ASYMMETRIC EFFECTS OF AGGREGATE DEMAND SHOCKS ACROSS U.S. INDUSTRIES:

EVIDENCE AND IMPLICATIONS

Magda Kandil
International Monetary Fund

INTRODUCTION

Recent research using aggregate macroeconomic data has produced strong evidence that supports the asymmetric effects of positive and negative demand shocks. Using quarterly data for the United States, the evidence of Cover [1992] suggests that positive money supply shocks do not have an effect on output while negative money-supply shocks do. Kandil [1995] provides evidence and explanation of the asymmetric effects of monetary shocks across a sample of major industrial countries. Kandil [1996; 2002a] analyzes the evidence of the asymmetric effects of aggregate demand shocks using aggregate data of real output, price, and wage for the United States. Kandil [1998; 1999] contrasts the evidence of supply-side asymmetry using aggregate demand shocks across samples of developing and industrial countries. Kandil [2001; 2002b] investigates asymmetry in the effects of monetary and government spending shocks using aggregate data for the United States. Other evidence on the asymmetry of business cycles includes De Long and Summers [1988], and Romer and Romer [1989].

The asymmetric impact of demand shocks on real output growth is not addressed in the context of mainstream business-cycle theories which include the equilibrium explanation pioneered by Lucas [1973] and neo-Keynesian models emphasizing nominal wage rigidity, e.g., Fischer [1977], Gray [1978] or price rigidity, e.g., Ball, Mankiw, Romer, et al [1988]. In the context of these explanations, the slope of the short-run aggregate supply curve is not likely to be different in the face of positive and negative demand shocks.

These implications are in sharp contrast to the aggregate empirical evidence for the United States. A positive demand shock appears to be operating along a very steep (or maybe a vertical) short-run aggregate supply curve. In contrast, a negative demand shock appears to operate along a very flat (or maybe a horizontal) short-run supply curve. Such evidence requires an adequate explanation. This paper focuses on identifying sources of observed aggregate asymmetry using disaggregate data. If wages

Magda Kandil: International Monetary Fund, 700 Nineteenth Street, N.W., Washington, D.C.20431. E-mail: mkandil@imf.org.

and/or prices are rigid in the downward direction and flexible in the upward direction, asymmetry exacerbates the inflationary effects of positive demand shocks on wage and price and the contractionary effects of negative shocks on real output

There are two theoretical explanations of asymmetric nominal flexibility. Sticky-wage contracting models, see, for example, Kandil [2002a], propose asymmetric wage indexation as a possible explanation of the asymmetric effects of demand shocks. On the other hand, theoretical efforts advocating sticky prices, see, for example, Ball and Mankiw [1992] propose the asymmetric adjustment of prices to provide an explanation. Determinants of asymmetric nominal flexibility as well as its implications vary across these alternatives. Nonetheless, both explanations establish the source of asymmetry on the supply-side. That is, asymmetry is the result of aggregate demand shifts along a kinked supply curve. Other theoretical explanations of supply-side asymmetry include insider-outsider models, see, for example, Blanchard and Summers [1988]; Lindbeck and Snower [1986], and asymmetric capacity constraints, see, for example, De Long and Summers [1988].

Other explanations of asymmetry, see, for example, Bernanke [1983], have argued, however, that the source of asymmetry lies on the demand side rather than on the supply side of the economy. Different size demand shifts in response to positive and negative shocks differentiate the effects of these shocks along a straight line supply curve.

The empirical investigation of the present paper aims to test the validity of competing explanations using disaggregate data to address two questions: (i) Are the asymmetries uncovered at the aggregate level widespread, or do they emerge due to huge asymmetries in a few sectors?, and (ii) what accounts for these asymmetries? Are they due to asymmetries at the sectoral level or the asymmetric transmission of aggregate demand shocks to sectoral demand shocks? At the industry level, supply-side asymmetry may differentiate the response of industrial variables to a given size industrial demand shock. In addition, the response of industrial demand to aggregate shocks may be different during booms and recessions. In Kandil [1995], the investigation of demand-side asymmetry at the aggregate level concerns the elasticity of aggregate demand with respect to specific shocks that underlie aggregate demand, e.g., monetary shocks.

This investigation will provide time-series evidence of the asymmetric effects of aggregate demand shocks on real output growth and wage and price inflation for a sample of U.S. industries. These effects are further decomposed as follows: (i) asymmetry in response to a given size *industrial* demand shock, and (ii) asymmetry in the response of industrial demand to *aggregate* demand shocks. Cross-industry analysis will then establish the paper's findings.

The evidence highlights the importance of supply-side and demand-side asymmetry across industries. Trend price inflation increases upward price flexibility relative to downward flexibility and exacerbates output contraction relative to expansion in the face of industrial demand shocks. The kinked-slope of the supply curve does not depend on conditions in the labor market. Further, industrial demand shifts are different in the face of positive and negative aggregate demand shocks. The variability of industrial demand increases wage and price inflation relative to deflation and increases output contraction relative to expansion in the face of aggregate demand shocks.

The first section provides a brief reference to theoretical explanations of asymmetry; the next describes the data and econometric methodology; the third presents the evidence of asymmetric fluctuations; and the following section evaluates the determinants and implications of asymmetry. A summary and conclusion are provided in the final section.

EXPLANATIONS OF ASYMMETRY

Agents are located in scattered sectors (industries) across the economy. Asymmetry in the response of industrial variables to aggregate demand shocks can be generally differentiated into demand- and supply-side channels. To illustrate, consider the following relationship:

$$Dv_{it} = a_v\{DNS_{it}\}, \qquad v = y, p, w \qquad a > 0. \tag{1}$$

Here, $D(.)$ is the first-difference operator. The log of industrial real output is denoted by y, where p and w denote the log values of industrial price level and the nominal wage. Unanticipated industrial demand growth is denoted by DNS_{it}. In period t, industrial real output growth, price inflation and nominal wage inflation are expressed as a function of contemporaneous unanticipated industrial demand growth where a_v denotes the effect on the specific variable.

Unanticipated industrial demand shocks can be differentiated, in turn, into positive and negative shocks. That is,

$$Dv_{it} = a_{pv}pos_{it} + a_{nv}neg_{it}, \quad v = y, p, w, \tag{2}$$

where, pos_{it} and neg_{it} denote positive and negative shocks to industrial demand growth. Conditions on the supply-side may differentiate the response of industrial variables to positive and negative shocks.

Supply-Side Asymmetry

A Sticky-Wage New Keynesian Explanation

Sticky-wage new-Keynesian models see, for example, Gray [1978] 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 nominal wage and salary negotiations across the economy are governed by contractual agreements. All contracts specify a contract length and a path of nominal wages based on available information at the time contracts were negotiated. Assume each contract stipulates an indexing parameter that allows for an additional adjustment of the nominal wage in response to unexpected changes in the price level. Nominal wage rigidity is dependent, therefore, on the length of labor contracts and the degree of indexation. High variability of industrial demand and/or high trend inflation of industrial output price increase the probability of fluctuations in demand and, in turn, incentives for nominal wage flexibility. This is consistent with shorter labor contracts and/or a higher degree of nominal wage indexation. Models of the variety of Gray [1978] have emphasized the dependency of contract length and the degree of nominal wage indexation on the variability of stochastic disturbances. Agents aim at minimizing deviation in output around its desired level, which corresponds to full-employment in the labor market in response to shocks that may realize following contract negotiation.

Nominal wage indexation may be larger, however, in response to positive demand shocks compared to negative shocks. For theoretical illustration, see Kandil [2002a]. Asymmetry may be the result of institutional settings that differentiate salary negotiations in the upward and downward directions.[1] Alternatively, asymmetry may be an endogenous response to uncertainty.[2]

Asymmetric nominal wage indexation establishes the possibility of supply-side asymmetry. Specifically, the downward rigidity of the nominal wage moderates the reduction in price inflation, while increasing output contraction, during recessions. In contrast, the upward flexibility of the nominal wage increases the inflationary effect of positive demand shocks and moderates output expansion.

A Sticky-Price New Keynesian Explanation

Sticky-price models, see, for example, Ball, Mankiw, Romer, et al [1988], have emphasized rigidity in the product market to explain economic fluctuations. Monopolistically competitive firms face small "menu costs" when they change prices. These are resources involved in announcing and implementing a price change. Given these costs, firms adjust prices at discrete intervals over time. Firms compare menu costs to the benefits of more frequent price adjustments. Higher variability of industrial demand and/or higher trend inflation of industrial output price increase the probability of fluctuations in demand and, in turn, incentives for price flexibility.

Each firm sets its price to the average of its expected profit maximizing prices. It is possible, however, that price flexibility may be asymmetric in response to positive and negative demand shocks. For a theoretical illustration of this possibility, see Ball and Mankiw [1992]. Other illustrations of state-dependent pricing include Caballero and Engel [1991]; Caplin and Leahy [1991]; Tsiddon [1991].

Positive trend inflation plays a key role in introducing asymmetries. Inflation causes firms' relative prices to decline automatically between adjustments. This requires greater adjustment of firms' desired prices in the face of positive shocks compared to negative shocks.[3] Price rigidity is independent, however, from nominal wage adjustments in the labor market. A larger price adjustment during expansionary demand periods, moderates real output expansion. In contrast, larger downward rigidity of price exacerbates output contraction in the face of negative demand shocks.

