

The Cyclical Behavior of the Price-Cost Markup

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The views in this paper are the authors' and do not necessarily represent the views or policies of the Board of Governors of the Federal Reserve System or its staff

Background

- ▶ Keynesian models from the 1930s through the 1970s assumed **sticky wages**
 - ▶ e.g., Keynes (1936), Phelps (1968), Taylor (1980)
- ▶ In the early 1980s the focus shifted to models with **sticky prices** and **imperfect competition**
 - ▶ Dunlop-Tarshis-Keynes controversy
 - ▶ Rotemberg (1982) and many others developed models with sticky prices and imperfect competition

Background

- ▶ Textbook New Keynesian model assumes **sticky prices** and **flexible wages**
 - ▶ e.g. Goodfriend and King (1997), Woodford (2003)
- ▶ Newer versions of the New Keynesian model assume both **sticky prices** and **sticky wages**
 - ▶ e.g. Erceg, Henderson, Levin (2000), Smets and Wouters (2003, 2007), Christiano, Eichenbaum, and Evans (2005)
- ▶ These models are used extensively by central banks

Role of Markups in New Keynesian Models

- ▶ The price-cost markup is a key part of the transmission mechanism in the New Keynesian model:
 - ▶ A positive demand shock leads output and marginal cost to increase. Because prices cannot adjust immediately, the markup falls.
 - ▶ A positive technology shock lowers marginal cost and raises output. Because prices cannot adjust immediately, the markup rises.

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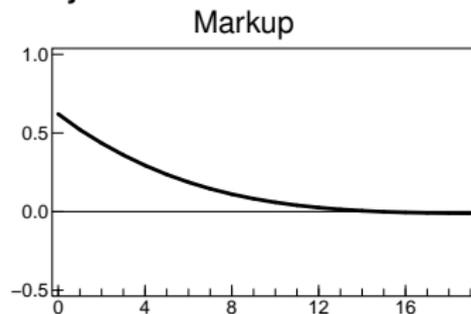
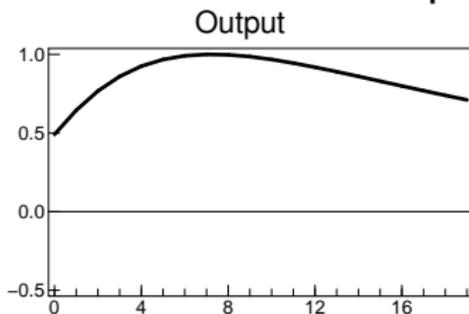
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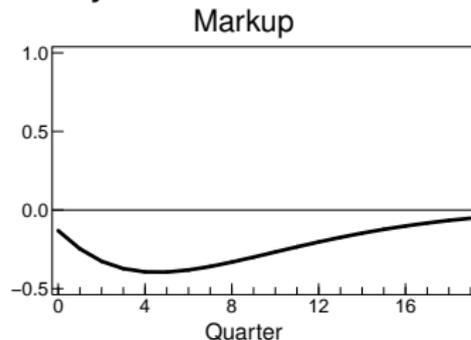
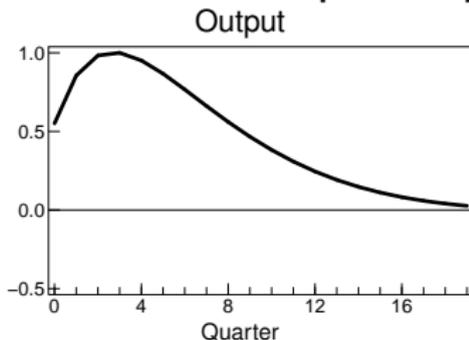
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 - ▶ A positive demand shock leads output and marginal cost to increase. Because prices cannot adjust immediately, the markup falls.
 - ▶ A positive technology shock lowers marginal cost and raises output. Because prices cannot adjust immediately, the markup rises.
- ▶ Leading New Keynesian models with **sticky prices** and **sticky wages**—such as EHL (2000), CEE (2005), and Smets and Wouters (2003, 2007)—also predict countercyclical markups in response to demand shocks.

Smets-Wouters' Model

Positive productivity shock



Expansionary monetary shock



Notes: Effects of expansionary shocks on output and markups.

Effect of a Demand Shock

- ▶ Neoclassical model

$$A \cdot F_L(L, K) = \frac{W}{P}$$

For constant A and K , an increase in L must be accompanied by a fall in W/P

Effect of a Demand Shock

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- ▶ New Keynesian model

$$A \cdot F_L(L, K) = \mathcal{M} \frac{W}{P}$$

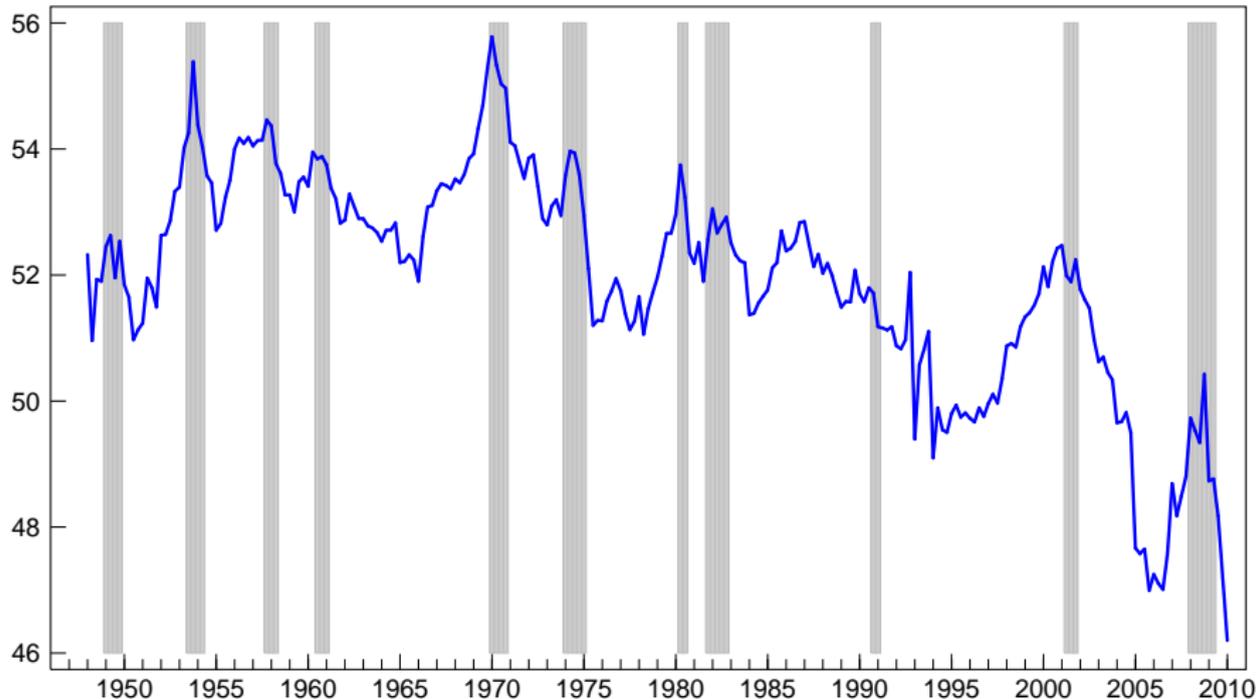
If markup \mathcal{M} falls, then both L and W/P can increase

Standard Measure of the Markup

- ▶ If marginal cost of labor is proportional to average cost, the price-cost markup is inversely proportional to labor share
- ▶ The New Keynesian Phillips curve literature (e.g. Galí-Gertler, 1999; Sbordone, 2002) argue that inverse labor share is a good approximation to the markup
- ▶ Thus, if markups are **countercyclical**, labor share must be **procyclical**
- ▶ Is it?

