial Dp}{\partial Dns} = b_4$	0.70* (2.50)	-7.053 (-0.68)	0.027	0.14 (0.57)	11.42** (1.64)	0.14	0.25 (1.17)	9.96** (1.34)	0.095
d. $\frac{\partial Drw}{\partial Dns} = d_4$	0.19 (1.15)	-8.43** (-1.37)	0.10	-0.13 (-0.83)	3.33 (0.73)	0.031	-0.12 (-0.87)	3.65 (0.77)	0.033
II. The Effects of Energy Price Shocks:									
a. $\frac{\partial Dnw}{\partial Dqs} = c_5$	0.048* (2.093)	-0.13 (-0.15)	0.0013	-0.0085 (-0.52)	1.62* (3.47)	0.41	0.022 (1.24)	0.88** (1.45)	0.11
b. $\frac{\partial Dy}{\partial Dqs} = a_5$	-0.018 (-0.99)	-0.076 (-0.12)	0.0008	-0.016 (-1.00)	-0.093 (-0.20)	0.0023	-0.036* (-2.69)	0.64** (1.37)	0.099
c. $\frac{\partial Dp}{\partial Dqs} = b_5$	0.026 (1.29)	-0.058 (-0.077)	0.0003	0.0059 (0.32)	0.57 (1.10)	0.066	0.016 (1.00)	0.32 (0.57)	0.019
d. $\frac{\partial Drw}{\partial Dqs} = d_5$	0.038** (1.46)	-0.56 (-0.58)	0.019	-0.0055 (-0.24)	0.89** (1.34)	0.095	0.011 (0.54)	0.46 (0.64)	0.024
III. The Effects of Productivity Shocks:									
a. $\frac{\partial Dnw}{\partial D\tau s} = c_6$	0.59** (1.47)	-14.51 (-0.98)	0.054	0.66* (1.81)	-13.50** (-1.31)	0.092	0.22 (0.66)	-0.13 (-0.011)	0.00
b. $\frac{\partial Dy}{\partial D\tau s} = a_6$	0.84 (2.42)	-16.53 (-1.28)	0.088	-0.21 (-0.70)	19.097* (2.26)	0.23	0.059 (0.21)	13.66** (1.43)	0.11
c. $\frac{\partial Dp}{\partial D\tau s} = b_6$	-0.68** (-1.40)	-0.67 (-0.037)	0.0001	-0.039 (-0.092)	-19.94** (-1.67)	0.14	-0.052 (-0.15)	-24.35* (-2.01)	0.19
d. $\frac{\partial Drw}{\partial D\tau s} = d_6$	0.87* (1.82)	-1.73 (-0.098)	0.0006	0.54 (1.24)	8.49 (0.68)	0.027	0.42 (1.14)	15.14 (1.19)	0.077

Notes:

- a_4, b_4, c_4, and d_4 measure the effects of aggregate demand shocks on real output growth, price inflation, and nominal and real wage inflation from the estimation of models (1) through (4).
- a_5, b_5, c_5, and d_5 measure the effects of energy price shocks on real output growth, price inflation, and nominal and real wage inflation from the estimation of models (1) through (4).
- a_6, b_6, c_6, and d_6 measure the effects of productivity shocks on real output growth, price inflation, and nominal and real wage inflation from the estimation of models (1) through (4).
- t-ratios are in parentheses
- * and ** denote statistical significance at the five and ten percent levels.

Table 4. Comovements Between Variables' Fluctuations Across Countries

I. Correlations in Response to Aggregate Demand Shocks	**Corr $(y,p)_n$**	**Corr $(y,nw)_n$**	**Corr $(y,rw)_n$**	**Corr $(p,nw)_n$**	**Corr $(p,rw)_n$**	**Corr $(nw,rw)_n$**
Correlation:	-0.55*	-0.65*	-0.021	0.77*	-0.001	0.33
Probability of 0 Correlation	(0.016)	(0.003)	(0.93)	(0.0001)	(0.99)	(0.17)
II. Correlations in Response to Energy Price Shocks	**Corr $(y,p)_q$**	**Corr $(y,nw)_q$**	**Corr $(y,rw)_q$**	**Corr $(p,nw)_q$**	**Corr $(p,rw)_q$**	**Corr $(nw,rw)_q$**
Correlation:	-0.41	0.056	0.44**	-0.10	-0.50*	0.43**
Probability of 0 Correlation	(0.83)	(0.82)	(0.059)	(0.68)	(0.03)	(0.064)
III. Correlations in Response to Productivity Shocks	**Corr $(y,p)_\tau$**	**Corr $(y,nw)_\tau$**	**Corr $(y,rw)_\tau$**	**Corr $(p,nw)_\tau$**	**Corr $(p,rw)_\tau$**	**Corr $(nw,rw)_\tau$**
Correlation:	-0.57*	-0.64*	-0.15	0.52*	-0.19	0.44**
Probability of 0 Correlation	(0.010)	(0.003)	(0.53)	(0.021)	(0.44)	(0.061)

Notes:

- $corr(.,.)_n$ measures correlation between the responses of two variables to aggregate demand shocks in models (1) through (4) across the sample of nineteen countries. For example, $corr(y,p)_n$ measures correlation between a_{4i} and b_{4i},. i = 1, ..., 19.
- $corr(.,.)_q$ measures correlation between the responses of two variables to energy price shocks in models (1) through (4) across the sample of nineteen countries. For example, $corr(y,p)_q$ measures correlation between a_{5i} and b_{5i}, i = 1, ...19.
- $corr(.,.)_\tau$ measures correlation between the responses of two variables to productivity shocks in models (1) through (4) across the sample of nineteen countries. For example, $corr(y,p)_\tau$ measures correlation between a_{6i} and b_{6i}, i = 1, ...19.
- * and ** denote statistical significance at the five and ten percents levels.