Demand-Side Asymmetry

Industrial demand shocks are induced, in turn, by aggregate shocks impinging on the economic system. Accordingly,

$$\begin{aligned} Dv_{it} &= a_{pv}\left\{\frac{\partial pos_{it}}{\partial pos_t}\right\}pos_t + a_{nv}\left\{\frac{\partial neg_{it}}{\partial neg_t}\right\}neg_t \\ &= A_{pv}pos_t + A_{nv}neg_t, \qquad v = y, p, w. \end{aligned} \tag{3}$$

Aggregate demand shocks are differentiated into positive and negative shocks, pos_t and neg_t. The difference between A_{pv} and A_{nv} measures asymmetry in the response of industrial variables to aggregate demand shocks. The magnitudes in curly brackets measure the size of industrial demand shifts in response to aggregate demand shocks. Models of demand-side asymmetry, differentiate the size of industrial demand shocks during booms and recessions. Structural and institutional parameters may differentiate the elasticity of industrial demand in response to positive and negative aggregate demand shocks. Examples are models concerned with credit rationing policies, as in Bernanke [1983].

One possible explanation relates to the presence of credit constraints which differentiate banks' willingness to lend during booms and recessions. During recessions, a higher risk of borrowers' bankruptcy prompt banks to ration credit. This credit constraint exacerbates the contractionary effect of a slowdown in spending during a recession. In contrast, credit constraints are not binding during a boom. Nonetheless, banks' willingness to lend may not stimulate an increase in spending without an increase in the demand for credit. This, in turn, decreases the effectiveness of expansionary policies that aim at increasing the availability of credit. Jackman and Sutton [1982] set a similar argument by focusing on the effect of interest rate changes on spending. They report that as interest rates rise (e.g., a tight monetary policy), consumption spending falls the full amount as a result of the increase in debt payments. In contrast, a decrease in interest rates (e.g., an expansionary monetary policy) induce higher levels of spending, but by an amount less than the change in liabilities. Similarly, Bernanke and Gertler [1989] analyze the relation between changes in the interest rate and investment demand. They find that large drops in investment are more likely to occur than large increases.

The change in agents' confidence at different phases of business cycles may further exacerbate asymmetry in industrial demand shifts during booms and recessions. If firms and consumers are more pessimistic during recessions, their reaction in spending is likely to be asymmetric.[4] For some empirical evidence along this line, see Gertler and Gilchrist [1991].

EMPIRICAL INVESTIGATION

The use of disaggregate data will identify asymmetry: (i) in the face of a given shift to industrial demand, and (ii) asymmetry in the face of aggregate demand shocks.

Appendix A describes the econometric methodology. Demand shocks are assumed to be randomly and symmetrically distributed around an anticipated steady-state trend. Positive (negative) shocks represent an increase (decrease) in demand growth above its steady-state trend. Asymmetry in the face of industrial demand shocks is dependent on the shape of the industrial supply curve. Asymmetry in the face of aggregate demand shocks is dependent on the supply curve, as well as asymmetry in the response of industrial demand to aggregate demand shocks.

Model Specification

The starting point is the specification of empirical models for the cyclical behavior of industrial real output, the price level and the nominal wage. Stationarity is tested following the suggestions of Nelson and Plosser [1982]. Based on the results of the KPSS test for non-stationarity, see Kwiatowski, Phillips, Schmidt, and Shin [1992], the variables under investigation are nonstationary in level and stationary in first difference. See Tables A1 and A2 for details. The results are robust in a test for the null-hypothesis of non-stationarity, see, for example, Dickey and Fuller [1981].[5] Given these results, the empirical models are specified in first-difference form as follows:

$$(4) \qquad Dy_{it} = a_0 + a_1 E_{t-1} Dq_t + a_2 Dqs_t + a_3 Dy_{it-1} + a_{4p} pos_{it} + a_{4n} neg_{it} + \eta_{y_{it}}$$

$$(5) \qquad Dp_{it} = b_0 + b_1 E_{t-1} Dq_t + b_2 Dqs_t + b_3 E_{t-1} DN_{it} + b_{4p} pos_{it} + b_{4n} neg_{it} + \eta_{p_{it}}$$

$$(6) \qquad Dw_{it} = c_0 + c_1 E_{t-1} Dq_t + c_2 Dqs_t + c_3 E_{t-1} DN_{it} + c_{4p} pos_{it} + c_{4n} neg_{it} + \eta_{w_{it}}$$

The empirical models replicate the reduced-form solutions of output, price, and the nominal wage, as implied by the intersection of an industry supply and demand curves. Producers vary the output supplied positively with unanticipated changes in demand and negatively with changes (both anticipated and unanticipated) in the energy price. Nominal variables adjust fully to anticipated demand shifts, eliminating their effect on output. As noted above, nominal rigidity determines fluctuations in the face of demand shocks in the short-run. Given nominal rigidity, producers adjust the output supplied positively in the face of unanticipated demand changes in the short-run.

$D(.)$ is the first-difference operator. The logarithm of industrial real output is denoted by y_{it} where p_{it} and w_{it} measure the logarithm of the price level and the nominal wage. The logarithm of the energy price is denoted by q_t.[6] Anticipated changes in the logarithm of the energy price are denoted by $E_{t-1}Dq_t$ and unanticipated changes are measured by Dqs_t. The nominal value of industrial output approximates realized demand for industrial output. $E_{t-1}DN_{it}$ denotes anticipated growth in industrial demand. Unanticipated growth in industrial demand given information at time t-1 is denoted by DNs_{it}. The positive and negative components of unanticipated growth in industrial demand are denoted by pos_{it} and neg_{it}. Finally, the terms η_{yit}, η_{pit}, and η_{wit} are stochastic errors in industry i at time t with mean zero and constant variance.

Equation (4) explains the growth of real output as a function of its lag, Dy_{it-1}. The empirical models of industrial price and wage inflation replicate the model of real output growth, except for anticipated growth in industrial demand. This component replaces the lagged dependent variable in the output equation.[7]

Changes in the energy price, both anticipated and unanticipated, are expected to have negative effects on real output growth, i.e., a_1 and a_2 are negative. The parameter a_3 approximates the degree of persistence characterizing real output growth. The larger this parameter, the higher is the degree of persistence characterizing real output growth. Positive a_{4p} and a_{4n} measure the expansionary and contractionary effects of industrial demand shocks on real output growth. Negative a_{4p} or a_{4n} would indicate, however, rigidity in the output adjustment to demand shocks. Supply-side constraints may prevent a positive response of industrial output to demand shocks. The asymmetric response of real output growth to industrial demand shocks is approximated by $(a_{4p} - a_{4n})$.[8]

Changes in the energy price, both anticipated and unanticipated, are expected to increase nominal wage and price inflation, i.e., b_1, b_2, c_1, and c_2 are positive. Anticipated demand shifts are expected to have positive effects on nominal wage and price inflation, i.e., the parameters b_3 and c_3 are positive. The larger these parameters, the faster is the speed of wage and price adjustments toward their full-equilibrium values. Positive b_{4p} and b_{4n} measure upward and downward flexibility of price inflation in response to industrial demand shocks. Negative b_{4p} or b_{4n} would indicate, however, rigidity in price adjustment to demand shocks. Rigidity may be the result of institutional constraints that prevent a timely adjustment of prices to demand shocks or in response to supply-side factors, e.g., a productivity shock, that may necessitate a reduction of price inflation despite expansionary demand shocks. Asymmetric price flexibility in response to industrial demand shocks is approximated by $(b_{4p} - b_{4n})$. Similarly, positive c_{4p} and c_{4n} approximate upward and downward flexibility of nominal wage inflation in response to industrial demand shocks. Negative c_{4p} or c_{4n} would indicate, however, rigidity in nominal wage adjustment to demand shocks. Asymmetric wage flexibility in response to industrial demand shocks is approximated by $(c_{4p} - c_{4n})$.[9]

Asymmetry in the response of industrial variables to *aggregate* demand shocks is likely to vary with conditions on the demand and supply sides of industries. To illustrate, the system of equations (4) through (6) is replaced as follows:

$$(7) \qquad Dy_{it} = a_0 + a_1 E_{t-1} Dq_t + a_2 Dqs_t + a_3 Dy_{it-1} + A_{4p} pos_t + A_{4n} neg_t + a_5 ss_{it} + \eta_{yit}$$

$$(8) \qquad Dp_{it} = b_0 + b_1 E_{t-1} Dq_t + b_2 Dqs_t + b_3 E_{t-1} DN_{it} + B_{4p} pos_t + B_{4n} neg_t + b_5 ss_{it} + \eta_{pit}$$

(9) $$Dw_{it} = c_0 + c_1 E_{t-1} Dq_t + c_2 Dqs_t + c_3 E_{t-1} DN_{it} + C_{4p} pos_t + C_{4n} neg_t + c_5 ss_{it} + \eta_{wit}$$

(10) $$DNs_{it} = d_0 + d_{pi} pos_t + d_{ni} neg_t + ss_{it}$$

The nominal value of Gross Domestic Product (GDP) approximates aggregate demand. The logarithm of GDP is denoted by N_t. The positive and negative components of unanticipated growth in *aggregate* demand are denoted by pos_t and neg_t.

