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Magda Kandil

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DEMAND SHOCKS AND THE CYCLICAL BEHAVIOR OF THE REAL WAGE: SOME INTERNATIONAL EVIDENCE

Magda Kandil*
International Monetary Fund

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The focus of this investigation is on the cyclical response of the real wage to demand shocks. This response differentiates the empirical validity of major New Keynesian explanations of business cycles. The empirical evidence, across industrial countries, highlights a moderate positive correlation between nominal wage and price flexibility in response to various demand shocks. Nonetheless, higher price flexibility moderates the effect of demand shocks on real output, while higher nominal wage flexibility increases, or does not determine, the effects of demand shocks on real output across countries. An increase in the response of the real wage to demand shocks therefore exacerbates their real effect on output, as predicted by sticky-price models. Further, demand shocks do not determine the difference in wage variability. Nominal wage variability increases, in turn, output variability across countries. In contrast, demand shocks differentiate price variability. Price variability moderates, in turn, output variability across countries.

JEL classification codes: E31, E32, E24
Key words: business cycles, sticky-wage, sticky-price, asymmetry, real wage; cyclicality, growth, inflation.

I. Introduction

The study of business cycles has been at the heart of macroeconomic theory for decades. Theoretical efforts have focused on providing an adequate explanation for sources of economic fluctuations. New Keynesian models of the last three decades have emphasized rigidity that interferes with market forces and exacerbates the effects of demand fluctuations on the supply side of the economy. The form of rigidity is in sharp contrast between sticky-wage and sticky-price models.

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* International Monetary Fund, 700 Nineteenth St. N. W. Washington D. C. 20431 (202) 623-4696. The author would like to thank an anonymous referee for helpful comments on an earlier draft.

Sticky-wage models of the seventies and eighties emphasize the role of contractual agreements in the labor market.[1] Given the cost of negotiating contracts, agents opt to change nominal wages at specific intervals. Nominal wage rigidity exacerbates cyclical fluctuations in the face of demand shocks. Specifically, a positive disturbance to aggregate demand decreases the real wage, causing output to rise above its natural (full-equilibrium) level. Accordingly, nominal wage rigidity exacerbates the countercyclical response of the real wage, increasing output fluctuations in the face of demand shocks.

Sticky-price models of the eighties emphasize the speed of price adjustment in the product market to explain economic fluctuations.[2] Given the cost of adjusting prices, firms opt to change prices at specific intervals. Price rigidity exacerbates cyclical fluctuations in the face of demand shocks. Specifically, constraints on price adjustment prompt producers to expand the output produced in the face of positive demand shocks. Accordingly, price rigidity exacerbates the procyclical response of the real wage, increasing output fluctuations in the face of demand shocks.

Researchers have tested these theories. These studies have focused on cyclical fluctuations of the real wage.[3] The evidence appears conflicting and, therefore, does not lend support to a given explanation.[4]

More recent developments in theoretical and empirical studies of New Keynesian macro economics have employed stochastic general equilibrium models (see, e.g., Christiano, Eichenbaum, and Evans 2005, Erceg, Henderson, and Levin 2000, and Smets and Wouters 2003).[5]

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[1] Contracts may be explicit formal agreements as in Taylor (1980) or implicit informal agreements of the form specified in Malcomson (1984).

[2] See, for example, Ball, Mankiw and Romer (1988).

[3] The cyclical behavior of the real wage is also an important element of other competing explanations of business cycles. In real business-cycle models, see, for example, Long and Plosser (1983), both the demand shock and the real wage are endogenous with respect to supply-side shocks. Technological advances, for example, increase the real wage and stimulate aggregate demand. Therefore, the real wage correlates procyclically with demand shocks in the short-run.

[4] The empirical literature on the cyclical behavior of the real wage can be classified into aggregate and disaggregate studies. The former includes Neftci (1978), Sargent (1978), Geary and Kennan (1982), Sumner and Silver (1989), Cho and Cooley (1990), Cushing (1990), and Kandil (1996) and (2001). Disaggregate studies include Bils (1985), Barsky and Solon (1989), Keane, Moffit and Runkle (1989), Solon, Barsky, and Parker (1994), Kandil and Woods (1995), and (1997), and Kandil (1999) and (2002).

[5] The traditional approach of New Keynesian models assumes a non-contingent nominal adjustment at regular time intervals. In contrast, modern stochastic general equilibrium models rely on a microeconomic

This paper studies the cyclical behavior of the real wage in response to aggregate demand shocks. The objective is to study the cyclical behavior of the real wage *and* the relative flexibility of the nominal wage and price. The data under investigation are for nineteen industrial countries. The analysis tests the effect of nominal price and wage rigidities on real magnitudes.

In the first step, empirical time-series models are specified and estimated, and the results are compared to theoretical implications. The main upshot is that in a majority of the countries (as well as on average), price flexibility exceeds nominal wage flexibility.

In a second step, cross-country differences in the output response to nominal demand shocks are related to differences in estimated measures of stickiness. The overall conclusion is that a high price flexibility relative to nominal wage flexibility contributes to smaller output fluctuations.

In a third step of the empirical investigation, the variability of the real wage is broken into a price part and a nominal wage part. The overall evidence across countries indicates that price flexibility to demand shocks, in contrast to wage flexibility, is a major determinant of real wage fluctuations. Accordingly, a high price variability, relative to nominal wage variability, contributes to a smaller output variability.

Overall, the combined evidence presents the following conclusion. Nominal wage flexibility in response to demand shocks is pronouncedly less significant compared to price flexibility in determining the variability of the real wage and output across countries. That is, a high price responsiveness to demand shocks tends to be crucial to dampen output fluctuations in a cross-country comparison.

II. Rigidity in labor and product markets: two theoretical views

To motivate the empirical investigation of the paper, this section offers a quick refresher background of two competing explanations for demand-driven economic fluctuations. The common theme that underlies these explanations is some sort of market failure that deviates the economy from its optimal response to changes in tastes and technology. The failure is based on rigid wages and/or prices.

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approach to generate nominal rigidities, whereby the response of nominal prices to aggregate demand fluctuations is tied to the optimizing behavior of wage and price setters.