Econometric Methodology

To estimate the empirical models in (1) through (4) proxies for agents' expectation of the growth in nominal GNP/GDP, energy price inflation, and the change in productivity are needed. Nominal GNP/GDP and productivity are endogenous according to the results of a formal test suggested by Engle (1982). Anticipated changes in nominal GNP/GDP and productivity are generated by taking the fitted values of reduced form equations in which the explanatory variables include a constant and lagged values of the first-difference of the log value of each of the money stock, real output, the price level, the nominal wage, the energy price, and productivity. Shocks to nominal GNP/GDP growth and the change in productivity are then formed by subtracting these forecasts from the actual values of these variables.

The energy price is exogenous according to the results of Engle's (1982) test. Obtaining a proxy for ex ante forecasts of energy price inflation is complicated by the assumption that the generating process experienced a structural change between 1973 and 1974 which is supported by the results of a formal test suggested by Dufour (1982). For both the period 1958-73 and the period 1974-98, the generating process is modeled as a second-order auto-regressive process. Subtracting these forecasts from the actual change yields the proxy of energy price shocks.

The maintained hypothesis for estimation is that agents are rational and that the information set used to specify the proxy for expectation is the same as the set used by agents. Given these assumptions, Pagan (1984,1986) showed that the use of regression proxies requires an adjustment of the covariance matrix of estimators of the parameters of the model containing expectational variables. A simple alternative is to estimate the expectation equations jointly with the rest of the model, thus avoiding the first-stage regression proxies. Therefore, it becomes necessary to estimate the model using 3SLS. The instrument list for estimation includes three lags of the first-difference of the short-term interest rate; three lags of the first-difference of the log value of each of real output, the price level, the nominal wage, labor productivity; and the current as well as the first three lagged values of the first-difference of the log value of the money supply, government spending and the energy price. The paper's evidence is robust with respect to variation in variables and lags in the forecast equations or the instruments list.

The results of Engle's (1982) test for serial correlation are consistent with the hypothesis that the error terms in (1) through (4) follow an auto-regressive process of order (1) in some cases. To maintain consistency across countries, the serial correlation correction requires that the estimated models be multiplied through by the filter $(1 - \rho L)$ where ρ is the serial correlation parameter and L is the lag operator. The estimates reported in Table 1 are for the models after transformation to get rid of serial correlation. The error terms in the transformed models are serially uncorrelated according to the results of Engle's (1982) test.

Table A1. Measures of Aggregate Uncertainty in Three Sub-samples

	Measures	of Aggregate	Uncertainty
Country	**1958-69**	**1970-79**	**1980-98**
Australia	0.031	0.040	0.022
Austria	0.023	0.027	0.017
Belgium	0.022	0.028	0.019
Canada	0.033	0.033	0.030
Denmark	0.029	0.019	0.020
Finland	0.021	0.040	0.035
France	0.022	0.012	0.029
Germany	0.030	0.025	0.011
Ireland	0.035	0.045	0.048
Italy	0.022	0.055	0.045
Japan	0.0084	0.039	0.013
Netherlands	0.029	0.026	0.012
New Zealand	0.018	0.055	0.041
Norway	0.040	0.020	0.047
Spain	0.046	0.041	0.014
Sweden	0.016	0.019	0.018
Switzerland	0.023	0.049	0.036
U.K.	0.013	0.039	0.029
U.S.	0.023	0.018	0.020
Across Countries:			
Average	0.026	0.033	0.027
Standard Deviation	0.0092	0.013	0.012

Note:

Aggregate uncertainty is measured by the standard deviation of the shocks to the growth of nominal GNP or GDP in each of the three sub-samples.

Data Description and Sources

Output: real and nominal GNP/GDP.

Price Level: the GNP/GDP deflator.

Nominal Wage: index of the wage rate per worker employed in the industrial sector per specified time period. The index includes payments in kind and family allowances and covers salaried employees as well as wage earners.

Energy Price: the unit value of exports of crude oil of the oil exporting countries.

Money Stock: the sum of currency outside banks and private sector demand deposits.

Short-Term Interest Rate: representatives of short-term market rates for the various countries, i.e., rates at which short-term borrowing are affected between financial institutions or rates at which short-term government paper is issued or traded in the market.

Government Spending: nominal values of all payments by government.

Labor Productivity: real output divided by total employment. Where data are available, this proxy was compared to a proxy that takes into account variation in labor hours. The empirical results are robust with respect to the use of this alternative proxy.

Sources: All data, except for the energy price and total employment, are taken from *International Financial Statistics,* year books, issued by the International Monetary Fund, Washington D.C. The energy price is taken from the *IMF Supplement to Price Statistics.* Total employment is taken from *Labor Force Statistics,* various issues (OECD). It was updated to 1987 using data from *Quarterly Labor Force Statistics,* No. 4, 1988 (OECD) country pages, and to 1998 using OECD *Economic Outlook,* June 1999, Table 37.

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