To test for possible asymmetry on the demand side, industrial demand shocks in (10) are regressed on the positive and negative components of unanticipated growth in aggregate demand. The parameters d_{pi} and d_{ni} determine the size of unanticipated shifts in industrial demand, DNs_{it}, in response to positive and negative aggregate demand shocks. The residual ss_{it} measures industry-specific disturbances.[10]

The parameters A_{4p} and A_{4n} measure output expansion and contraction in the face of aggregate demand shocks. Similarly, the parameters B_{4p} and B_{4n} measure price inflation and deflation and the parameters C_{4p} and C_{4n} measure wage inflation and deflation in the face of aggregate demand shocks. The effects of aggregate demand shocks on industrial variables are determined by conditions on the supply-side for the specific industry (i.e., (a_{4p}, a_{4n}) for output, (b_{4p}, b_{4n}) for price, and (c_{4p}, c_{4n}) for the nominal wage in equations (4) through (6)), and the size of industrial demand shifts during expansions and contractions (d_{pi}, d_{ni}) in equation (10).[11]

EMPIRICAL RESULTS

The empirical investigation focuses on annual data for 28 private disaggregated sectors (industries) of the U.S. economy over the sample period 1960-2000.[12] The sample comprises a large subset of industries in the United States. These industries were chosen because they are the only two-digit industries for which hourly nominal wage data were available for the estimation period. This section summarizes the time-series evidence of asymmetric fluctuations.

First, the empirical models (4) through (6) are estimated jointly to determine the asymmetric effects of *industrial* demand shocks. Second, the empirical models (7) through (10) are estimated jointly to account for demand-side asymmetry in the response of industrial variables to *aggregate* demand shocks.

Evidence of Supply-Side Asymmetry

Table 1 presents the parameters measuring the response of real output growth, wage inflation, and price inflation to the positive and negative components of unanticipated *industrial* demand shocks. The parameters measuring the response of industrial variables to a given size industrial demand are determined by conditions on the supply side.

Output expansion is significant in the face of an increase in industrial demand in twelve industries. There is evidence, however, of rigidity to expand output, as evident by the negative significant response to positive shocks, in Mining. Conditions on the supply side may prevent output expansion despite the increase in demand. Output contraction is significant in the face of a decrease in industrial demand in twenty-two industries.

Price inflation is significant in the face of an increase in industrial demand in eight industries. Rigidity to increase prices is evident by the negative significant response to demand expansion in Apparel and Other Textile Products. Downward price flexibility is evident by the positive significant response to demand contraction in three industries. Downward price rigidity is evident by the negative significant response to demand contraction in four industries. That is, producers resist to adjust prices downward despite demand contraction. In general, the evidence indicates moderate flexibility (i.e., elastic supply curve) of industrial price inflation in the face of positive and negative shocks.

Wage inflation is evident by the positive and significant response to demand expansion in two industries. There is evidence, however, of rigidity to increase wages, as evident by the negative significant response to demand expansion in two industries. Downward wage flexibility is evident by the positive significant response to demand contraction in two industries. Evidence of rigidity is consistent with the negative and significant response of wages in the face of demand contraction in Construction. In general, the evidence indicates moderate flexibility (i.e., elastic labor supply curve) of industrial wage inflation in the face of positive and negative shocks.

The difference in the response of industrial real output growth to a given shock to industrial demand, $(a_{4p} - a_{4n})$ in (4), indicates a kinked-slope supply curve. This difference is negative and statistically significant for 11 industries, indicating a larger output contraction. In contrast, this difference is positive and statistically significant for 3 industries, indicating a larger output expansion. Consistently, the difference in the response of price inflation to a given shock to industrial demand $(b_{4p} - b_{4n})$ in (5), is positive and statistically significant for 7 industries, indicating a higher price inflation. In contrast, this difference is negative and statistically significant for 3 industries, indicating faster deflation in the face of demand contraction.

In the labor market, asymmetry is measured by the difference in the response of industrial nominal wage inflation to a given shock to industrial demand, $(c_{4p} - c_{4n})$ in (6). This difference is positive and statistically significant for 9 industries, indicating a faster nominal wage inflation. In contrast, this difference is negative and statistically significant for 5 industries, indicating a faster nominal wage deflation.

Based on correlation coefficients across industries, asymmetry of nominal wage adjustment does not determine asymmetry of output and price adjustments to a given shock to industrial demand.

Asymmetry in the Face of Aggregate Demand Shocks

Table 2 summarizes the responses of industrial real output growth and wage and price inflation to the positive and negative components of *aggregate* demand shocks. Statistical significance is more prevalent in Table 2, in the face of aggregate demand shocks, compared to Table 1, in the face of a given size industrial demand shock.

Hence, variation in industrial demand in the face of aggregate demand shocks is a major factor that differentiates cyclical fluctuations across industries.

Output expansion is significant in the face of an increase in aggregate demand in six industries. Output contraction is evident and significant in the face of negative aggregate demand shocks in sixteen industries. Price inflation is significant in the face of an expansion of aggregate demand in three industries. There is evidence, however, of rigidity to adjust prices upward during economic expansion in two industries. Producers may resort to price reduction to increase competitiveness during economic booms. Alternatively, price reduction may be in response to supply-side factors, e.g., productivity increase. The evidence of significant price reduction during recession is limited to one industry, Finance, Insurance, and Real Estate. The evidence,

TABLE 1
Measures of Industrial Supply-Side Asymmetry

Industry	a_{4p}	a_{4n}	a_{4p}-a_{4n}	b_{4p}	b_{4n}	b_{4p}-b_{4n}	c_{4p}	c_{4n}	c_{4p}-c_{4n}
Mining	-0.34**	0.43*	-0.77*	0.92*	0.40*	0.52**	0.078	-0.043	0.12
	(-1.81)	(2.50)	(-4.10)	(3.08)	(2.05)	(1.74)	(0.97)	(-0.81)	(1.50)
Metal Mining	0.072	0.45	-0.38	0.82*	0.59*	0.23	0.0097	0.025	-0.02
	(0.26)	(1.58)	(-1.37)	(2.95)	(2.08)	(0.83)	(0.33)	(0.94)	(-0.52)
Coal Mining	0.096	0.011	0.085	0.93*	0.91*	0.02	-0.13	0.40*	-0.53*
	(0.57)	(0.04)	(0.50)	(5.02)	(2.84)	(0.11)	(-1.17)	(1.96)	(-4.77)
Nonmetallic Minerals	0.41	0.99**	-0.58	0.52	0.57	-0.05	-0.035	-0.0034	-0.03
Except Fuel	(0.72)	(1.75)	(-1.02)	(1.08)	(1.19)	(-0.10)	(-0.47)	(-0.05)	(-0.42)
Construction	0.86*	0.90*	-0.04	-0.023	0.14	-1.16	0.0064	-0.21**	0.22*
	(2.80)	(2.46)	(-0.13)	(-0.08)	(0.39)	(-0.57)	(0.06)	(-1.75)	(2.03)
Manufacturing	0.57	1.84*	-1.27*	0.074	-0.53*	0.60*	0.062	0.042	0.02
	(1.66)	(4.15)	(-3.70)	(0.43)	(-2.29)	(3.51)	(0.86)	(0.51)	(0.28)
Durable Goods	0.43	1.87*	-1.44*	0.19	-0.50*	0.69*	0.073	0.026	0.047
	(1.28)	(4.65)	(-4.29)	(1.01)	(-2.12)	(3.67)	(1.39)	(0.45)	(0.89)
Lumber and Wood	0.47	0.78	-0.31	0.54	0.15	0.39	0.14*	-0.01	0.15*
Products	(1.02)	(1.36)	(-0.67)	(1.32)	(0.32)	(0.95)	(2.02)	(-0.12)	(2.16)
Furniture and	0.73	1.83*	-1.1*	0.10	-0.75*	0.85*	-0.036	-0.025	-0.01
Fixtures	(1.31)	(2.64)	(-1.97)	(0.42)	(-2.26)	(3.57)	(-0.59)	(-0.32)	(-0.18)
Stone, Clay, and	0.43	1.34*	-0.91*	0.43*	-0.24	0.67*	0.039	0.008	0.03
Glass Products	(1.59)	(5.39)	(-3.36)	(2.09)	(-1.19)	(3.26)	(0.77)	(0.16)	(0.61)
Primary Metal	0.42	1.18*	-0.76*	0.11	0.29	-0.18	0.13*	-0.038	0.17*
Industries	(1.40)	(4.52)	(-2.53)	(0.60)	(1.57)	(-0.98)	(2.00)	(-0.63)	(2.58)
Fabricated Metal	0.64**	1.80*	-1.16*	-0.27	-0.25	-0.02	0.10	-0.05	0.15*
Products	(1.90)	(4.58)	(-3.44)	(-1.03)	(-0.86)	(-0.76)	(1.43)	(-0.75)	(2.15)
Machinery, Except	0.41	0.54*	-0.13	0.60*	0.49*	0.11	0.029	-0.011	0.04
Electrical	(1.30)	(2.35)	(-0.41)	(2.31)	(2.49)	(0.42)	(0.81)	(-0.40)	(1.12)
Electric and	1.06*	1.28*	-0.22	-0.30	0.0076	-0.31	-0.11**	0.075	-0.19*
Electronic Equipment	(2.62)	(2.61)	(-0.54)	(-1.30)	(0.03)	(-1.33)	(-1.87)	(1.06)	(-3.15)
Motor Vehicles	0.61	1.56*	-0.95*	0.019	-0.10	0.12	0.18*	-0.022	0.20*
and Equipment	(1.63)	(3.12)	(-2.54)	(0.13)	(-0.57)	(0.81)	(5.57)	(-0.65)	(6.25)
Other Transportation	1.42*	0.59**	0.83*	-0.53	-0.075	-0.45	0.066	-0.15	0.22**
	(3.46)	(1.75)	(2.02)	(-0.26)	(-0.41)	(-0.22)	(0.58)	(-1.53)	(1.90)
Instruments and	0.17	1.34*	-1.17*	0.066	0.42**	-0.35	-0.058	-0.0069	-0.05
Related Products	(0.36)	(2.58)	(-2.48)	(0.28)	(1.70)	(-1.50)	(-0.55)	(-0.07)	(-0.48)
Misc. Manufacturing	0.71	1.33*	-0.62	-0.30	-0.12	-0.18	-0.13*	0.073	-0.20*
Industries	(1.05)	(2.03)	(-0.92)	(-0.69)	(-0.30)	(-0.41)	(-2.27)	(0.94)	(-3.54)