A. A sticky-wage New Keynesian explanation

Sticky-wage New-Keynesian models have emphasized rigidity in the labor market to explain economic fluctuations. Labor contracts specify in advance the nominal wage that prevails for the contract duration. Assume wage and salary negotiations across the economy are governed by contractual agreements. All contracts specify a duration and a path of nominal wages based on available information. Negotiating contracts entails a fixed cost. In deciding on the optimal contract length, agents compare these costs to the benefits of more frequent recontracting. An increase in aggregate uncertainty increases the risk of fixing the nominal wage and decreases agents' incentives to write long contracts.

Following contracts' negotiation, a positive disturbance to aggregate demand raises the price of the output produced. Absent any stipulation for wage indexation, the increase in price lowers the real product wage faced by firms, causing output and employment to rise above their natural (full-equilibrium) levels. Nominal wage rigidity exacerbates the countercyclical response of the real wage, increasing output fluctuations in response to demand shocks.

B. A sticky-price New Keynesian explanation

Sticky-price models have emphasized rigidity in the product market to explain economic fluctuations. Monopolistically competitive firms face small "menu costs" when they change prices. These are costs involved in changing prices such as the cost of posting new price lists, customers' dissatisfaction with price change and the effort involved in implementing a price change. In deciding on the frequency of price adjustment, firms compare the menu cost to the benefits of more frequent price adjustment. Higher uncertainty increases risk and, therefore, motivates incentives to pay the menu cost.[6]

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[6] While the traditional approach has presented menu cost as the main reason of generating stickiness in prices, most of the recent literature care about other factors for price stickiness, such as Mankiw and Reis (2002) suggesting information stickiness or Woodford (2002 a,b) suggesting strategic complement. The menu cost could be relatively small for a firm's price setting since most of the prices of the existing products are revised at least every three to four months even in low inflation environment (see, e.g., Bils and Klenow 2004 using monthly data). Using US weekly data, Midrigan (2007) and Kehoe and Midrigan (2007) suggest that the price revision period is even shorter, in average of three weeks. Similar results are suggested using other countries' data as well.

Assume each market contains imperfectly competitive firms that change prices at discrete intervals. Each firm sets its price to the average of expected profit maximizing prices for the period when the price will be in effect. Firms opt to change the output produced in response to demand shocks that are realized after prices have been set. A positive disturbance to aggregate demand raises the output produced and increases labor demand, causing a rise in the real wage.[7]

C. A sticky-wage and sticky-price explanation

Several models have been developed in this decade which incorporate both wage and price stickiness at the same time (see, e.g., Erceg, Henderson and Levin 2000, and Amato and Laubach 2003). Estimating a model that allows for both wage and price stickiness, Amato and Laubach (2003) reach a conclusion that an empirically relevant case is one in which wage stickiness is slightly larger than price stickiness, but not much.

D. Sticky wages or sticky prices?

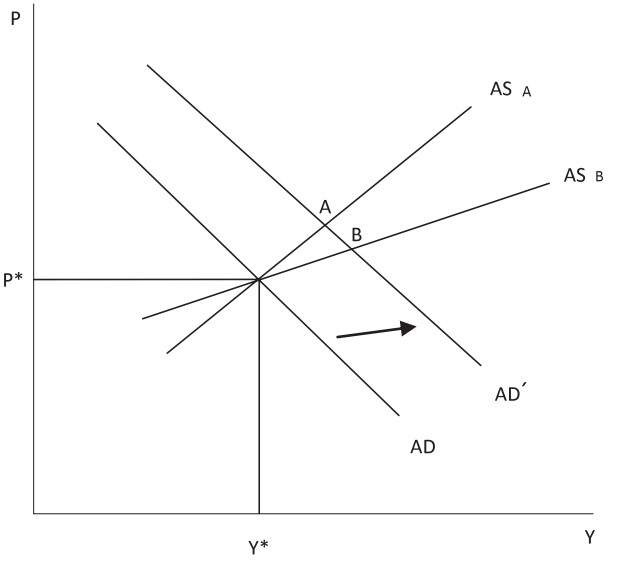
Both the sticky-wage and sticky-price explanations predict that the degree of nominal rigidity differentiates the slope of the short-run supply curve and, therefore, the size of output fluctuations in the face of demand shocks. To illustrate the difference between the two explanations, assume two economies that are subject to a positive demand shock of equal size, as illustrated in Figure 1.

Initially, the aggregate demand curve AD is consistent with the full-equilibrium levels of output and price, Y* and P*. Following the realization of a positive demand shock, the aggregate demand curve shifts to a new position, as determined by AD'. The allocation of the demand shock between output and price is dependent on the slope of the short-run supply curve. In Figure 1, the slope of the supply curves, AS_A and AS_B, differentiates the effects of the demand shock for the two economies under consideration, as illustrated by points A and B in the graph.

Sticky-wage explanations of business cycles predict that the difference between points A and B is dependent on the degree of nominal wage rigidity in the labor market. The flatter supply curve is consistent with a higher nominal wage rigidity for country B compared to country A. Subsequently, point B is consistent with a

[7] Even if one assumes that the wage path is irrelevant or indeterminate, the sluggish price path renders the real wage procyclical in response to demand shocks.

Figure 1. Effects of positive demand shocks under sticky-wage and sticky-price scenarios



higher rigidity of the nominal wage, relative to price, and, therefore, a reduction in the real wage compared to point A. The reduction in the real wage is consistent with an increase in the output response to demand shocks for point B compared to point A.

Sticky-price models advocate that the difference between points A and B is dependent on price rigidity in the product market. Subsequently, point B is consistent with a reduction in price flexibility, relative to nominal wage flexibility, and, therefore, an increase in the real wage compared to point A. The increase in the real wage is consistent with an increase in the output response to demand shocks for point B compared to point A.

III. Empirical models and theoretical predictions

Below are empirical models for the cyclical behavior of the real wage and accompanying fluctuations.