Labor Share in Private Business

Percent



Notes: Labor share is wage and salary disbursements divided by income without capital consumption adjustment. Shaded areas indicate NBER-dated recessions; latest recession assumed to have ended in 2009:Q3.

- ▶ If labor share is countercyclical, how can markups also be countercyclical?
- ▶ After showing that the labor share is countercyclical, Rotemberg and Woodford (1999) discuss at length why MC might be more procyclical than AC
- ▶ MC may be more procyclical than AC in the presence of:
 - ▶ Hourly wages that increase with average hours per worker
 - ▶ Adjustment costs
 - ▶ Lower elasticity of substitution between L and K (i.e., non-Cobb-Douglas production function)
 - ▶ Increasing returns to scale

What This Paper Does

1. Re-evaluate cyclicalness of markups based on average cost for several broad aggregates
2. Construct factors to adjust average costs to properly capture marginal cost
3. Assess cyclicalness of aggregate markups based on marginal cost, both unconditionally and in response to a monetary policy shock
4. Study response of markup to government spending shocks in 4-digit manufacturing data

Findings

1. Markups are procyclical or acyclical
 - ▶ In both aggregate and industry data, for several measures of the business cycle
2. Aggregate evidence
 - ▶ Markups trough during recessions and peak in the middle of expansions
 - ▶ Markups are procyclical in response to monetary shocks
3. Detailed industry evidence
 - ▶ Markups are acyclical in response to government spending–induced increases in shipments

Outline

Theoretical Framework

Estimating the Marginal-Average Wage Adjustment

The Cyclical Behavior of Markups

Effect of a Monetary Policy Shock on Markups

Discussion of the Aggregate Results

Industry Analysis

Theoretical Markup

$$(1) \quad \mathcal{M} = \frac{P}{MC}$$

Key points for measuring marginal cost, MC :

- ▶ A cost-minimizing firm should equalize the marginal cost of raising output across all possible margins
- ▶ Inputs with adjustment costs have more complicated marginal cost structures
- ▶ We focus on **average hours per worker**, which evidence suggests has negligible adjustment costs

Cost Minimization

- ▶ Firms choose average hours per worker, h , to minimize

$$(2) \quad \text{Cost} = W_A(h) \cdot hN + (\text{terms not involving } h)$$

subject to $\bar{Y} = F(A \cdot hN, \dots)$.

- ▶ $W_A(h)$ is the average hourly wage
- ▶ N is the number of workers
- ▶ Y is gross output
- ▶ A is the level of labor-augmenting technology

Average Wage

- ▶ Bils (1987) argued that W_A may be increasing in h because of the additional cost of overtime hours
- ▶ We specify the average wage as

$$(3) \quad W_S \left[1 + \rho\theta \left(\frac{v}{h} \right) \right] = \lambda F_1(A \cdot hN, \dots)A$$

- ▶ W_S is the straight-time wage
- ▶ ρ is the premium for overtime hours
- ▶ θ is the fraction of overtime hours that command a premium
- ▶ v is average overtime hours per worker

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 - ▶ v is average overtime hours per worker
- ▶ The **last term** captures the idea that firms may have to pay a premium for hours worked beyond a 40-hour workweek

First-Order Condition for h

- ▶ The first-order condition for h is

$$(4) \quad W_S \left[1 + \rho\theta \left(\frac{dv}{dh} \right) \right] = \lambda F_1(A \cdot hN, \dots)A$$

- ▶ λ is the Lagrange multiplier on the constraint ($= MC$)
- ▶ dv/dh is the marginal change in overtime hours for a marginal change in average hours
- ▶ F_1 is the derivative of $F()$ w.r.t. effective labor, $A \cdot hN$

Marginal Cost

- ▶ Marginal cost of increasing output is

$$(5) \quad MC = \lambda = \frac{W_S \left[1 + \rho\theta \left(\frac{dv}{dh} \right) \right]}{AF_1(A \cdot hN, \dots)}$$

- ▶ dv/dh is the marginal change in overtime hours for a marginal change in average hours
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- ▶ The denominator is marginal product of increasing h
- ▶ The numerator is marginal cost of increasing h
 - ▶ Equal to marginal cost of increasing output via N or K

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Linking Average Wage and Marginal Wage

- ▶ The true marginal cost of raising h is

$$(6) \quad W_M = W_S \left[1 + \rho\theta \left(\frac{dv}{dh} \right) \right]$$

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$$(6) \quad W_M = W_S \left[1 + \rho\theta \left(\frac{dv}{dh} \right) \right]$$

- ▶ Relationship between average wage and marginal wage is

$$(7) \quad \frac{W_M}{W_A} = \frac{1 + \rho\theta \left(\frac{dv}{dh} \right)}{1 + \rho\theta \left(\frac{v}{h} \right)}$$

Measuring Markups (Cobb-Douglas)

- ▶ Markup using average wages:

$$(10) \quad \mathcal{M}_A = \frac{P}{W_A / [\alpha (Y/hN)]} = \frac{\alpha}{s}$$

- ▶ Markup using marginal wages:

$$(11) \quad \mathcal{M}_M = \frac{P}{W_M / [\alpha (Y/hN)]} = \frac{\alpha}{s (W_M/W_A)}$$

- ▶ $s = (W_A hN)/PY$ is the labor share

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Estimating the Marginal-Average Wage Adjustment

$$(7) \quad \frac{W_M}{W_A} = \frac{1 + \rho\theta\left(\frac{dv}{dh}\right)}{1 + \rho\theta\left(\frac{v}{h}\right)}$$

To construct the ratio of marginal to average wages we require

1. Ratio of overtime hours to average hours
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Measuring v/h

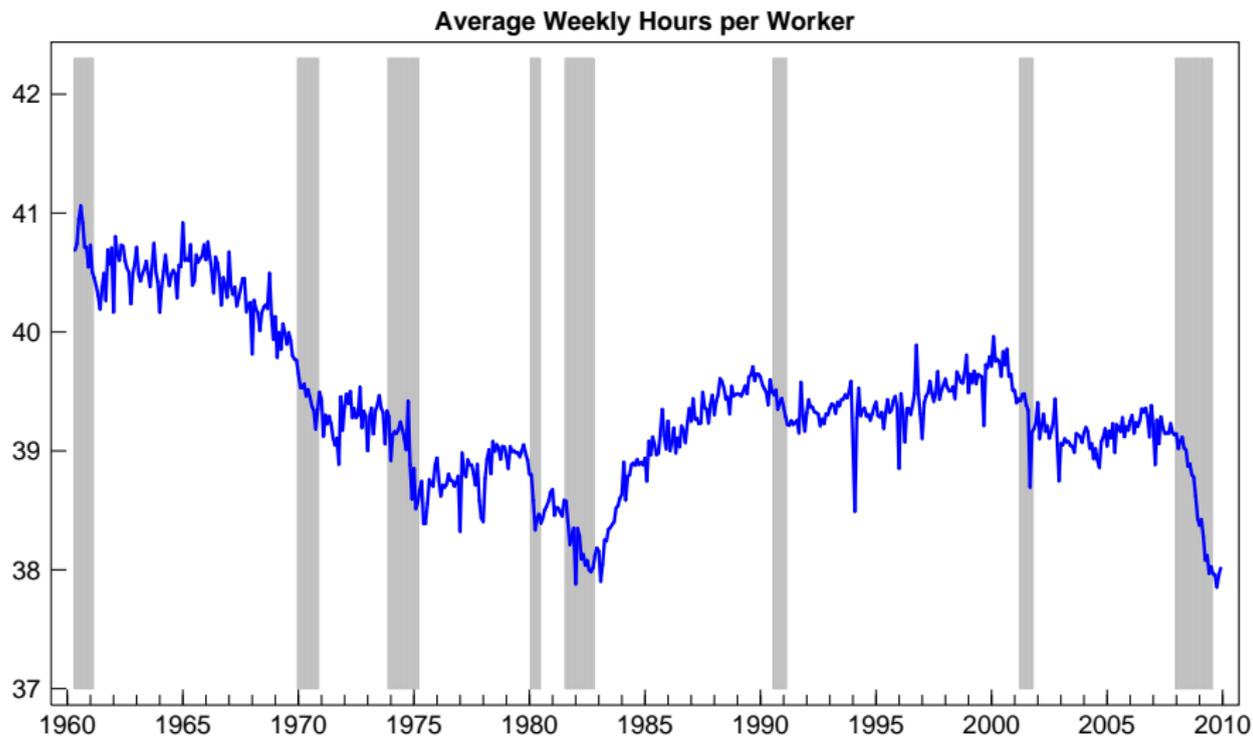
- ▶ There are readily available data on workweek and overtime hours for manufacturing (CES)
- ▶ Even at its post-WWII peak, manufacturing accounted for only a third of employment; it now accounts for less than 10 percent of employment
- ▶ We construct new series on average hours and overtime hours for the entire economy using a previously underutilized data source