TABLE 1–*Continued*
Measures of Industrial Supply-Side Asymmetry

Industry	a_{4p}	a_{4n}	a_{4p}-a_{4n}	b_{4p}	b_{4n}	b_{4p}-b_{4n}	c_{4p}	c_{4n}	c_{4p}-c_{4n}
Nondurable Goods	1.23*	1.47*	-0.24	-0.0058	-0.81*	0.80*	-0.17	0.0003	-0.17
	(2.88)	(2.23)	(-0.56)	(-0.02)	(-2.23)	(2.77)	(-1.35)	(0.00)	(-1.35)
Food and	-0.022	0.32	-0.34	0.88	0.93	-0.05	0.12	-0.15	0.27*
Kindred Products	(-0.04)	(0.47)	(-0.62)	(1.66)	(1.39)	(-0.10)	(1.06)	(-0.83)	(2.39)
Tobacco	0.094	1.69*	-1.60*	1.20*	-0.58	1.78*	-0.22	0.21	-0.43*
Manufactures	(0.12)	(2.16)	(-2.037)	(2.38)	(-1.02)	(3.53)	(-1.30)	(1.12)	(-2.54)
Textile Mill	1.74*	0.14	1.16*	-0.45	0.72	-1.17*	0.019	0.16*	-0.14*
Products	(3.02)	(0.25)	(2.78)	(-0.83)	(1.44)	(-2.16)	(0.35)	(3.49)	(-2.60)
Apparel and Other	1.76*	0.69	1.07*	-0.88*	0.19	-1.07*	-0.19	0.23	-0.42*
Textile Products	(3.44)	(1.20)	(2.091)	(-2.56)	(0.52)	(-3.11)	(-1.04)	(1.23)	(-2.30)
Paper and	0.85	1.13	-0.28	0.029	-0.11	0.14	0.0019	-0.044	0.046
Allied Products	(1.43)	(1.45)	(-0.47)	(0.06)	(-0.17)	(0.29)	(0.03)	(-0.53)	(0.72)
Printing and	0.84**	1.24*	-0.40	-0.036	-0.18	0.14	-0.041	-0.016	-0.025
Publishing	(1.76)	(2.32)	(-0.84)	(-0.08)	(-0.37)	(0.32)	(-0.39)	(-0.15)	(-0.24)
Chemicals and	1.00*	0.98**	0.02	0.17	-0.23	0.40	-0.065	0.044	-0.11
Allied Products	(2.39)	(1.82)	(0.048)	(0.46)	(-0.48)	(1.082)	(-0.83)	(0.44)	(-1.39)
Petroleum and	1.51*	0.27	1.24	-0.24	0.48	-0.72	0.11	-0.032	0.14
Coal Products	(2.05)	(0.39)	(1.68)	(-0.32)	(0.69)	(-0.96)	(1.23)	(-0.37)	(1.59)
Rubber and Misc.	0.29	1.22**	-0.93	0.12	-0.30	0.42	0.19	-0.032	0.22**
Plastic Products	(0.40)	(1.89)	(1.28)	(0.34)	(-1.09)	(1.19)	(1.66)	(-0.37)	(1.94)
Leather and	0.88*	0.39	0.49	-0.15	0.46	-0.61*	-0.0083	0.018	-0.03
Leather Products	(2.49)	(0.90)	(1.39)	(-0.53)	(1.40)	(-2.16)	(-0.19)	(0.32)	(-0.60)
Wholesale Trade	1.51*	0.27	1.24	-0.24	0.48	-0.72	0.11	-0.032	0.14
	(2.05)	(0.39)	(1.68)	(-0.32)	(0.69)	(-0.96)	(1.23)	(-0.37)	(1.59)
Retail Trade	0.44	1.10*	-0.66	0.49	-0.08	0.57	0.32	-0.042	0.36**
	(0.79)	(2.70)	(-1.19)	(0.94)	(-0.21)	(1.09)	(1.51)	(-0.29)	(1.71)
Finance, Insurance,	0.091	0.93*	-0.84*	0.78**	0.23	0.55	0.037	0.032	0.01
and Real Estate	(0.26)	(2.49)	(-2.40)	(1.91)	(0.53)	(1.35)	(0.14)	(0.14)	(0.02)

Notes:

- Empirical Models:

$$Dy_{it} = a_0 + a_1 E_{t-1} Dq_t + a_2 Dqs_t + a_3 Dy_{it-1} + a_{4p} pos_{it} + a_{4n} neg_{it} + \eta_{yit}$$

$$Dp_{it} = b_0 + b_1 E_{t-1} Dq_t + b_2 Dqs_t + b_3 E_{t-1} DN_{it} + b_{4p} pos_{it} + b_{4n} neg_{it} + \eta_{pit}$$

$$Dw_{it} = c_0 + c_1 E_{t-1} Dq_t + c_2 Dqs_t + c_3 E_{t-1} DN_{it} + c_{4p} pos_{it} + c_{4n} neg_{it} + \eta_{wit}$$

- a_{4p} and a_{4n} approximate the expansionary and contractionary effects of *industrial* demand shocks on industrial real output. a_{4p} - a_{4n} approximates asymmety in output adjustment to industrial demand shocks.
- b_{4p} and b_{4n} approximate the inflationary and deflationary effects of *industrial* demand shocks on industrial price. b_{4p}-b_{4n} approximates asymmety in price flexibility in response to industrial demand shocks.
- c_{4p} and c_{4n} approximate the inflationary and deflationary effects of *industrial* demand shocks on industrial wage. c_{4p}-c_{4n} approximates asymmety in wage flexibility in response to industrial demand shocks.
- t-ratios are in parentheses.
- * and ** denote significance of asymmetry at the five and ten percent levels.

however, appears pervasive for downward rigidity of price during economic slowdown. This is evident by the negative and statistically significant coefficients in the face of negative aggregate demand shocks in four industries.

Nominal wage inflation is significant in the face of demand expansion in nine industries. There is no evidence of a significant reduction of nominal wage inflation in the face of demand contraction. In contrast, nominal wage inflation responds negatively and significantly to aggregate demand contraction in four industries. That is, wage inflation is increasing despite demand contraction, providing strong evidence of rigidity to adjust wage inflation downward.