A. Model specification

The models approximate the reduced-form solutions in standard business-cycle models. The reduced-form solutions are based on a specification of the aggregate supply curve

in which cyclical fluctuations in real output are dependent on demand and supply shocks. The stationarity of the variables under investigation is tested following the suggestions of Nelson and Plosser (1982). Based on the results of the Dickey-Fuller test for stationarity (see, e.g., Dickey and Fuller 1981), the variables under investigation are nonstationary in level and stationary in first-difference. Given these results, the empirical models are specified in first-difference form as follows:

$$Drw_t = a_0 + a_1 DE_{t-1} q_t + a_2 Dqs_t + a_3 DE_{t-1} d_t + a_4 Dds_t + v_{rwt}, \quad (1)$$

$$Dnw_t = b_0 + b_1 DE_{t-1} q_t + b_2 Dqs_t + b_3 DE_{t-1} d_t + b_4 Dds_t + v_{nwt}, \quad (2)$$

$$Dp_t = c_0 + c_1 DE_{t-1} q_t + c_2 Dqs_t + c_3 DE_{t-1} d_t + c_4 Dds_t + v_{pt}, \quad (3)$$

$$Dy_t = d_0 + d_1 DE_{t-1} q_t + d_2 Dqs_t + d_3 Dy_{t-1} + d_4 Dds_t + v_{yt}. \quad (4)$$

Here, $D(.)$ is the first-difference operator.[8] The logarithm of the real wage is denoted by rw_t.[9] The logarithm of the nominal wage and the price level are denoted by nw_t and p_t, while y_t measures the logarithm of real output.[10] The logarithm of the energy price given information at time $(t\text{-}1)$ is denoted by $E_{t-1}q_t$. Unanticipated change in the energy price is measured by the difference between q_t and its forecast and denoted by qs_t. Anticipated demand shifts given information at time $(t\text{-}1)$ are denoted by $E(t\text{-}1)d_t$. Unanticipated demand shifts are denoted by ds_t. Aggregate demand shifts are measured by the logarithm of nominal GNP or GDP. This is a broad measure of aggregate spending that accounts for several specific shocks that underlie aggregate demand. Finally, the terms v_{rwt}, v_{nwt}, v_{pt}, and v_{yt} are stochastic errors at time t with mean zero and constant variance.[11]

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[8] Shocks on the right-hand side are not co-integrated with the trend components of the dependent variables. In addition, the anticipated components of demand and supply shifts, while non-stationary, do not jointly exhibit a common stochastic trend with the dependent variables.

[9] By construction, $Drw_t = Dnw_t - Dp_t$. This implies that $a_j = b_j - c_j, j = 0,\ldots,4$. To satisfy these constraints, equations (1) through (4) are estimated jointly.

[10] In both sticky-wage and sticky-price models, agents adjust nominal variables fully to anticipated demand shifts, eliminating their effect on real output. In contrast, anticipated supply-side shifts enter the production function and, in turn, determine real output.

[11] The residuals from the estimated models are purely random and orthogonal to supply and demand shifts that enter the model.

Wages and prices are expected to adjust fully to anticipated changes in the energy price. Nonetheless, the final impact on the real wage is likely to depend on the energy input ratio. In addition, the response of the real wage to unanticipated energy price shifts is likely to vary in response to wage and price flexibility in the short-run. An increase in the energy price increases the cost of living, creating inflationary pressures on the nominal wage that yield positive estimates for b_1 and b_2.[12] An increase in the energy price increases the cost of the output produced, increasing price inflation and increasing real growth that yield positive estimates for c_1 and c_2 and negative estimates for d_1 and d_2.

Assuming flexible nominal wage and price in response to anticipated demand shifts, in line with the theoretical predictions, a_3 is expected to be zero.[13] The parameters b_3 and c_3 measure the nominal wage and price adjustments to anticipated demand shifts, neutralizing their effects on real output growth. The lagged dependent variable in the output equation accounts for possible persistence in adjustment, yielding a positive estimate of d_3.[14]

The parameter a_4 approximates the cyclical behavior of the real wage in response to demand shocks.[15] Wage flexibility in response to demand shocks is measured by b_4, while c_4 approximates price flexibility. Zero or negative b_4 and c_4 indicate rigidity in wage and price adjustments to demand shocks.[16] The parameter d_4 approximates cyclical fluctuations in real output in response to demand shocks.

According to sticky-wage models, nominal wage rigidity exceeds price rigidity and the real wage moves counter-cyclically in response to demand shocks. That is, wage rigidity results in a smaller b_4 parameter which induces the following effects:

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[12] The relation between labor and capital in the production process is likely also to determine the response of the nominal wage to the energy price. If labor and capital are substitutes, the inflationary effect of the energy price on the nominal wage is likely to be larger.

[13] The real wage response to anticipated demand shifts may deviate from zero, assuming wages and/or prices do not adjust fully to anticipated demand shifts.

[14] It is possible that output growth correlates negatively with its lag. In cases where output overresponds to contemporaneous shocks, producers may be inclined to shrink the output produced in the following period.

[15] Contemporaneous effects capture cyclical fluctuations over a year, which varies with the relative flexibility of wages and prices.

[16] For example, nominal wage and price inflation may be decreasing despite unanticipated growth in demand, reflecting institutional or structural rigidity.

$$b_4 \downarrow \rightarrow c_4 \downarrow, \quad c_4 > b_4 \rightarrow a_4 < 0, \quad |a_4| \uparrow \rightarrow d_4 \uparrow .$$

According to sticky-price models, wages may take the form of installment payments that do not vary with the cycle,[17] or may vary in response to demand and supply conditions. Price rigidity correlates, therefore, with a pro-cyclical response of the real wage to demand shocks. That is, price rigidity results in a smaller c_4 parameter which induces the following effects:

$$c_4 \downarrow \rightarrow b_4 > c_4 \rightarrow a_4 > 0, \quad a_4 \uparrow \rightarrow d_4 \uparrow .$$

B. Econometric methodology

The surprise terms that enter models (1) through (4) are unobservable, necessitating the construction of empirical proxies before estimation can take place. Thus, the empirical models include an equation that describes the process generating nominal GNP/GDP growth. The predicted values from this equation are the proxies for agents' expectation of the change in aggregate demand that enters the empirical model.

Obtaining a proxy for agents' forecast of nominal GNP/GDP growth is complicated by the fact that the level of nominal GNP/GDP is endogenous, as evident by the results of the test suggested by Engle (1982). Anticipated aggregate demand growth is generated by taking the fitted values of a reduced form equation for the change in the log value of nominal GNP/GDP in which the explanatory variables include two lags of the change in the short-term interest rate and two lags of the log first-difference of real output, the price level, the nominal wage rate, and the energy price. Structural break dummies are introduced in the forecast equation, as necessary.

The energy price is exogenous according to the results of Engle's (1982) test. Given evidence of structural break, following Dufour (1982), forecasts for the energy price for both the 1965-73 and 1974-05 periods are modeled as a second-order autoregressive process. The proxy for energy price surprises is then formed by subtracting these forecasts from the actual change in the energy price.