Measuring v/h

- ▶ The BLS *Employment and Earnings* publication provides monthly data on the number and average hours of persons at work (Cociuba, Prescott, and Ueberfeldt, 2009)
- ▶ *Employment and Earnings* also reports the number of persons at work by hours worked
 - ▶ Hours worked reported in ranges (e.g., 35–39, 40, 41–48)
 - ▶ We use data from the March CPS to calculate the average of actual hours worked for each published range
 - ▶ This yields an approximation of the full distribution of hours worked, not just the mean
- ▶ We consider any hours worked over 40 hours per week to be “overtime” hours—they need not be paid a premium

Measuring v/h

- ▶ We also use monthly CPS data to create household-based hours for all employees in manufacturing in order to compare to the establishment-based series for production workers.
- ▶ Again, we consider any hours worked over 40 hours per week to be “overtime” hours.

Fig. 1. Average Weekly Hours per Worker, All Workers

Notes: Shaded areas indicate NBER-dated recessions.

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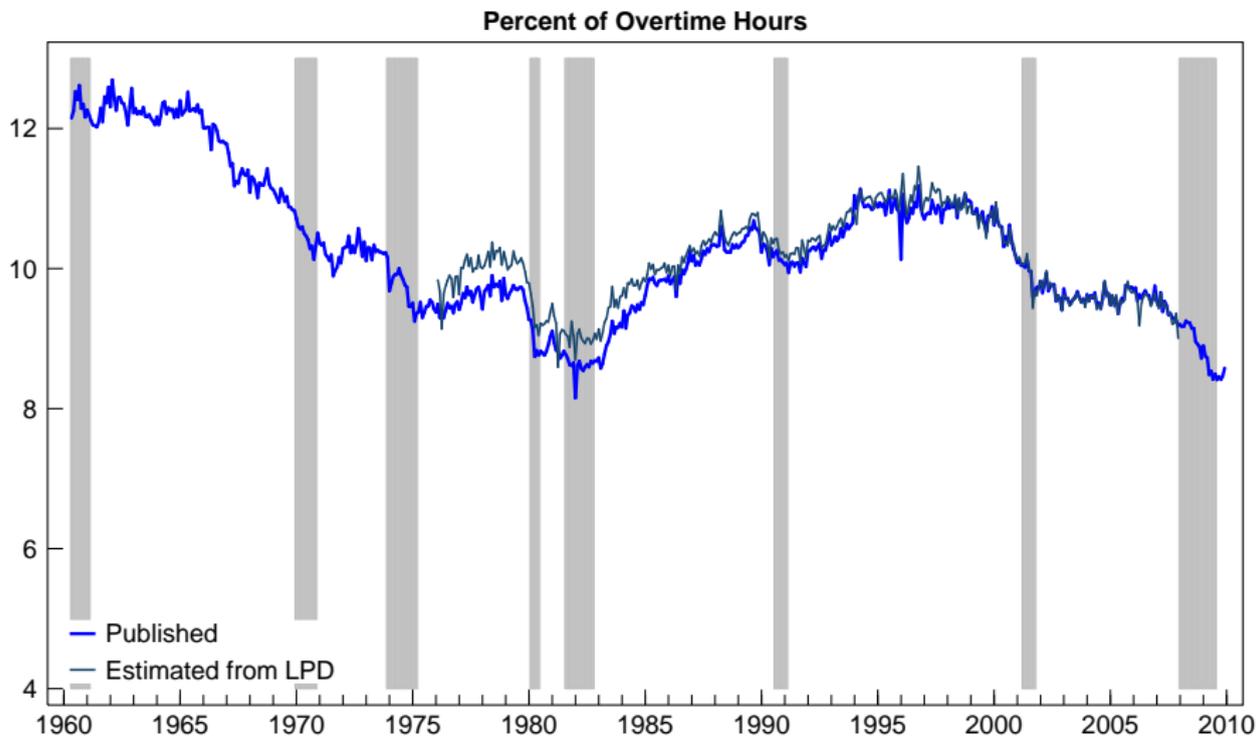
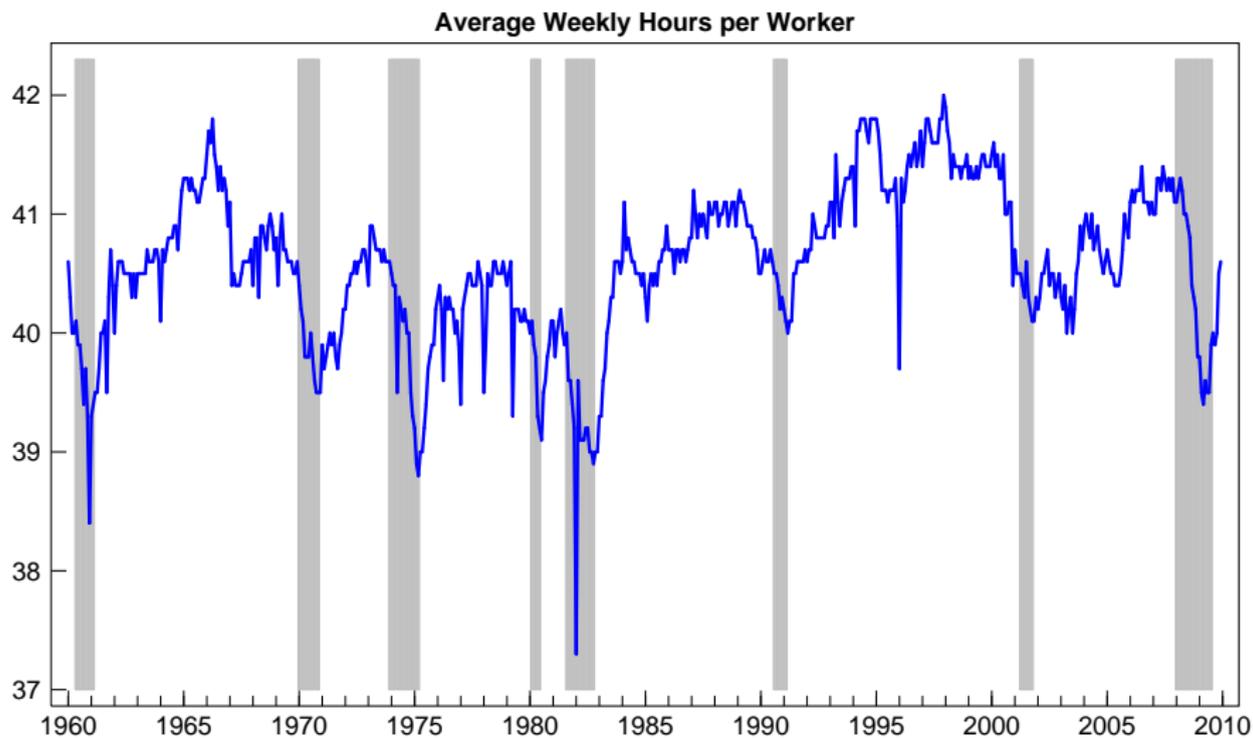
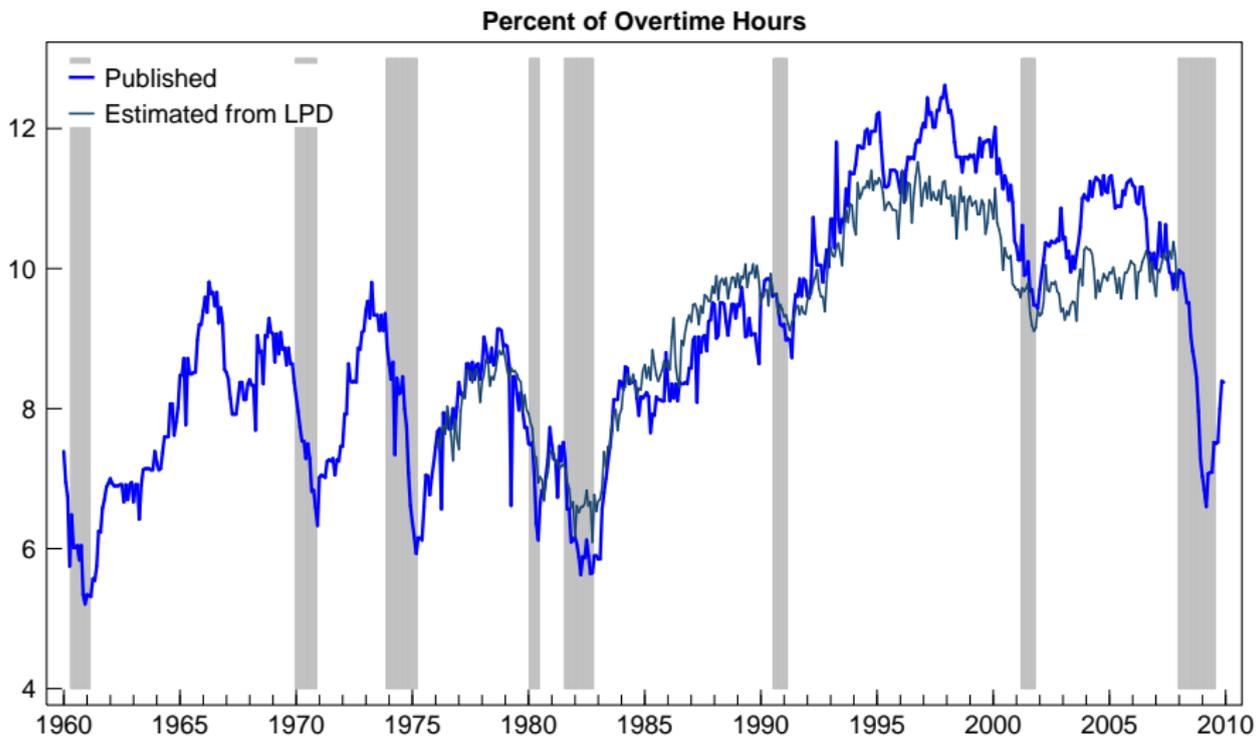
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Fig. 2. Average Weekly Hours per Worker, Manufacturing