TABLE 2
The Asymmetric Effects of Aggregate Demand Shocks on Industrial Real Output, Prices, and Wages

Industry	A_{4p}	A_{4n}	$A_{4p}-A_{4n}$	B_{4p}	B_{4n}	$B_{4p}-B_{4n}$	C_{4p}	C_{4n}	$C_{4p}-C_{4n}$
Mining	-0.50	3.78*	-4.28*	0.20	-1.82	2.02*	0.29	-0.23	0.52
	(-0.63)	(3.94)	(-5.39)	(0.22)	(-1.63)	(2.22)	(0.76)	(-0.61)	(1.36)
Metal Mining	-1.83	1.17	-3.00	13.22*	-3.29	16.51*	0.99*	-0.34	1.33*
	(-0.56)	(0.31)	(-0.92)	(4.27)	(-0.86)	(5.33)	(2.46)	(-0.86)	(3.30)
Coal Mining	-0.29	-1.28	0.99	-1.06	-0.97	-0.09	0.76	0.20	0.56
	(-0.27)	(-1.10)	(0.92)	(-0.41)	(-0.34)	(-0.035)	(1.25)	(0.29)	(0.92)
Nonmetallic Minerals	0.31	2.89	-2.58	-1.66	-1.07	-0.59	0.34**	-0.15	0.49*
Except Fuel	(0.18)	(1.31)	(-1.50)	(-1.29)	(-0.65)	(-0.46)	(1.75)	(-0.80)	(2.52)
Construction	1.56*	1.72*	-0.16	-0.019	-0.97	0.95	0.21	-0.36	0.57*
	(2.96)	(3.44)	(-0.30)	(-0.03)	(-1.53)	(1.50)	(0.90)	(-1.60)	(2.44)
Manufacturing	0.93	3.16*	-2.23*	0.40	-0.93*	1.33*	0.28**	0.077	0.20
	(1.18)	(3.70)	(-2.83)	(1.12)	(-2.39)	(3.72)	(1.76)	(0.51)	(1.28)
Durable Goods	0.99	4.38*	-2.39*	0.73	-1.16*	1.89*	0.29**	0.13	0.16
	(0.95)	(3.87)	(-3.25)	(1.40)	(-2.11)	(3.62)	(1.91)	(0.85)	(1.054)
Lumber and Wood	1.71	-0.49	2.20	3.30*	2.14	1.16	0.69*	-0.073	0.76*
Products	(0.91)	(-0.21)	(1.17)	(2.26)	(1.30)	(0.79)	(2.63)	(-0.29)	(2.91)
Furniture and	1.68	3.30*	-1.62	-0.024	-1.30	1.28	-0.21	0.0079	-0.22
Fixtures	(1.12)	(2.00)	(-1.08)	(-0.03)	(-1.64)	(1.60)	(-1.14)	(0.04)	(-1.18)
Stone, Clay, and	0.90	4.20*	-3.30*	1.29**	-1.37**	2.66*	0.31	-0.052	0.36**
Glass Products	(1.06)	(4.77)	(-3.89)	(1.87)	(-1.86)	(3.86)	(1.63)	(-0.28)	(1.90)
Primary Metal	2.15	6.33*	-4.18*	0.083	0.39	-0.31	0.98*	0.32	1.30*
Industries	(1.17)	(2.77)	(-2.27)	(0.08)	(0.32)	(-0.30)	(2.66)	(-0.89)	(3.53)
Fabricated Metal	1.64	4.10*	-2.46*	-0.63	-0.56	-0.07	0.28	-0.056	0.34*
Products	(1.58)	(3.60)	(-2.37)	(-1.03)	(-0.80)	(-0.11)	(1.64)	(-0.34)	(1.97)
Machinery, Except	-0.23	5.58*	-5.81*	1.16	-1.95	3.11**	0.29**	0.12	0.17
Electrical	(-0.14)	(3.06)	(-3.54)	(0.63)	(-0.91)	(1.69)	(1.82)	(0.74)	(1.067)
Electric and	1.57	2.79**	-1.22	-0.13	-0.72	0.59	-0.15	-0.068	-0.082
Electronic Equipment	(1.16)	(1.84)	(-0.90)	(-0.20)	(-1.01)	(0.91)	(-0.73)	(-0.34)	(-0.40)
Motor Vehicles	1.77	9.95*	-8.18*	0.76	-1.27	2.03**	0.61	0.55	0.06
and Equipment	(0.59)	(2.92)	(-2.73)	(0.67)	(-1.04)	(1.79)	(1.41)	(1.23)	(0.14)
Other Transportation	0.11	-0.94	1.05	0.52	-0.79	1.31*	0.44	0.11	0.33
	(0.07)	(-0.55)	(0.67)	(0.84)	(-1.31)	(2.12)	(1.49)	(0.37)	(1.12)
Instruments and	0.70	2.66	-1.96	0.81	-0.62	1.43*	0.29	-0.61*	0.90*
Related Products	(0.55)	(1.63)	(-1.54)	(1.25)	(-0.78)	(2.21)	(1.00)	(-2.15)	(3.10)
Misc. Manufacturing	-0.069	3.79	-3.86*	0.57	-1.89	2.46*	-0.15	0.021	-0.17
Industries	(-0.04)	(1.64)	(-2.24)	(0.47)	(-1.31)	(2.03)	(-0.82)	(0.12)	(-0.93)

TABLE 2 –*Continued*
The Asymmetric Effects of Aggregate Demand Shocks on Industrial Real Output, Prices, and Wages

Industry	A_{4p}	A_{4n}	$A_{4p}-A_{4n}$	B_{4p}	B_{4n}	$B_{4p}-B_{4n}$	C_{4p}	C_{4n}	$C_{4p}-C_{4n}$
Nondurable Goods	0.80	1.46*	-0.66	-0.029	-0.029	0.00	0.055	-0.22	0.28**
	(1.42)	(2.43)	(-1.17)	(-0.44)	(-0.08)	(0.00)	(0.34)	(-1.40)	(1.70)
Food and	1.013	0.63	0.38	-2.14*	0.17	-2.31*	0.13	-0.37*	0.50*
Kindred Products	(1.55)	(0.78)	(0.59)	(-2.09)	(0.16)	(-2.26)	(0.85)	(-2.52)	(3.27)
Tobacco	-1.21	-0.52	-0.69	-0.75	0.54	-1.29	0.68	-1.05*	1.73*
Manufactures	(-0.71)	(-0.30)	(-0.40)	(-0.42)	(0.31)	(-0.72)	(1.56)	(-2.23)	(3.97)
Textile Mill	-0.94	3.09	-4.03*	1.25	-0.63	1.88	0.56*	0.027	0.53*
Products	(-0.48)	(1.58)	(-2.06)	(0.79)	(-0.36)	(1.19)	(2.42)	(0.11)	(2.30)
Apparel and Other	0.16	1.86	-1.10	0.32	-0.48	0.80	0.59**	-0.98	0.69*
Textile Products	(0.14)	(1.54)	(-1.49)	(0.52)	(-0.79)	(1.30)	(1.89)	(-0.32)	(2.20)
Paper and	2.72*	1.21	1.51	0.075	-1.47	1.54	0.11	-0.24	0.35*
Allied Products	(2.19)	(0.90)	(1.22)	(0.07)	(-1.28)	(1.44)	(0.64)	(-1.52)	(2.04)
Printing and	0.40	1.44**	-1.04	-0.68	-0.90	0.83	0.074	-0.19	0.26
Publishing	(0.60)	(1.93)	(-1.56)	(-0.12)	(-1.58)	(1.47)	(0.42)	(-1.10)	(1.50)
Chemicals and	2.29*	1.21	1.08	1.04	-1.24	2.28*	0.25	-0.35*	0.60*
Allied Products	(2.10)	(1.01)	(0.99)	(1.23)	(-1.49)	(2.70)	(1.34)	(-1.95)	(3.22)
Petroleum and	0.84	-0.12	0.96	2.16	0.40	1.76	0.69	-0.39	1.08*
Coal Products	(0.43)	(-0.06)	(0.49)	(1.08)	(0.18)	(0.88)	(1.35)	(-0.71)	(2.11)
Rubber and Misc.	-0.45	5.43*	-5.88*	-0.11	-1.46*	1.35*	-0.25	0.21	-0.46
Plastic Products	(-0.35)	(3.63)	(-4.57)	(-0.17)	(-2.25)	(2.09)	(-0.87)	(0.79)	(-1.60)
Leather and	3.42*	1.82	1.60	0.97	-0.84	1.81	0.38	-0.33	0.71*
Leather Products	(2.16)	(1.10)	(1.01)	(0.85)	(-0.62)	(1.59)	(1.67)	(-1.48)	(3.12)
Wholesale Trade	-0.73	1.29	-2.02	1.25	0.38	0.87	0.23	-0.10	0.33*
	(-0.59)	(1.06)	(-1.63)	(1.38)	(0.36)	(0.96)	(1.54)	(-0.72)	(2.21)
Retail Trade	0.65**	1.80*	-1.15*	-0.013	-0.72	0.71	0.21	0.12	0.09
	(1.75)	(4.48)	(-3.10)	(-0.03)	(-1.40)	(1.63)	(0.94)	(0.55)	(0.40)
Finance, Insurance,	0.53**	0.63**	-0.10	-1.27*	0.93*	-2.20*	0.18	0.072	0.11
and Real Estate	(1.80)	(1.73)	(-0.34)	(-2.76)	(2.10)	(-4.78)	(1.37)	(0.34)	(0.82)

Notes:

- Empirical Models:

$$Dy_{it} = a_0 + a_1 E_{t-1} Dq_t + a_2 Dqs_t + a_3 Dy_{it-1} + A_{4p} pos_t + A_{4n} neg_t + a_5 ss_{it} + \eta_{yit}$$

$$Dp_{it} = b_0 + b_1 E_{t-1} Dq_t + b_2 Dqs_t + b_3 E_{t-1} DN_{it} + B_{4p} pos_t + B_{4n} neg_t + b_5 ss_{it} + \eta_{pit}$$

$$Dw_{it} = c_0 + c_1 E_{t-1} Dq_t + c_2 Dqs_t + c_3 E_{t-1} DN_{it} + C_{4p} pos_t + C_{4n} neg_t + c_5 ss_{it} + \eta_{wit}$$

- A_{4p} and A_{4n} approximate the expansionary and contractionary effects of *aggregate* demand shocks on industrial real output. $A_{4p} - A_{4n}$ approximates asymmetry in output adjustment to aggregate demand shocks.
- B_{4p} and B_{4n} approximate the inflationary and deflationary effects of *aggregate* demand shocks on industrial price. $B_{4p} - B_{4n}$ approximates asymmetry in price flexibility in response to aggregate demand shocks.
- C_{4p} and C_{4n} approximate the inflationary and deflationary effects of *aggregate* demand shocks on industrial wage. $C_{4p} - C_{4n}$ approximates asymmetry in wage flexibility in response to aggregate demand shocks.
- t-ratios are in parentheses.
- * and ** denote significance of asymmetry at the five and ten percent levels.