Having accounted for necessary structural breaks in the forecast equations, there is no evidence of structural break in the estimated reduced-form models. To obtain efficient estimates and ensure correct inferences (i.e., to obtain consistent variance

[17] Installment payments imply "regular" adjustments of the nominal wage that take place independently of the business cycle.

estimates), the empirical models are estimated *jointly* with the equation that determines the proxy variables following the suggestion of Pagan (1984 and 1986). To account for endogeneity, the instrument list includes three lags of the first-difference of the interest rate and three lags of the log first-difference of real output, the price level, and the nominal wage rate, as well as the current value and three lags of the log first-difference of government spending, the money supply, and the energy price.[18] The results of Engle's (1982) test for serial correlation in simultaneous equation models are consistent with the presence of first-order autoregressive errors in some models. To eliminate serial correlation, the estimated models are transformed through the filter $(1 - \rho L)$ where ρ is the serial correlation parameter and L is the lag operator.

IV. Real wage adjustment and accompanying fluctuations: the basic evidence

The models (1) through (4) are estimated using annual data for nineteen industrial countries as follows: 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. The sample period for investigation extends from 1965 to 2005.[19] Description and sources of the data are provided in Appendix A.

To conserve space, Table A1 of Appendix A summarizes the parameters that approximate the effects of aggregate demand shocks, unanticipated nominal GNP/GDP shifts, on real wage growth, ∂Drw/∂Dns, nominal wage growth, $\partial Dnw/\partial Dns$, price inflation, $\partial Dp/\partial Dns$, and real output growth, $\partial Dy/\partial Dns$.

Price flexibility exceeds nominal wage flexibility (or nominal wage rigidity exceeds price rigidity) and the real wage adjusts counter-cyclically in Australia, Belgium, Canada, France, Italy, Japan, the Netherlands, Norway, New Zealand, Spain, and Sweden. Nominal wage flexibility exceeds price flexibility (or price rigidity exceeds nominal wage rigidity) and the real wage adjusts pro-cyclically in

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[18] Joint estimation has the advantage of allowing the system of equations to spell out parameters of stickiness in a simultaneous equation model. This structural approach is preferred over stochastic general equilibrium models that rely on ad hoc judgement involving Bayesian or other simulation based methods to estimate corresponding parameters from micro data (see, e.g., Smets and Wouters 2003, Onatski and Williams 2004, Bils and Klenow 2004, and Dickens et al. 2007).

[19] To the extent that the duration of price setting is one year or shorter (see, e.g., Bils and Klenow 2005 and Dhyne et al. 2005), annual data would spell out price flexibility in the face of cyclical fluctuations within a year.

Austria, Denmark, Finland, Germany, Ireland, Switzerland, the United Kingdom and the United States.[20] In general, however, upward flexibility of both wage and price exceeds downward flexibility, indicating a faster nominal adjustment to the positive shock, compared to the negative shock.[21] Across countries, the mean difference between price and wage flexibility is positive, 0.13, suggesting higher price flexibility compared to nominal wage flexibility in response to aggregate demand shocks, on average. The largest positive difference is for Spain where price flexibility appears pronouncedly larger than nominal wage flexibility. The negative difference is the largest, in absolute value, for Finland where nominal wage flexibility appears pronouncedly larger than price flexibility.

The remaining evidence in Table A1 concerns the cyclical effects of specific shocks that underlie aggregate demand. The effects are approximated by the parameter estimates, a_4, b_4, c_4 and d_4 in the empirical models (1) through (4) employing shocks to the money supply, *ms*, private consumption, *cs*, investment, *is*, government consumption, *gs*, and exports, *xs*, sequentially.[22] The evidence in response to specific demand shocks also highlights the possibility of a procyclical or countercyclical adjustment of the real wage that varies with the relative flexibility (rigidity) of the nominal wage and price.

V. Theoretical hypotheses and cross-section evidence

The time-series evidence does not clearly identify a cyclical pattern in the real wage. Because the relative stickiness of prices and wages is likely to vary across countries, researchers might be able to use cross country data to explain variation in the cyclical behavior of real wages.

Differentiating between the implications of sticky-wage and sticky-price models of business cycles is dependent on (i) the correlation between nominal wage and price flexibility, and (ii) the effect of deviation between nominal wage and price flexibility

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[20] It is important to note that the real wage response to aggregate demand shocks is generally insignificant. Hence, the time-series evidence does not differentiate between the implications of sticky-wage and sticky-price models.

[21] For more details on asymmetry in nominal adjustments and the cyclicality of the real wage during booms and recessions see Kandil (1996) and (2002).

[22] To conserve space, Table A1 summarizes the parameters with respect to monetary shocks. Other parameters are available upon request. To measure these effects, the empirical models are re-estimated, substituting shifts to specific demand for aggregate demand shifts in the models (1) through (4).

on the size of output fluctuations in response to demand shocks. Both factors determine the relation between output fluctuations and the cyclical behavior of the real wage.

A. Nominal flexibility and fluctuations in real output and the real wage across countries

Data for the cross-section analysis are based on the time-series evidence of the effects of demand shocks on real output growth and accompanying fluctuations in the nominal wage, the real wage and price.[23] Table 1 presents the correlation between nominal wage and price flexibility and the results from five cross-section regressions.[24] These regressions evaluate variation across countries in the effect of demand shocks on real output in response to nominal wage flexibility, *wf*, price flexibility, *pf*, both nominal wage and price flexibility, price flexibility *relative* to nominal wage flexibility, (*pf-wf*), and real wage flexibility, *rwf*. All five regressions are estimated for the various measures of demand shocks under investigation.

Segment I of Table 1 presents the evidence across countries in response to unanticipated changes in nominal GNP/GDP, *ns* shocks.The correlation between nominal wage and price flexibility in response to *ns* shocks is small, 0.37, and statistically insignificant. The dependent variable in the cross-section regressions of segment I measures the response of real output growth to aggregate demand shocks, $\partial Dy/\partial Dns$. The coefficient in line I.a. measures the effect of nominal wage flexibility on output fluctuations. This coefficient is negative, but statistically insignificant. The coefficient in line I.b. measures the effect of price flexibility on output fluctuations. This coefficient is negative and statistically significant. The coefficients in line I.c. are from cross-section regressions that measure the effects of both nominal wage and price flexibility on output fluctuations. Nominal wage flexibility, in contrast to regression I.a., exhibits moderate stabilizing effect on output. More importantly, in line I.d., an increase (decrease) in price responsiveness *relative* to nominal wage responsiveness decreases (increases) the output response to demand shocks. Consistently, real output fluctuations increase with the real wage response to demand shocks, as evident by the positive coefficient in line I.e.