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Estimating dv/dh

- ▶ Bils (1987) used the following difference approximation to the marginal change in overtime hours resulting from an increase in average hours:

$$\Delta v_t = \alpha + \eta_t \Delta h_t + \xi_t$$

- ▶ Bils specified η_t as polynomial function of h and time trends
 - ▶ Justification: A given increase in average hours would require more overtime hours if the starting level of average hours was higher
 - ▶ Potential problems: effect of higher moments of the hours distribution and observations for which $\Delta h_t = 0$ but $\Delta v_t \neq 0$
- ▶ Ideally, we want to estimate the “average marginal” change at the *worker* level

Estimating dv/dh

- ▶ We use individual-level data from Nekarda's (2009) Longitudinal Population Database, a monthly panel data set constructed from CPS microdata that matches individuals across all months, available for 1976 to 2007
- ▶ For each matched individual i who is employed in two consecutive months we calculate

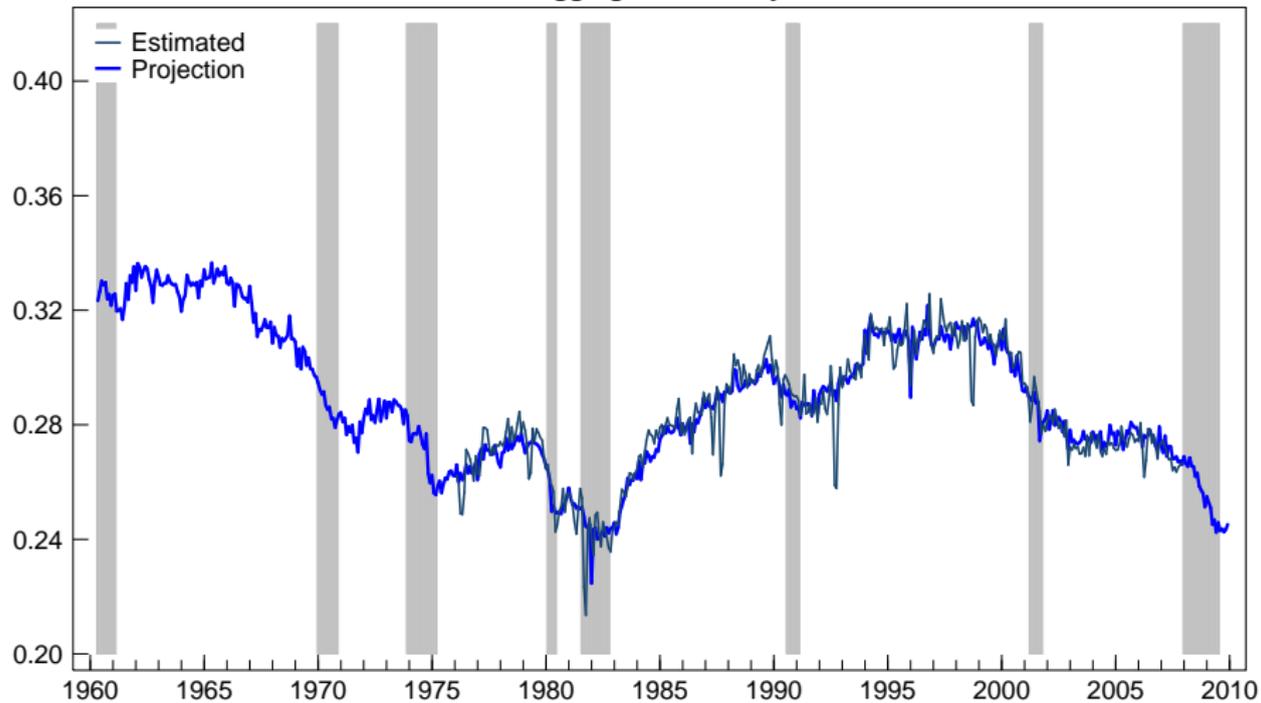
$$\left(\frac{\Delta v}{\Delta h}\right)_{it} = \frac{v_{it} - v_{i(t-1)}}{h_{it} - h_{i(t-1)}}$$

- ▶ For each month t we take the average over all individuals:

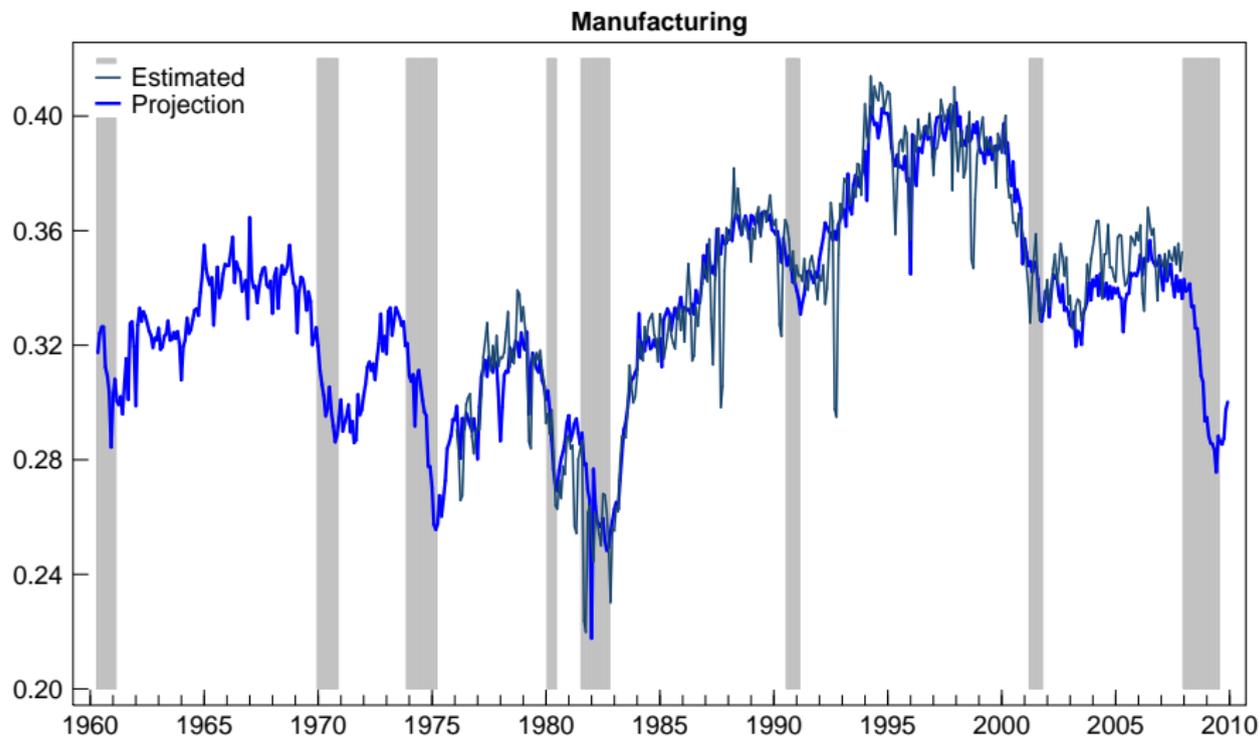
$$\left(\frac{\Delta v}{\Delta h}\right)_t = \frac{1}{P_t} \sum_{i=1}^{P_t} \left(\frac{\Delta v}{\Delta h}\right)_{it}$$

Estimating dv/dh

- ▶ We found that variables from our aggregate EE data explained 90 percent of the variation of the estimated average $(\Delta v/\Delta h)_t$ over 1976 to 2007
- ▶ For all civilian workers, the key variables were average hours of civilian workers and the fraction of workers working 30 to 40 hours per week
- ▶ For manufacturing workers, the key variables were average hours of production workers in manufacturing and the fraction of all civilian workers who were employed 15–39 hours, exactly 40 hours, and 41 hours and more
- ▶ We used these fitted values from the regression to project the dv/dh series over 1960 to 2009

Fig. 3. Estimated dv/dh **Aggregate Economy**

Notes: Shaded areas indicate NBER-dated recessions.

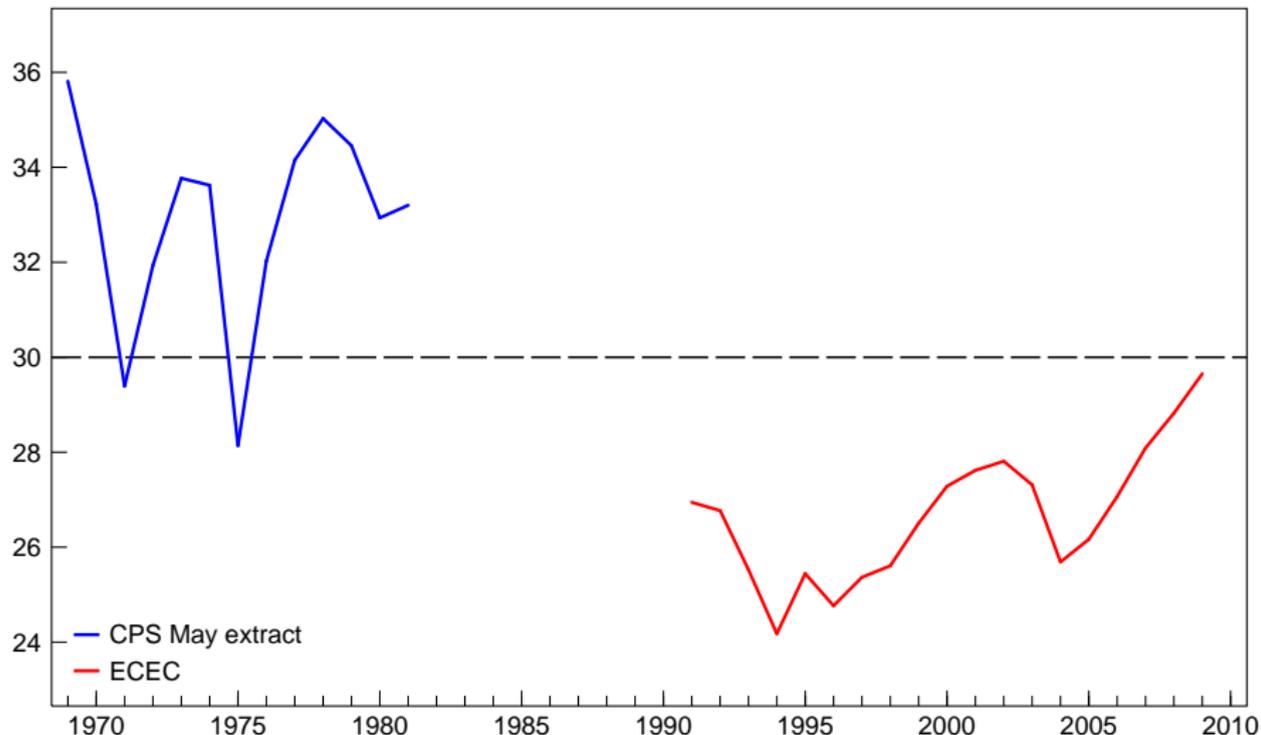
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Estimating the Marginal-Average Wage Adjustment

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To construct the ratio of marginal to average wages we require

1. Ratio of overtime hours to average hours
2. Marginal change in overtime hours with respect to change in average hours
3. Fraction of overtime hours that command a premium
4. Premium paid for overtime hours

Fig. 4. Fraction of Overtime Hours Paid a Premium

Notes: The implied θ for the early sample is based on individual worker reports of hours worked and whether they are paid a premium from the May CPS extract. The implied θ for the later sample is based on aggregated data on wages and salaries and overtime compensation from the Employer Cost survey, coupled with our constructed measure of v/h .