In the empirical models (7) through (9), asymmetry in the response of industrial variables to aggregate demand shocks is likely to vary with demand and supply conditions. It is evident that asymmetry is generally larger, in absolute magnitude, in response to aggregate demand shocks (Table 2) compared to industrial demand shocks (Table 1).[13] That is, asymmetry in the size of industrial demand shifts exacerbates the difference between variables' adjustments to aggregate demand shocks during booms and recessions.

The asymmetric response of industrial real output growth to aggregate demand shocks is measured by the difference between the expansionary effect, A_{4p}, and the contractionary effect, A_{4n}, in model (7). In Table 2, output contraction exceeds expansion with a difference that is statistically significant for many industries. In contrast, where expansion exceeds contraction the difference is not statistically significant for any industry.

The asymmetric response of industrial price inflation to aggregate demand shocks is measured by the difference between the inflationary effect, B_{4p}, and the deflationary effect, B_{4n}, in model (8). In Table 2, prices are more flexible in the upward direction and the difference is statistically significant for many industries. In contrast, for the Food and Kindred Products and Finance, Insurance and Real Estate industries, price inflation appears to decelerate at a higher rate compared to the rate at which it accelerates in response to aggregate demand shocks, and the difference is statistically significant.

The asymmetric response of industrial nominal wage inflation to aggregate demand shocks is measured by the difference between the inflationary effect, C_{4p}, and the deflationary effect, C_{4n}, in model (9). In Table 2, wages are more flexible in the upward direction and the difference is statistically significant for many industries. There is no evidence that the reduction in nominal wage inflation during recessions exceeds its increase during expansions.

Based on correlation coefficients across industries, an increase in upward wage flexibility correlates with an increase in price inflation and a decrease in output expansion in response to aggregate demand shocks. The downward flexibility of the nominal wage does not correlate with a faster price deflation across industries. While downward price flexibility moderates output contraction, downward wage flexibility correlates with a larger output contraction.

DETERMINANTS OF ASYMMETRY AND IMPLICATIONS

Coefficient estimates from Tables 1 and 2 approximate the average time-series response of variables to demand shocks over time.[14] These responses are regressed on determinants of the stochastic structure, trend inflation, and demand variability for each industry. The results evaluate how the average response to demand shocks varies across industries.

Determinants of Supply-Side Asymmetry

The parameters measuring the response of industrial variables to a given size industrial demand shock (in Table 1) are determined by conditions on the supply side of each industry. According to explanations of supply-side asymmetry, demand variability and/or trend price inflation determine asymmetry across industries.

Table 3 summarizes the results of regressing cyclical fluctuations in response to a given size industrial demand shock (in Table 1) to trend inflation and demand variability across industries. Trend inflation is measured by the time-series average of the change in the log value of industrial price ($\bar{\pi}_i$). Three measures of demand variability are calculated: variability of positive shocks, σ_{posi}, variability of negative shocks, σ_{negi}, and overall variability, σ_{dsi}, both positive and negative. Variability is measured by the standard deviation of the empirical proxy for industrial demand shocks in the time-series models.

TABLE 3
Determinants of Supply-Side Asymmetry Across Industries

Dependent Variables	Explanatory Variables and R^2 constant	$\bar{\pi}$	σ_{posi}	σ_{negi}	σ_{dsi}	
I. Wage Fluctuations:						
a. c_{4p}	0.023	-0.32	0.22			0.003
	(0.30)	(-0.17)	(0.22)			
b. c_{4n}	0.081	-2.24		0.17		0.054
	(1.15)	(-1.25)		(0.21)		
c. c_{4p}- c_{4n}	-0.07	1.99			0.13	0.012
	(-0.50)	(0.59)			(0.16)	
II. Price Fluctuations:						
a. b_{4p}	-0.63*	15.77*	8.51*			0.26
	(-2.90)	(2.31)	(2.35)			
b. b_{4n}	0.18	-9.59		5.82**		0.17
	(0.68)	(-1.40)		(1.90)		
c. b_{4p}- b_{4n}	-0.74*	24.93*			0.024	0.22
	(-1.96)	(2.81)			(0.012)	
III. Output Fluctuations:						
a. a_{4p}	1.55*	-17.90*	-8.85*			0.26
	(5.18)	(-2.40)	(-2.24)			
b. a_{4n}	0.75*	12.21		-4.31		0.11
	(2.28)	(1.46)		(-1.15)		
c. a_{4p} - a_{4n}	0.74**	-30.00*			-0.88	0.17
	(1.42)	(-2.45)			(-0.31)	

Notes:

- c_{4p}, b_{4p}, a_{4p} measure the effects of a positive shock to *industrial* demand on industrial wage inflation, price inflation, and real output growth in models (1) through (3).
- c_{4n},b_{4n},a_{4n} measure the effects of a negative shock to *industrial* demand on industrial wage inflation, price inflation, and real output growth in models (1) through (3).
- c_{4p}- c_{4n}, b_{4p}- b_{4n}, a_{4p} - a_{4n} measure asymmetry in the effects of positive and negative *industrial* demand shocks on industrial wage inflation, price inflation, and real output growth in models (1) through (3).
- $\bar{\pi}_i$ approximates trend industrial price inflation, the sample average of the change in the log value of industrial price.
- $\sigma_{posi,}$ σ_{negi}, and σ_{dsi} denote the standard deviation of positive shocks, negative shocks, and both positive and negative shocks to industrial demand.
- t-ratios are in parentheses.
- * and ** denote statistical significance at the five and ten percent levels.

Trend inflation and demand variability do not determine nominal wage flexibility. Trend inflation and the variability of expansionary demand shocks increase upward price flexibility across industries. In contrast, prices appear downwardly rigid, as evident by the negative, although statistically insignificant coefficient, in the face of higher trend inflation, across industries. In contrast, the variability of demand shocks increases downward price flexibility. Trend price inflation and demand variability moderate output expansion. In addition, output contraction increases the higher trend inflation across industries.

Overall, trend price inflation increases upward price flexibility relative to downward flexibility and exacerbates output contraction relative to expansion across industries. Contrary to the implications of the sticky-wage explanation, conditions in the labor market do not support the endogeneity of nominal wage flexibility or its asymmetry in the face of industrial demand shocks. In contrast, the evidence appears consistent with the sticky-price explanation of supply-side asymmetry. That is, the kinked-shape of the industrial supply curve, to the extent that it exists, appears to be dependent on asymmetric price flexibility which increases with trend price inflation across industries.

Determinants of Asymmetry in the Face of Aggregate Demand Shocks

Variables' responses to aggregate demand shocks (in Table 2) combine the effects of industrial demand shifts and supply-side constraints. Table 4 presents the results from cross-industry regressions that determine the effects of trend inflation and demand variability on asymmetric fluctuations in wage, price, and real output in response to *aggregate* demand shocks (in Table 2). Nominal wages are more downwardly rigid the higher trend price inflation, as evident by the negative and statistically significant coefficient across industries. Hence, asymmetric wage flexibility increases with trend inflation. Demand variability increases wage and price inflation relative to deflation. Consistently, demand variability increases output contraction relative to expansion.

Overall, fluctuations of industrial variables in response to *aggregate* demand shocks do not highlight the effects of trend inflation on supply-side asymmetry. This appears to be consistent with the limited evidence of significant asymmetry in Table 1 compared to Table 2. Accordingly, demand variability appears more dominant in determining the asymmetric effects of *aggregate* demand shocks on industrial variables.

SUMMARY AND CONCLUSION

The present investigation has offered a comprehensive disaggregated evaluation of the asymmetric effects of aggregate demand shocks in the United States. Expansionary and contractionary aggregate demand shocks may have different effects on variables across the economy. The empirical investigation provides a detailed analysis of the short-run cyclical behavior of real output, prices, and wages using data for 28 private industries in the United States. The analysis was conducted by estimating both time-series and cross-section regressions.