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[23] Cross-section regressions utilize point estimates from the time-series models. Standard errors determine the accuracy of point estimates. To correct for the two-step procedure, an error-in-variables correction for the variance of the parameter in question follows the suggestion of Gawande (1997).

[24] Statistical significance is based on critical values that correspond to one-sided test at the five or ten percent level.

Table 1. Nominal wage and price flexibility and the destabilizing effect of real wage fluctuations across countries

Dependent variable	Correlation (*wf*,*pf*)	Shock	$\frac{\partial Dns}{\partial Dds}$	Explanatory variables *wf*	*pf*	(*pf*-*wf*)	*rwf*
		I.a.		-0.26			
				(-0.82)			
		I.b.			-0.95*		
					(-6.35)		
$\frac{\partial Dy}{\partial Dns}$	0.37	I.c.		0.19	-1.00*		
	[0.11]			(0.97)	(-6.24)		
		I.d.				-0.71*	
						(-3.54)	
		I.e.					0.70*
							(4.26)
		II.a.	-0.39	-0.023			
			(-1.29)	(-0.065)			
		II.b.	0.28		-0.77*		
			(0.93)		(-3.43)		
$\frac{\partial Dy}{\partial Dms}$	0.22	II.c.	0.28	0.12	-0.78*		
	[0.38]		(0.90)	(0.43)	(-3.37)		
		II.d.	-0.0018			-0.53*	
			(-0.006)			(-2.52)	
		II.e.	-0.055				0.47*
			(-0.19)				(2.60)
		III.a.	0.99*	-0.067			
			(3.92)	(-0.44)			
		III.b.	1.054*		-0.28*		
			(4.59)		(-2.024)		
$\frac{\partial Dy}{\partial Dcs}$	-0.073	III.c.	1.061*	-0.09	-0.29*		
	[0.77]		(4.53)	(-0.64)	(-2.03)		
		III.d.	1.01*			-0.098	
			(4.05)			(-0.95)	
		III.e.	0.97*				0.10
			(3.87)				(0.79)
		IV.a.	0.67*	0.044			
			(2.97)	(0.25)			
		IV.b.	0.77*		-0.38**		
			(3.52)		(-1.61)		
$\frac{\partial Dy}{\partial Dis}$	0.29	IV.c.	0.81*	0.15	-0.45*		
	[0.23]		(3.60)	(0.87)	(-1.80)		
		IV.d.	0.76*			-0.22*	
			(3.39)			(-1.36)	
		IV.e.	0.74*				0.27*
			(3.66)				(2.095)

Table 1 (continued). Nominal wage and price flexibility and the destabilizing effect of real wage fluctuations across countries

Dependent variable	Correlation (*wf*,*pf*)	Shock	$\frac{\partial Dns}{\partial Dds}$	Explanatory variables *wf*	*pf*	(*pf*-*wf*)	*rwf*
		V.a.	0.34	1.17*			
			(0.71)	(3.59)			
		V.b.	1.26*		-1.18*		
			(1.85)		(-2.37)		
$\frac{\partial Dy}{\partial Dgs}$	0.38 [0.11]	V.c.	0.10	1.00*	-0.83*		
			(0.16)	(3.26)	(-2.03)		
		V.d.	0.27			-0.94*	
			(0.89)			(-4.54)	
		V.e.	0.26				1.11*
			(0.83)				(4.32)
		VI.a.	0.28	0.22*			
			(1.23)	(1.38)			
		VI.b.	0.36		0.0047		
			(1.21)		(0.026)		
$\frac{\partial Dy}{\partial Dxs}$	0.37 [0.12]	VI.c.	0.35	0.23**	-0.071		
			(1.20)	(1.39)	(-0.38)		
		VI.d.	0.46*			-0.16	
			(1.90)			(-1.17)	
		VI.e.	0.54*				0.28*
			(2.44)				(2.28)

Notes: $\partial Dy / \partial ds, ds = ns, ms, cs, is, gs, xs$, approximate the response of real output growth to aggregate demand shocks and the shocks to the money supply, private consumption, investment, government consumption and exports. The variables *wf*, *pf*, and *rwf* measure the corresponding flexibility of the nominal wage, price and the real wage in response to each of the shocks. Variables' responses to demand shocks are approximated by the time-series coefficients from the estimation of the empirical models (1) through (4). $\partial Dns / \partial Dds, ds = ns, ms, cs, is, gs, xs$, approximate the size of aggregate demand shocks in response to specific shocks to the money supply, private consumption, investment, government consumption, and exports. Correlation (.,.) denotes statistical correlation, where [.] denotes probability of zero correlation. t-ratios are in parentheses. * and ** denote statistical significance at the five and ten percent levels.

Cyclical fluctuations in response to specific demand shocks are dependent on the size of aggregate demand shifts. The remainder of the cross-country regressions in Table 1 include proxies for the size of aggregate demand shocks, where $\partial Dns/\partial Dds$ for $ds = ms, cs, is, gs, xs$ approximates the demand response to shocks in the money supply, private consumption, investment, government consumption, and exports.

The correlation between nominal wage and price flexibility in response to specific demand shocks is small, ranging from -0.073 for private consumption shocks to 0.38 for government consumption shocks. More importantly, nominal wage flexibility does not moderate output fluctuations. Instead, output fluctuations increase significantly with nominal wage flexibility with respect to government consumption

and export shocks. In contrast, price flexibility moderates output fluctuations significantly in the face of monetary shocks, private consumption shocks, investment shocks, and government consumption shocks.

In a regression that combines both wage and price flexibility, the latter exhibits a stronger stabilizing effect on output in the face of various measures of specific demand shocks. Further, an increase (decrease) in price flexibility *relative* to nominal wage flexibility moderates (increases) output fluctuations, which is statistically significant in the face of monetary shocks, investment shocks, and government consumption shocks. Consistently, real output fluctuations increase significantly with the real wage in response to these shocks, as well as export shocks.

The combined evidence highlights a relatively more important role for price flexibility, compared to nominal wage flexibility on output fluctuations. Contrary to the implications of sticky-wage models, nominal wage flexibility does not vary with the output-inflation tradeoff and real wage fluctuations in the face of demand shocks. Consistent with sticky-price models, an increase in price flexibility *relative* to nominal wage flexibility moderates output fluctuations. Similarly, an increase in price rigidity *relative* to nominal wage rigidity exacerbates output fluctuations.