Estimating the Marginal-Average Wage Adjustment

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Value of ρ

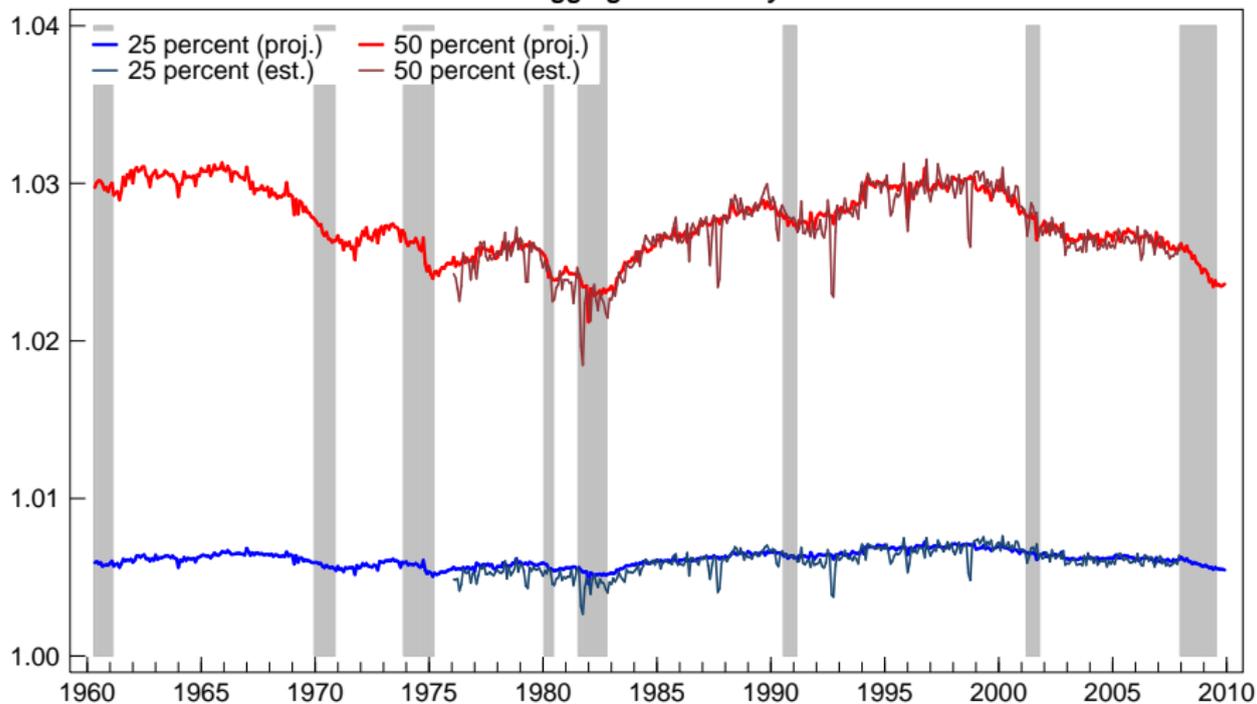
- ▶ Statutory overtime premium is 50% for covered employees
- ▶ Trejo (1991), Hamermesh (2006): effective rate is around 25%
- ▶ CES overtime hours for manufacturing are defined as those that command a premium
- ▶ Our aggregate economy hours are simply hours worked above 40 hours

Estimating the Marginal-Average Wage Adjustment

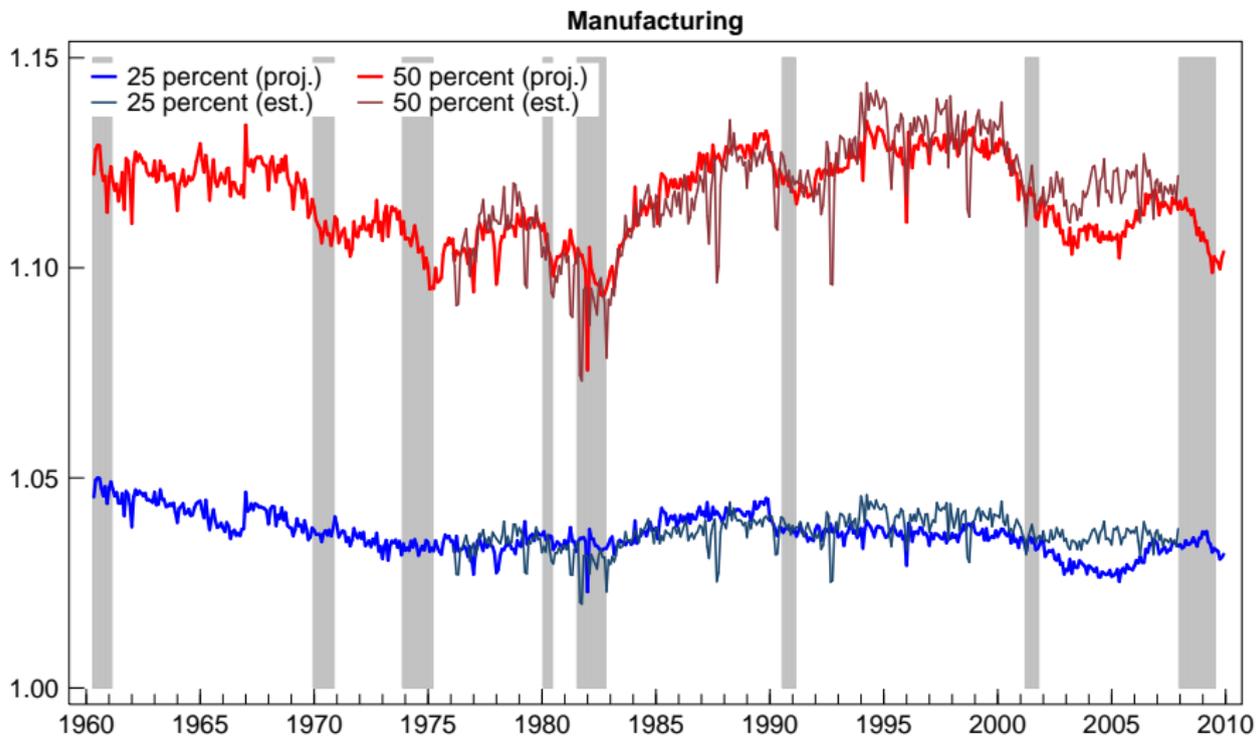
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Fig. 5. Marginal-Average Wage Adjustment Factor**Aggregate Economy**

Notes: Adjustment factor is $\frac{W_M}{W_A}{}_t = \frac{1+\rho(dv/dh)_t}{1+\rho(v/h)_t}$. Shaded areas indicate NBER-dated recessions.

Fig. 5. Marginal-Average Wage Adjustment Factor

Notes: Adjustment factor is $\frac{W_M}{W_A}_t = \frac{1+\rho(dv/dh)_t}{1+\rho(v/h)_t}$. Shaded areas indicate NBER-dated recessions.