TABLE 4
Determinants of the Asymmetric Effects of Aggregate Demand Shocks Across Industries

Dependent Variables	Explanatory Variables and R^2 constant	$\bar{\pi}$	σ_{posi}	σ_{negi}	σ_{dsi}	
I. Wage Fluctuations:						
a. C_{4p}	-0.13	4.23	9.63*			0.45
	(-0.87)	(1.11)	(4.80)			
b. C_{4n}	0.25**	-11.59*		0.29		0.21
	(1.52)	(-2.79)		(0.16)		
c. C_{4p}- C_{4n}	-0.39	16.67*			3.45*	0.25
	(-1.39)	(2.52)			(2.21)	
II. Price Fluctuations:						
a. B_{4p}	-0.27	-37.36	66.49*			0.37
	(-0.21)	(-1.14)	(3.84)			
b. B_{4n}	-0.82	18.76		-14.75*		0.20
	(-1.43)	(1.29)		(-2.26)		
c. B_{4p}- B_{4n}	-0.36	-42.86			38.78*	0.44
	(-0.23)	(-1.15)			(4.43)	
III. Output Fluctuations:						
a. A_{4p}	0.82	8.00	-11.52			0.054
	(1.10)	(0.43)	(-1.17)			
b. A_{4n}	2.30	-30.22		31.20*		0.14
	(1.64)	(-0.85)		(1.96)		
c. A_{4p} - A_{4n}	-1.49	33.61			-16.46**	0.15
	(-0.94)	(0.90)			(-1.88)	

Notes:

- C_{4p}, B_{4p}, A_{4p} measure the effects of a positive shock to *aggregate* demand on industrial wage inflation, price inflation, and real output growth in models (4) through (6).
- C_{4n}, B_{4n}, A_{4n} measure the effects of a negative shock to *aggregate* demand on industrial wage inflation, price inflation, and real output growth in models (4) through (6).
- C_{4p}-C_{4n}, B_{4p}- B_{4n}, A_{4p} - A_{4n} measure asymmetry in the effects of positive and negative *aggregate* demand shocks on industrial wage inflation, price inflation, and real output growth in models (4) through (6).
- $\bar{\pi}_i$ approximates trend industrial price inflation, the sample average of the change in the log value of industrial price.
- σ_{posi}, σ_{negi}, and σ_{dsi} denote the standard deviation of positive shocks, negative shocks, and both positive and negative shocks to industrial demand.
- t-ratios are in parentheses.
- * and ** denote statistical significance at the five and ten percent levels.

Assuming aggregate demand follows a stochastic trend that varies with macroeconomic fundamentals, shocks are distributed symmetrically around this trend. Shocks are independent of the state of the economy. A positive demand shock may be consistent with a boom period or may arise in response to a specific demand stimulus during recessionary periods.

The time-series results provide evidence that asymmetry uncovered at the aggregate level is widespread in the face of *aggregate* demand shocks for many industries of the United States. Specifically, the contractionary effect of aggregate demand shocks exceeds the expansionary effect on real output for many industries. Further, the inflationary effects of aggregate demand shocks exceed the deflationary effects on wage and price for many industries. The inflationary effect of positive shocks raises concerns about the effectiveness of demand-side policies to stimulate real activity during a recession. The large contractionary effect of negative demand shocks also raises concern about the adverse effect of disinflationary policies on real activity.[15] Given asymmetric effects, the variability of aggregate demand has a net negative effect on output growth and a net positive effect on price inflation.

The cross-sectional analysis has focused on explaining asymmetries. The kinked supply curve in the product market is not readily explained by asymmetric nominal wage flexibility across industries. Instead, supply-side asymmetry is consistent with asymmetric price flexibility that varies with trend price inflation across industries. Trend inflation increases upward price flexibility relative to downward flexibility, increasing output contraction relative to expansion, for a given size industrial demand shock.

Demand variability highlights asymmetry at the sectoral level as well as asymmetry in the transmission of aggregate demand shocks to sectoral demand shocks. Specifically, demand variability increases nominal wage and price inflation relative to deflation in the face of *aggregate* demand shocks across industries. Consistently, output contraction exceeds expansion the higher demand variability across industries.

In summary, the detailed evaluation of cyclical fluctuations across 28 private industries of the U.S. economy provides strong evidence concerning the asymmetric effects of *aggregate* demand shocks. Demand-side and, to a lesser extent, supply-side asymmetries differentiate fluctuations in industrial variables during booms and recessions, contributing to asymmetries uncovered at the aggregate level.

Appendix A Empirical Methodology

To estimate the empirical models (4) through (7), a proxy for forecasted growth in industrial demand is needed. The first-difference of the logarithm of the nominal value of the output produced in the industry (a stationary series) approximates realized industrial demand growth and is endogenous according to Engle's [1982] test. Further, the forecast equation accounts for the nominal value of output in industries that qualify as good instruments for demand from a given industry. Following the suggestions of Shea [1993], these industries are selected based on the 1977 detailed input-output study. Accordingly, anticipated growth in industrial demand is generated by taking the fitted values of a reduced-form equation in which the explanatory variables include a constant and two lagged values of the log first-difference of industrial real output, industrial price level, industrial nominal wage, industrial labor productivity, the nominal value of the output produced in industries that demand a large share of the relevant industry output and contribute with a small share to its cost, the energy price and nominal GDP. The proxy for industrial demand shocks is then formed by subtracting this forecast from the actual value for industrial demand growth.

To estimate the empirical models (7) through (10) a proxy for forecasted aggregate demand growth is needed. The first-difference of the logarithm of nominal GDP approximates aggregate demand growth (a stationary series) and is endogenous according to the results of a formal test suggested by Engle [1982]. Accordingly, nominal GDP growth is generated by taking the fitted values of a reduced-form equation in which the explanatory variables include a constant and two lagged values of the log first-difference of industrial real output, industrial price level, industrial labor productivity, the energy price, and nominal GDP itself. The proxy for aggregate demand shocks is then formed by subtracting this forecast from the actual values for nominal GDP growth.

Obtaining a proxy for *ex ante* forecasts of the change in the logarithm of the energy price is complicated by the assumption that the generating process experienced a structural change between 1973-1974. This assumption is supported by the results of a formal test suggested by Dufour [1982]. For both the period 1960-1973 and the period 1974-2000, the generating process is modelled as a second-order autoregressive, or AR(2). The proxy for energy price surprises is then formed by subtracting these forecasts from the actual change in the log value of the energy price. By accounting for structural break in the energy price, statistical tests indicate the stability of estimated models over the sample period. There is no evidence of significant structural break in nominal GDP according to the results of Dufour [1982] test.

The maintained hypothesis for the 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. As suggested by Mishkin [1982], a simple alternative is to estimate the expectation equations jointly with the rest of the model, thus avoiding the use of the first stage regression proxies.

The empirical models are estimated jointly along with the equations generating forecast proxies using 3SLS. The instrument list for endogenous variables in the system (nominal industry output or aggregate nominal output) includes four lags of the log first difference of all endogenous variables in the system: nominal GDP; and industrial real output, the output price, the nominal wage and labor productivity, as well as current and four lags of the log first-difference of the energy price, government spending and the money supply. The results are robust with respect to variation in the choice of variables and/or their lags in the instruments list.

Following the suggestions of Cover [1992], positive and negative shocks to demand growth are defined for the joint estimation as follows:

$$neg_i = -\frac{1}{2}\{\text{abs}(shock_t) - shock_t\}$$

$$pos_i = \frac{1}{2}\{\text{abs}(shock_t) + shock_t\}$$

where abs(.) is the absolute value operator and $shock_t$ measures unanticipated growth in aggregate or industrial demand, as described above.

TABLE A1
The KPSS Statistics for Null of Level Stationary
(The 5% critical value is 0.463)

	Lag Truncation Parameter				
Variables	**0**	**1**	**2**	**3**	**4**
Agriculture					
Output	2.93	1.58	1.11	0.87	0.73
Price	2.88	1.50	1.03	0.80	0.66
Construction					
Output	0.55	0.31	0.23	0.20	0.18
Price	3.38	1.75	1.20	0.93	0.76
Finance					
Output	3.35	1.76	1.21	0.94	0.78
Price	3.41	1.77	1.21	0.94	0.77
Manufacturing					
Output	3.16	1.70	1.19	0.93	0.79
Price	3.41	1.76	1.20	0.93	0.76
Durable Goods					
Output	3.26	1.72	1.20	0.94	0.78
Price	3.40	1.75	1.20	0.92	0.76
Non-durable Goods					
Output	3.31	1.74	1.21	0.94	0.78
Price	3.43	1.77	1.21	0.93	0.77
Mining					
Output	1.80	1.03	0.75	0.61	0.52
Price	2.92	1.49	1.02	0.78	0.64
Retail					
Output	3.33	1.75	1.22	0.95	0.79
Price	3.43	1.78	1.22	0.94	0.77
Service					
Output	3.40	1.77	1.22	0.95	0.79
Price	3.44	1.78	1.23	0.95	0.78
Transportation					
Output	3.29	1.73	1.20	0.94	0.78
Price	3.42	1.76	1.20	0.92	0.76
Whole Sale Trade					
Output	3.30	1.74	1.21	0.95	0.79
Price	3.37	1.73	1.18	0.91	0.75

Test Description:
The KPSS (Kwiatowski, Phillips, Schmidt, and Shin) stationarity test procedure examines the null hypothesis of stationarity of a univariate time series. The KPSS test assumes that a time series variable X could be decomposed into the sum of a deterministic trend, a random walk, and a stationary error. Then the random walk term is assumed to have two components: an anticipated component and an error term. The stationarity of the error term is established by testing if the variance of the error is zero. If the calculated lag truncation variable is greater than 0.463, we reject the null hypothesis of stationarity.