B. Real wage variability: determinants and implications

Output growth increases with the growth in the real wage in response to aggregate and specific demand shocks across countries. The growth of the real wage is dependent, however, on nominal wage inflation and price inflation as follows:

$$Drw_t = Dnw_t - Dp_t \tag{5}$$

Accordingly, the variability of the real wage is decomposed as follows:

$$V(Drw_t) = V(Dnw_t) + V(Dp_t) - 2\,\mathrm{cov}(Dnw_t, Dp_t). \tag{6}$$

Here, V(.) denotes variability and Cov(.,.) denotes covariance. Real wage variability is decomposed into the variability of nominal wage inflation, the variability of price inflation, and the covariance between price inflation and wage inflation. Table 2 presents the data for real wage variability and its underlying components.

Table 2. Real wage variability and the underlying components

Country	$V(Drw_t)$	$V(Dnw_t)$	$V(Dp_t)$	$Cov(Dnw_t, Dp_t)$	$\%Dnw_t$	$\%Dp_t$
Australia	0.00600	0.00140	0.00140	0.00110	0.50	0.50
Austria	0.00045	0.00100	0.00031	0.00043	1.27	-0.27
Belgium	0.00082	0.00190	0.00070	0.00089	1.23	-0.23
Canada	0.00032	0.00110	0.00098	0.00088	0.68	0.32
Denmark	0.00045	0.00120	0.00069	0.00072	1.067	-0.067
Finland	0.00110	0.00190	0.00140	0.00110	0.72	0.28
France	0.00040	0.00180	0.00100	0.00120	1.50	-0.50
Germany	0.00035	0.00081	0.00028	0.00037	1.26	-0.26
Ireland	0.00070	0.00310	0.00280	0.00260	0.71	0.29
Italy	0.00220	0.00430	0.00430	0.00320	0.50	0.50
Japan	0.00060	0.00330	0.00170	0.00220	1.83	-0.83
Netherlands	0.00069	0.00170	0.00099	0.00100	1.014	-0.014
Norway	0.00162	0.00170	0.00110	0.00059	0.69	0.31
New Zealand	0.00090	0.00290	0.00260	0.00230	0.67	0.33
Switzerland	0.00092	0.00095	0.00047	0.00025	0.76	0.24
Spain	0.00170	0.00370	0.00240	0.00220	0.88	0.12
Sweden	0.00063	0.00120	0.00081	0.00069	0.81	0.19
U.K.	0.00050	0.00200	0.00250	0.00200	0.00	1.00
U.S.	0.00008	0.00051	0.00057	0.00050	0.13	0.87

Notes: $V(Drw_t), V(Dnw_t), V(Dp_t)$ denote the variability of real wage inflation, nominal wage inflation, and price inflation. $Cov(Dnw_t, Dp_t)$ denotes the covariance between nominal wage and price inflation; $\%Dnw = \{V(Dnw) - Cov(Dnw, Dp)\} / V(Drw)$, the share of nominal wage inflation of real wage variability; $\%Dp = \{V(Dp) - Cov(Dnw, Dp)\} / V(Drw)$, the share of price inflation of real wage variability.

Regressions across countries shed additional light on the empirical validity of the contending explanations. First, cross-country regressions will evaluate the effects of nominal wage and price responsiveness to aggregate and specific demand shocks on real wage variability. Second, cross-country regressions will evaluate variation in real output variability with the components of real wage variability across countries.

Given the decomposition in equation (6), the variability of the real wage in response to demand shocks can be expressed as follows:

$$a_{rw}^2 V(Dds) = b_{nw}^2 V(Dds) + c_p^2 V(Dds) - 2b_{nw} c_p V(Dds). \quad (7)$$

The magnitude on the left-hand side measures the variability of the real wage in response to demand shocks. The first component on the right-hand side measures the contribution of the nominal wage, the second contribution measures the

contribution of price and the last component measures covariance. Contributions are approximated by the parameters from the time-series model and the variance of the relevant demand shock, $V(Dds)$, over time. In Table 3, these contributions are the independent variables in cross-section regressions that seek to verify their relevance to real wage variability across countries.

Table 3. Nominal wage and price flexibility in response to demand shocks and fluctuations in the real wage across countries

Explanatory Variables	(1) *V*(*Dp*)	(2) *V*(*Dnw*)	(3) *Cov*(*Dnw,Dp*)	(4) *V*(*Dp*) -*Cov*(*Dnw,Dp*)	(5) *V*(*Dnw*) -*Cov*(*Dnw,Dp*)
$b_{4n}^2 V(Dns)$		1.96	1.44		0.12
		(1.02)	(1.19)		(0.16)
$c_{4n}^2 V(Dns)$	2.30*		1.62*	0.62*	
	(4.52)		(3.49)	(3.27)	
$b_{4m}^2 V(Dms)$		2.043	1.57		-0.047
		(0.94)	(1.12)		(-0.057)
$c_{4m}^2 V(Dms)$	4.66*		3.63*	0.90*	
	(3.50)		(3.28)	(1.73)	
$b_{4c}^2 V(Dcs)$		0.41	-0.024		0.54
		(0.29)	(-0.027)		(1.063)
$c_{4c}^2 V(Dcs)$	4.28*		3.34*	0.93*	
	(3.90)		(3.46)	(2.16)	
$b_{4i}^2 V(Dis)$		1.65	-0.46		1.029
		(0.72)	(-0.24)		(1.24)
$c_{4i}^2 V(Dis)$	3.40**		3.41*	0.14	
	(1.53)		(1.76)	(0.19)	
$b_{4g}^2 V(Dgs)$		2.24	0.17		0.22
		(1.19)	(0.11)		(0.31)
$c_{4g}^2 V(Dgs)$	4.88*		3.21*	1.61*	
	(4.55)		(2.62)	(4.79)	
$b_{4x}^2 V(Dxs)$		1.17	0.05		0.66**
		(0.93)	(0.059)		(1.48)
$c_{4x}^2 V(Dxs)$	2.32*		1.61*	0.71*	
	(4.72)		(3.25)	(4.19)	

Notes: $b_{4d}, d = n,m,c,i,g,x,$ measure wage flexibility in the empirical model (1) through (4) in response to aggregate demand shocks and the shocks to the money supply, private consumption, investment, government consumption, and exports. Selected estimates are summarized in Table A1. $c_{4d}, d = n,m,c,i,g,x,$ measure price flexibility in the empirical model (1) through (4) in response to aggregate demand shocks and the shocks to the money supply, private consumption, investment, government consumption, and exports. Selected estimates are summarized in Table A1. $V(ds), d = n,m,c,i,g,x,$ measure the variability of aggregate demand shocks and the shocks to the money supply, private consumption, investment, government consumptin and exports. The dependent variables measure components of real wage variability, *V*(*Drw*), according to the decomposition: $V(Drw_t) = V(Dnw_t) + V(Dp_t) - 2Cov(Dnw_t, Dp_t)$, *where V*(*Dnw*) is nominal wage variability, *V*(*Dp*) is price variability and *Cov*(*Dnw,Dp*) measures covariance between nominal wage and price. t-ratios are reported in parentheses.