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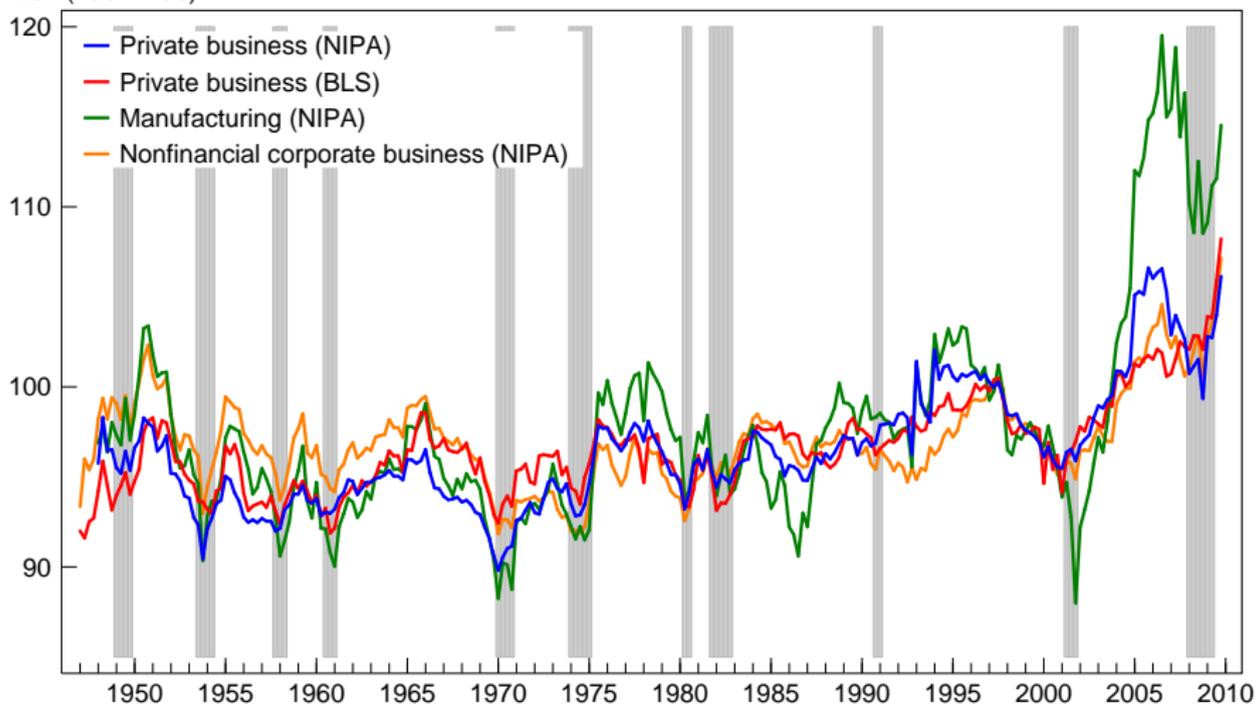
Effect of a Monetary Policy Shock on Markups

Discussion of the Aggregate Results

Industry Analysis

Fig. 6. Aggregate Price-Cost Markup

Index (1997=100)

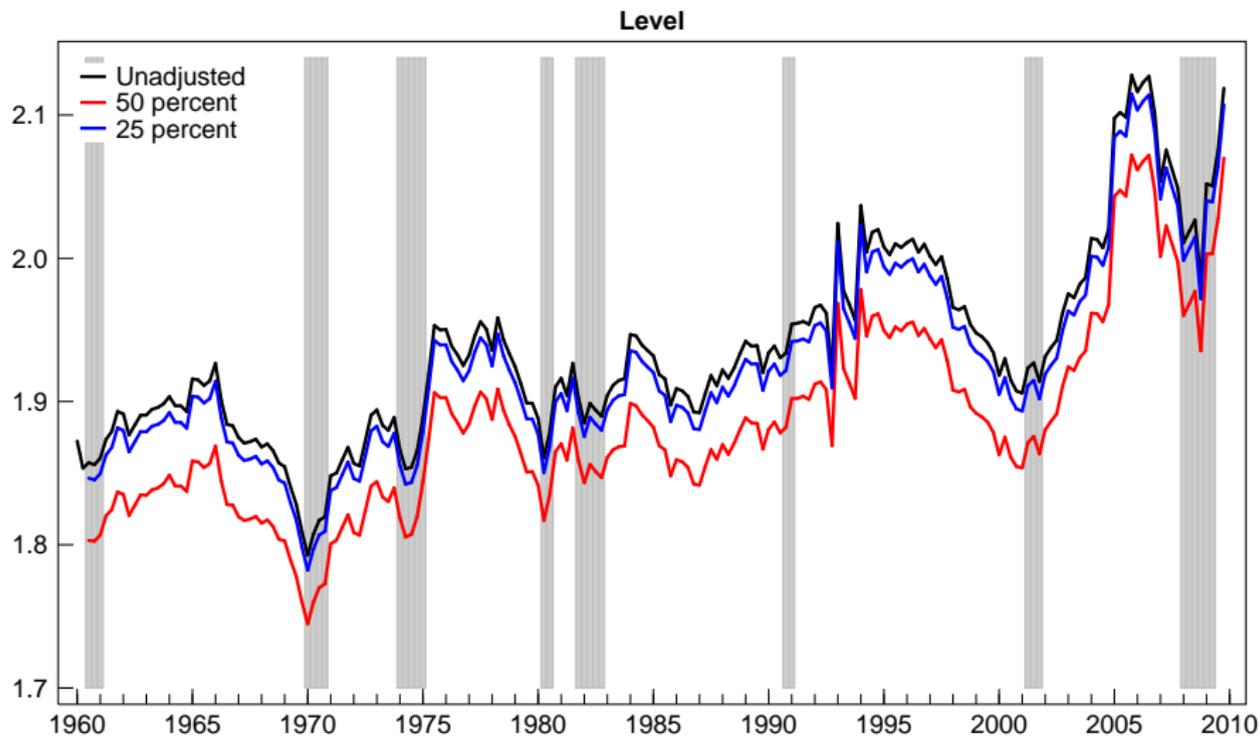


Notes: Markup in nonfinancial corporate business is compensation divided by gross value added less taxes on production; other NIPA markups are wage and salary disbursements divided by income without capital consumption adjustment. BLS markup is inverse of index of labor share. Shaded areas indicate NBER-dated recessions.

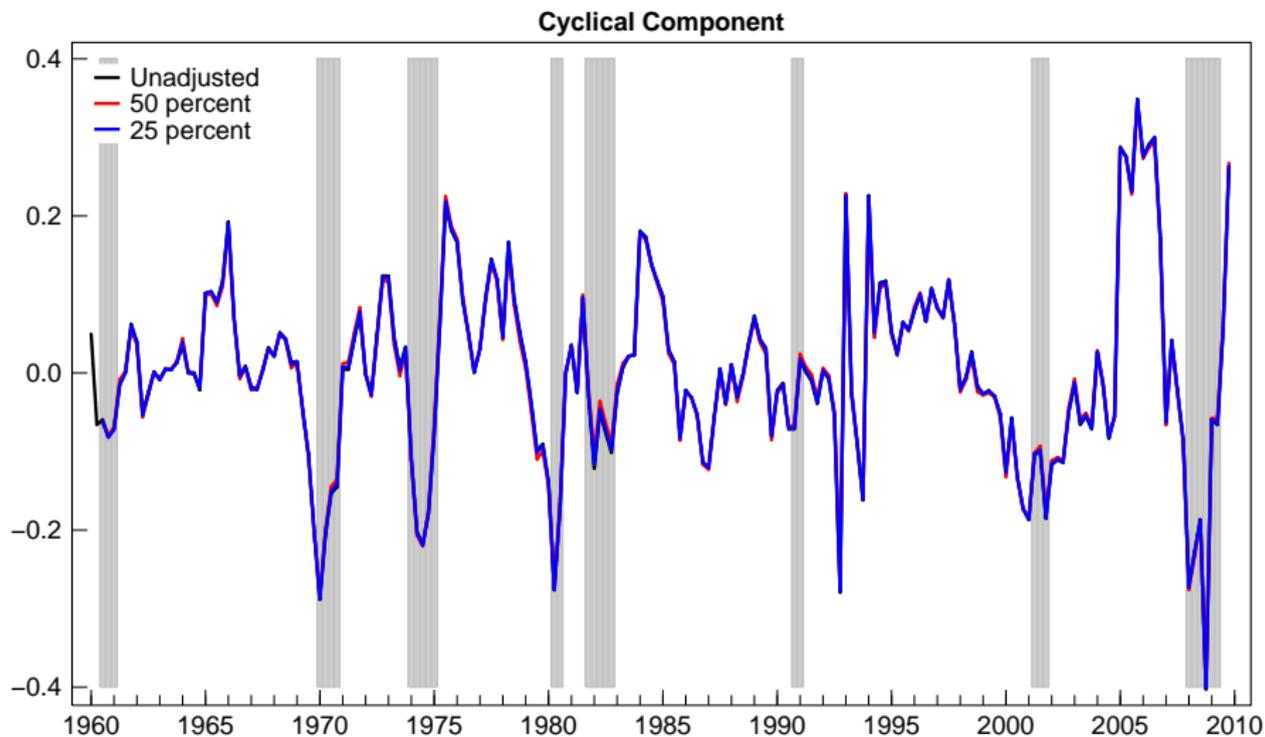
Tab. 1. Cyclicity of the Price-Cost Markup

<i>Markup Measure</i>	<i>Recession indicator</i>	<i>Correlation with real GDP</i>	
		<i>HP filter</i>	<i>First difference</i>
<i>Average markup</i>			
1. Nonfinancial corporate business	-0.020***	0.169*	0.297***
2. Private business (NIPA)	-0.022***	0.151*	0.176*
3. Private business (BLS)	-0.020***	0.296***	0.517***
4. Manufacturing	-0.041***	0.367***	0.329***

Source: Authors' calculations using quarterly data from the BLS and NIPA for 1960:2–2009:4.