The results of Engle [1982] test for the presence of serial correlation in a simultaneous-equation model indicate that the error terms of the empirical models follow an autoregressive process of order one for some industries. For these industries, the estimated empirical models are multiplied through by the filter $(1\text{-}\rho L)$ where ρ is the serial correlation parameter and L is the lag operator. The serial correlation parameter is estimated jointly with the rest of the model's parameters. The residuals from the empirical models after the transformation are purely random and serially uncorrelated.

TABLE A2
The KPSS Statistics for Null of Level Stationary
(The 5% critical value is 0.463)

	Lag Truncation Parameter				
Variables	**0**	**1**	**2**	**3**	**4**
Construction					
Employment	3.40	1.79	1.25	0.98	0.81
Wage	3.50	1.83	1.26	0.97	0.80
Finance					
Employment	3.61	1.87	1.28	0.99	0.81
Wage	3.63	1.88	1.30	1.00	0.83
Manufacturing					
Employment	0.54	0.33	0.27	0.24	0.23
Wage	3.61	1.86	1.28	0.98	0.81
Mining					
Employment	0.85	0.44	0.31	0.24	0.20
Wage	3.59	1.85	1.27	0.98	0.80
Retail					
Employment	3.58	1.86	1.29	1.00	0.83
Wage	3.59	1.86	1.27	0.98	0.81
Service					
Employment	3.59	1.87	1.29	0.99	0.82
Wage	3.51	1.84	1.27	0.99	0.82
Transportation					
Employment	3.42	1.81	1.26	0.99	0.83
Wage	3.58	1.85	1.26	0.97	0.80
Whole Sale Trade					
Employment	3.57	1.86	1.28	0.99	0.82
Wage	3.58	1.86	1.28	0.99	0.82
Energy Price	3.17	1.62	1.11	0.85	0.70
Money Supply	3.62	1.88	1.29	0.99	0.82
Gov. Spending	3.34	1.76	1.22	0.95	0.79
Nominal GDP	3.63	1.88	1.29	1.00	0.82

Test Description:
The KPSS (Kwiatowski, Phillips, Schmidt, and Shin) stationarity test procedure examines the null hypothesis of stationarity of a univariate time series. The KPSS test assumes that a time series variable X could be decomposed into the sum of a deterministic trend, a random walk, and a stationary error. Then the random walk term is assumed to have two components: an anticipated component and an error term. The stationarity of the error term is established by testing if the variance of the error is zero. If the calculated lag truncation variable is greater than 0.463, we reject the null hypothesis of stationarity.

Appendix B Data Description and Sources

Sample Period: 1960-2000

The following annual data were taken from:

The National Income and Product Accounts of the United States, 1929-82 Statistical Tables. U.S. Department of Commerce/Bureau of Economic Analysis. Updates for the years 1983-2000 are provided in the July issues of *Survey of Current Business.*

1. Nominal GNP by Industry-Table 6.1.
2. GNP by Industry in Constant Dollars (1982=100)-Table 6.2.
3. Sectoral Price Level=Nominal output by Industry/Constant Dollar Output by Industry.
4. Full-time Equivalent Employees by Industry-Table 6.6B.
5. Sectoral Productivity=the ratio of constant dollar output to the full-time equivalent employees by industry.

The average annual hourly nominal wage rate data for sectoral production workers were taken from:

1. *Employment, Hours, and Earnings, United States, 1909-84,* Volume I and II, Establishment Survey Data, U.S. Department of Labor, Bureau of Labor Statistics, March 1985, Bulletin 1312-22 (for the years 1947-1982).
2. *Supplement to Employment, Hours, and Earnings, United States, 1909-84,* Revised establishment data, U.S. Department of Labor, Bureau of Labor Statistics, August 1989 (for the years 1983-1988).
3. *Employment and Earnings,* Revised establishment data on employment, hours, and earnings for the United States, 1989-2000 (for the years 1989-2000).

Other series are as follows:

1. Producers Price Index (1982=100) for Fuels, Power and Related Products. *Historical Series 1926-2000,* the U.S. Department of Labor, Bureau of Labor Statistics.

NOTES

1. Firms may be reluctant to take aggressive measures towards adjusting nominal wages in the downward direction during recessionary periods. This is because the search and training cost of hiring new workers may actually exceed the perceived loss of retaining workers at wages that exceed the marginal physical product of labor during recessions.

2. In a situation where positive and negative shocks to industrial demand are not equally variable (for example, industries that are subject to larger shifts in industrial demand during periods of economic expansions compared to contractions), agents' incentives for the optimal degree of indexation may be asymmetric.
3. When a firm wants a lower relative price (in the face of a negative demand shock), inflation does much of the work, decreasing the need to pay the menu costs to adjust prices. By contrast, inflation decreases the firm's relative price when firms actually desire a higher price in the face of positive shocks, creating a large gap between desired and actual prices.
4. For example, if consumers do not believe in the Federal reserve's ability to stimulate demand through expansionary monetary policy, they continue to make pessimistic forecasts during a recession. Consequently, lower interest rates may not provide a very strong incentive for consumers to increase spending during a recession. Likewise, firms may not be inclined to increase borrowing for investment in response to a lower interest rate if they do not believe the economy will rebound from a recession.
5. Given the evidence of nonstationarity, cointegration tests are necessary to verify possible cointegration between the nonstationary dependent variables and nonstationary variables in the empirical model (anticipated energy price and demand). The residual of the cointegration regression is nonstationary, rejecting the hypothesis that the nonstationary variables exhibit a common stochastic trend.
6. While the investigation is concerned with asymmetry in response to demand fluctuations, it is important to account for major sources of supply-side shifts to increase the accuracy of approximating the effects of demand shifts in the empirical models. Depending on the energy usage in the input process, changes in the energy price are likely to affect industrial variables across the economy.
7. By construction, anticipated demand shifts are function of lagged wages and prices. This eliminates the need to account for lagged dependent variables in equations (5) and (6). Experiments that include lagged dependent variables in (5) and (6) support this implication. Further, additional lags of output are statistically insignificant in (4). Anticipated demand shifts are orthogonal, by construction, to unanticipated shifts. Accordingly, the qualitative results of the paper's analysis remain robust with respect to a modification that accounts for $E_{t-1}DN_{it}$ in the output equation.
8. Asymmetry is not dependent on the size of the shocks. The procedure assumes that the distribution of the shocks, regardless of its size, is symmetric. Hence, a large positive shock would be offset by a large negative shock, according to the symmetric distribution. Asymmetry, therefore, measures asymmetric effects of symmetric positive and negative shocks on economic variables.
9. $(a_{4p}-a_{4n})$ and $(b_{4p}-b_{4n})$ are determined by the shape of the output supply curve in response to a given size, positive or negative, industrial demand shock. Similarly, $(c_{4p}-c_{4n})$ is determined by the shape of the labor supply curve in response to a given size, positive or negative, industrial demand shock. That is, the size of the demand shock is irrelevant in determining asymmetry.
10. ss_{it} disturbances may be the result of shifts in demand across industries or industry-specific supply disturbances.
11. For example, A_{4p} in (7) is determined by the response of industrial demand to expansionary aggregate demand shocks, d_{pi} in (10), and the response of real output to a given expansionary shock to industrial demand, a_{4p} in (4).
12. Description and sources of data are described in Appendix B. According to the Standard Industrial Classification (S.I.C.) system in Table 1, private sectors of the U.S. economy are grouped by division. Within the divisional aggregates are the component sectors. Some of the component sectors are further disaggregated into subcomponent sectors. The sample under investigation comprises 6 divisional aggregates. Two of the divisional aggregates are further disaggregated into 24 component industries. Only annual data are available at the level of disaggregation under consideration.
13. The asymmetric response of industrial demand to aggregate demand shocks is measured by the difference between the expansionary effect, d_{pi}, and the contractionary effect, in model (10). Details are available upon request. Industrial demand contraction exceeds expansion and the difference is statistically significant for many industries. In contrast, demand expansion exceeds contraction and the difference is statistically significant for the following industries: Tobacco

Manufactures; Paper and Allied Products; Chemicals and Allied Products; and Petroleum and Coal Products. The latter industries produce non-durable goods. The demand for durables is generally subject to a larger contraction compared to non-durables during recessions and to a smaller expansion compared to non-durables during booms. This is consistent with the effect of credit constraints on the demand for durables, exacerbating the contractionary effect of a slowdown in spending during a recession, and with a slow increase in demand, despite the availability of credit, during expansions.

14. Parameters in the time-series models are estimated with an error. To adjust for this error, parameters employed in the cross-section regression are weighted by the inverse of their standard error in the time-series model. That is, parameters that are more variable are discounted more heavily in the cross-industry regression.
15. The estimation technique requires a large number of observations and, therefore, does not allow separating estimation according to the state of the business cycle. I have experimented with a dummy variable on positive and negative shocks in the early nineties. The coefficients of the dummy variables indicate that negative demand shocks reinforced output contraction while positive shocks had a larger effect on price inflation.

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