Overall, nominal wage flexibility does not determine wage variability or its covariance with price inflation. Consequently, fluctuations in the nominal wage are by and large due to supply-side factors. In contrast, price flexibility determines the variability of price inflation and its covariance with nominal wage inflation across countries.
Table 4 presents cross-country regressions that illustrate the difference in real output variability in response to (i) the variability of wage inflation, (ii) the variability of price inflation, (iii) the covariance between wage inflation and price inflation, (iv) the "net variability" of wage inflation, and (v) the "net variability" of price inflation. Real output variability, $V(Dy)$, is measured by the variance of real output growth across countries.

Table 4. Real output variability *V*(*Dy*) and real wage fluctuations across countries

Estimate	Explanatory variables		R^2
(1)	Constant	*V*(*Drw*)	0.025
	0.00049*	0.063	
	(5.51)	(0.66)	
(2)	Constant	*V*(*Dnw*)	0.230
	0.00036*	0.095*	
	(3.90)	(2.24)	
(3)	Constant	*V*(*Dp*)	0.053
	0.00048*	0.046	
	(5.77)	(0.98)	
(4)	Constant	*Cov*(*Dnw,Dp*)	0.15
	0.00043*	0.093*	
	(5.08)	(1.71)	
(5)	Constant	*V*(*Dnw*)-*Cov*(*Dnw,Dp*)	0.20
	0.00039*	0.24*	
	(4.43)	(2.03)	
(6)	Constant	*%Dnw*	0.12
	0.00040	0.00017**	
	(3.89)	(1.54)	
(7)	Constant	*V*(*Dp*)-*Cov*(*Dnw,Dp*)	0.067
	0.00057*	(0.16)	
	(10.77)	(-1.11)	
(8)	Constant	*%Dp*	0.12
	0.00057*	-0.00017**	
	(11.51)	(-1.54)	

Notes: *V*(*Dy*), *V*(*Drw*), *V*(*Dnw*), *V*(*Dp*) denote the variability of real output growth, real wage inflation, nominal wage inflation and price inflation. *Cov*(*Dnw,Dp*) denotes covariance between nominal wage and price inflation. *%Dnw=V*(*Dnw*)-*Cov*(*Dnw,Dp*)/(*Drw*) is the share of nominal wage inflation of real wage variability, as reported in Table 2. *%Dp=V*(*Dp*)-*Cov*(*Dnw,Dp*)/*V*(*Drw*) is the share of price inflation of real wage variability, as reported in Table 2. t-ratios are in parentheses. * and ** denote statistical significance at the five and ten percent levels.

An increase in the share of price of real wage variability moderates output variability across countries. In contrast, an increase in the share of the nominal wage of real wage variability exacerbates output variability across countries.

VI. Conclusions

This investigation has focused on the cyclical behavior of the real wage and output fluctuations. Wage rigidity, attributed to explicit or implicit contracts, produces a counter-cyclical response of the real wage that exacerbates output variability. Sticky-price explanations of business cycles establish the source of rigidity in the product market. Faced with menu costs, producers may be reluctant to adjust prices in the short-run, exacerbating output fluctuations. Price rigidity determines, therefore, the pro-cyclical response of the real wage and exacerbates output variability.

The empirical investigation has focused on hypotheses that differentiate the validity of the competing explanations of business cycles. Using data for a group of nineteen industrial countries, the time-series evidence highlights nominal wage and price flexibility with respect to aggregate and specific demand shocks. The analysis considers the implications on the cyclical behavior of the real wage and output fluctuations.

Nominal wage and price flexibility exhibit some, although moderate, correlation in response to demand shocks. The implication is the real wage may move counter-cyclically or pro-cyclically with the relative speed of adjusting wages and prices during business cycles. An increase in price flexibility relative to wage flexibility decreases the real wage and moderates output fluctuations during a boom. In contrast, a reduction in the real wage, reflecting more downward rigidity of prices relative to wages, exacerbates output contraction during a downturn.

Demand shocks do not differentiate the variability of the nominal wage. It appears, therefore, that nominal wage variability is dominated by supply-side factors. Consequently, output variability increases with the variability of the nominal wage. In contrast, price flexibility with respect to demand shocks differentiates price variability. Accordingly, output variability decreases with respect to price variability across countries.

To summarize, across a sample of nineteen industrial countries price flexibility varies independently from conditions in the labor market. This variation determines the cyclical behavior of the real wage and accompanying output fluctuations in response to demand shocks. Consequently, higher growth of the real wage exacerbates output expansion while a reduction in the real wage exacerbates contraction. The

sluggishness of price adjustment appears, therefore, more important, compared to nominal wage rigidity, in determining the cyclical behavior of the real wage and output fluctuations across industrial countries.

Appendix: Data sources

To estimate the paper's models, the following series are necessary:

1. The real value of aggregate output as measured by real GDP, series 99b.r or 99b.p, or GNP, series 99a.r. GDP measures are used for all countries except for Germany and Japan for which GNP measures are used.

2. Aggregate demand: The nominal value of aggregate output as measured by nominal GDP, series 99b, or nominal GNP, series 99a.c.

3. The price level: The price of aggregate output as measured by the GDP deflator, series 99b divided by 99b.r or 99b.p, or the GNP deflator, series 99a.c divided by series 99a.r.

4. The wage rate: Index of the wage rate per worker employed in the industrial sector per specified time period, series 65.

5. The money stock: The sum of currency outside banks and private sector demand deposits, series 34.b.

6. Short-term interest rates: Representatives of short-term market rates for the various countries, i.e., rates at which short-term borrowing is affected between financial institutions or rates at which short-term government paper is issued or traded in the market, series, 60b, 60c, 60I, or 61.

7. Private consumption: The nominal value of private purchases of goods and services for consumption, series 96f.c.

8. Investment: The nominal value of private and public purchases of goods and services for investment, series 93e.c.

9. Government consumption: The nominal value of government purchases of goods and services for consumption, series 91f.c.

10. The nominal value of foreign purchases of goods and services, series 90c.c.

11. The energy price: The price of Venezuelan petroleum, series 76aad.

All annual series are available over the sample period 1965-2005 from the International Financial Statistics available on tapes from the *International Monetary Fund*.

Table A1. The time series evidence of cyclical fluctuations in response to aggregate and monetary shocks

Country	$\frac{\partial Drw}{\partial Dns}$	$\frac{\partial Dnw}{\partial Dns}$	$\frac{\partial Dp}{\partial Dns}$	$\frac{\partial Dy}{\partial Dns}$	$\frac{\partial Drw}{\partial Dms}$	$\frac{\partial Dnw}{\partial Dms}$	$\frac{\partial Dp}{\partial Dms}$	$\frac{\partial Dy}{\partial Dms}$
Australia	-0.27	0.21	0.48*	0.63*	-0.34*	-0.23*	0.12	-0.085
	(-0.96)	(0.78)	(2.34)	(3.31)	(-2.17)	(-2.01)	-1.37	(-0.64)
Austria	0.046	0.076	0.042	1.21*	-0.032	0.054	0.12	-0.05
	(0.15)	(0.34)	(0.21)	(4.62)	(-0.31)	-0.55	-1.34	(-0.49)
Belgium	-0.16	-0.22	-0.054	0.61*	-0.20	-0.13	0.082	-0.22
	(-0.69)	(-0.98)	(-0.27)	(2.21)	(-1.17)	(-0.77)	-0.68	(-1.35)
Canada	-0.22	-0.25	-0.045	1.25*	0.03	-0.011	-0.036	-0.054
	(-1.04)	(-1.22)	(-0.26)	(2.79)	(0.45)	(-0.23)	(-0.97)	(-0.59)
Denmark	0.31	0.28	-0.017	0.85*	0.025	0.085	0.043	-0.19
	(1.11)	(0.86)	(-0.11)	(2.96)	(0.18)	-0.46	-0.54	(-0.95)
Finland	0.60	1.031*	0.38	0.75*	-0.046	0.1	0.11	0.25**
	(1.15)	(1.86)	(1.16)	(1.68)	(-0.18)	-0.44	-0.9	-1.64
France	-0.13	0.08	0.39*	0.47*	0.11	0.036	-0.059	-0.022
	(-0.28)	(0.17)	(2.51)	(3.52)	(0.67)	-0.21	(-0.59)	(-0.32)
Germany	0.37*	0.42*	0.10	0.96*	-0.083	-0.059	0.028	-0.40*
	(2.11)	(2.18)	(0.75)	(4.68)	(-0.78)	(-0.35)	-0.28	(-2.16)
Ireland	0.12	0.66*	0.56*	0.45*	0.30*	0.043	-0.33*	0.13
	(0.32)	(2.05)	(2.82)	(2.34)	(2.54)	-0.25	(-2.91)	-1.3
Italy	-0.84*	0.12	0.91*	0.023	0.73*	0.074	-0.38	0.099
	(-2.79)	(0.40)	(9.10)	(0.18)	(1.72)	-0.15	(-0.83)	-0.81
Japan	-0.042	-0.014	0.0041	0.83**	-0.11	0.019	0.12	-0.098
	(-0.14)	(-0.03)	(0.01)	(1.84)	(-1.21)	-0.14	-0.77	(-0.66)
Netherlands	-0.17	0.38*	0.55*	0.29**	0.005	0.074	-0.093	-0.23**
	(-0.75)	(1.86)	(3.49)	(1.64)	(0.02)	-0.28	(-0.39)	(-1.52)
Norway	-0.65	0.084	0.87*	0.11	-0.25	-0.14	0.077	-0.15**
	(-1.34)	(0.17)	(3.44)	(0.55)	(-1.23)	(-0.64)	-0.55	(-1.65)
N. Zealand	-0.17	0.49**	0.87*	0.13	-0.046	-0.41*	-0.2	-0.094
	(-0.47)	(1.44)	(5.22)	(0.47)	(-0.25)	(-1.83)	(-0.83)	(-0.63)
Switzerland	0.027	0.35	0.34*	0.46*	0.28**	0.21	-0.12	-0.034
	(0.05)	(0.67)	(1.72)	(1.95)	(1.45)	-1.04	(-1.31)	(-0.28)
Spain	-1.10*	0.42*	1.20*	-0.27**	0.57*	-0.24	-0.78*	0.64*
	(-5.83)	(2.00)	(7.57)	(-1.58)	(2.42)	(-1.10)	(-3.12)	-3.13

Table A1 (continued). The time series evidence of cyclical fluctuations in response to aggregate and monetary shocks

Country	$\frac{\partial Drw}{\partial Dns}$	$\frac{\partial Dnw}{\partial Dns}$	$\frac{\partial Dp}{\partial Dns}$	$\frac{\partial Dy}{\partial Dns}$	$\frac{\partial Drw}{\partial Dms}$	$\frac{\partial Dnw}{\partial Dms}$	$\frac{\partial Dp}{\partial Dms}$	$\frac{\partial Dy}{\partial Dms}$
Sweden	-0.69	0.13	0.30	-0.047	0.11	0.011	-0.059	0.093
	(-0.89)	(0.23)	(1.18)	(-0.10)	(0.68)	-0.08	(-0.78)	(-0.75)
U.K.	0.12	0.62*	0.51*	0.49*	0.02	-0.083	-0.064	-0.082
	(0.49)	(3.24)	(2.40)	(2.65)	(0.31)	(-1.17)	(-1.06)	(-1.26)
U.S.	0.091	0.23*	0.15*	0.78*	0.31*	-0.065	-0.35*	-0.07
	(1.19)	(3.24)	(1.84)	(5.21)	(2.30)	(-0.51)	(-2.70)	(-0.18)

Notes: $\partial D./\partial Dns, \partial D./\partial Dms$, measure the effects of aggregate demand and monetary shocks on the real wage, the nominal wage, price and real output. The effects of other demand shocks –private consumption, private investment, government spending and exports– are available upon request. t-ratios are in parentheses. * and ** denote statistical significance at the five and ten percent levels.

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