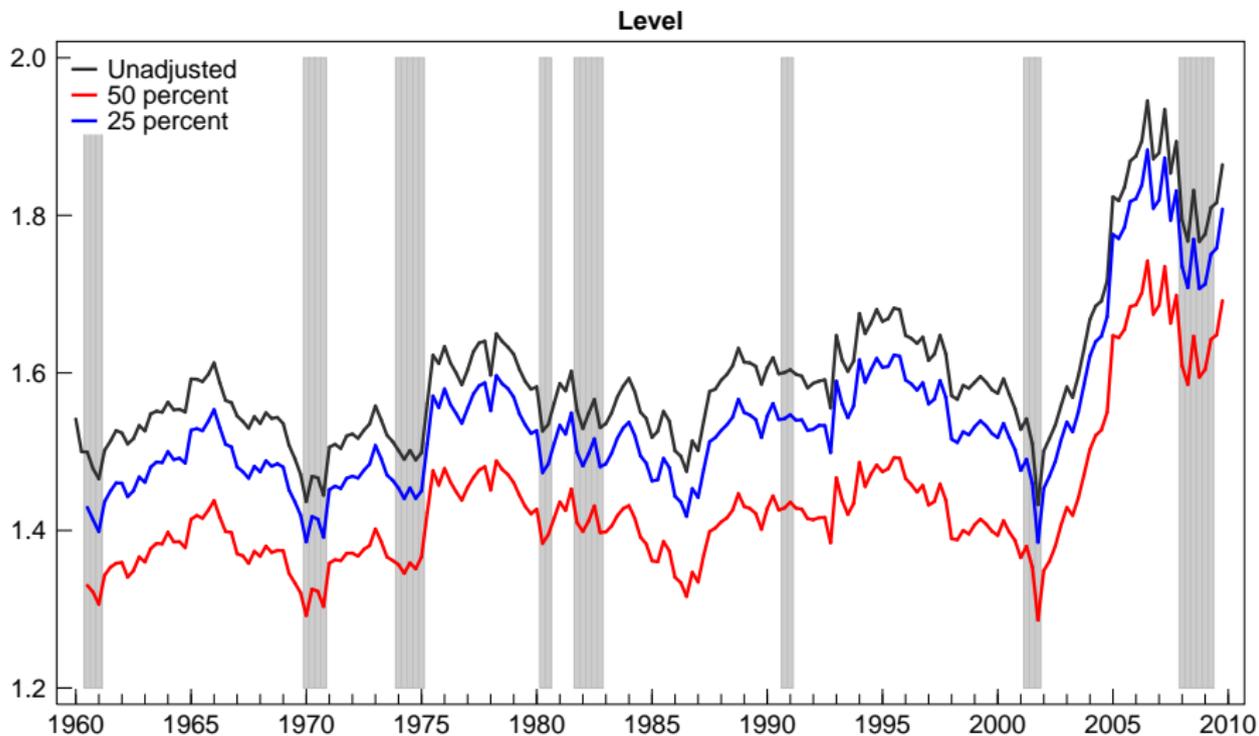
Fig. 7. Marginal Price-Cost Markup, Aggregate Economy

Notes: Unadjusted plots average markup in private business sector; remaining series are marginal markup with indicated overtime premium. Cyclical component extracted using HP filter ($\lambda = 1,600$). Shaded areas indicate NBER-dated recessions.

Fig. 7. Marginal Price-Cost Markup, Aggregate Economy

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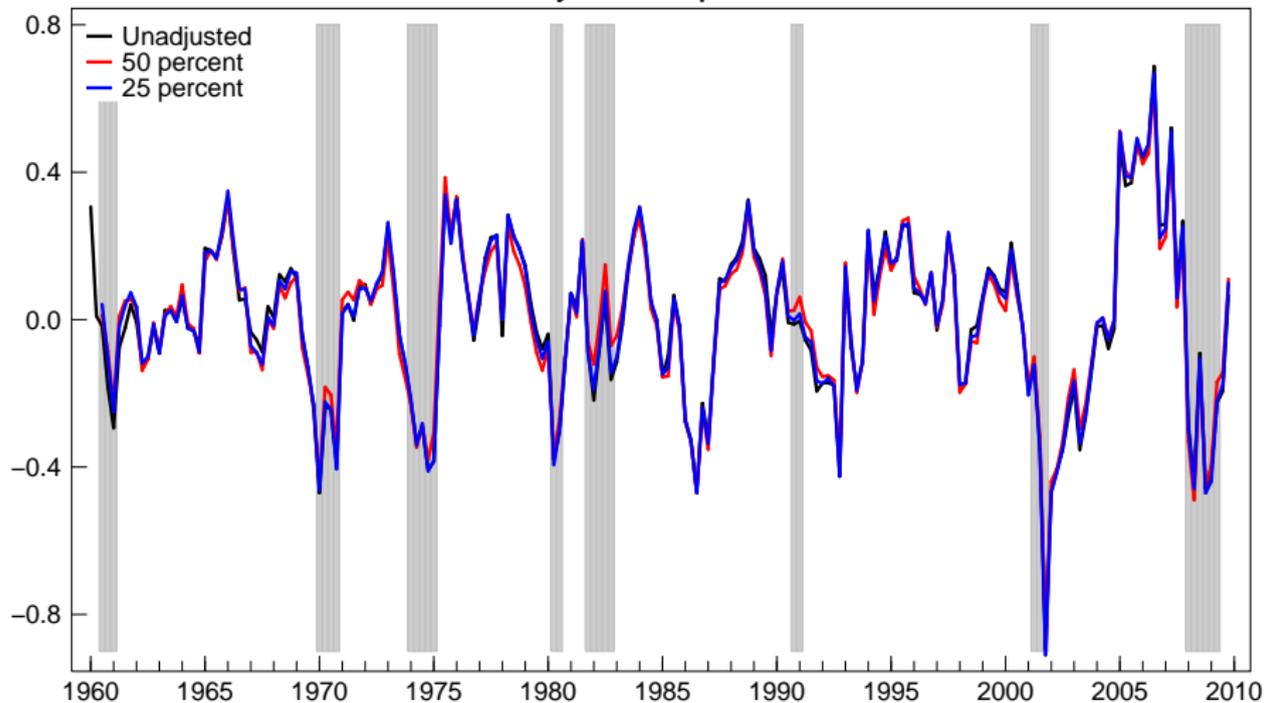
Fig. 9. Marginal Price-Cost Markup, Manufacturing



Notes: Unadjusted plots average markup in manufacturing sector; remaining series are marginal markup with indicated overtime premium. Cyclical component extracted using HP filter ($\lambda = 1,600$). Shaded areas indicate NBER-dated recessions.

Fig. 9. Marginal Price-Cost Markup, Manufacturing

Cyclical Component



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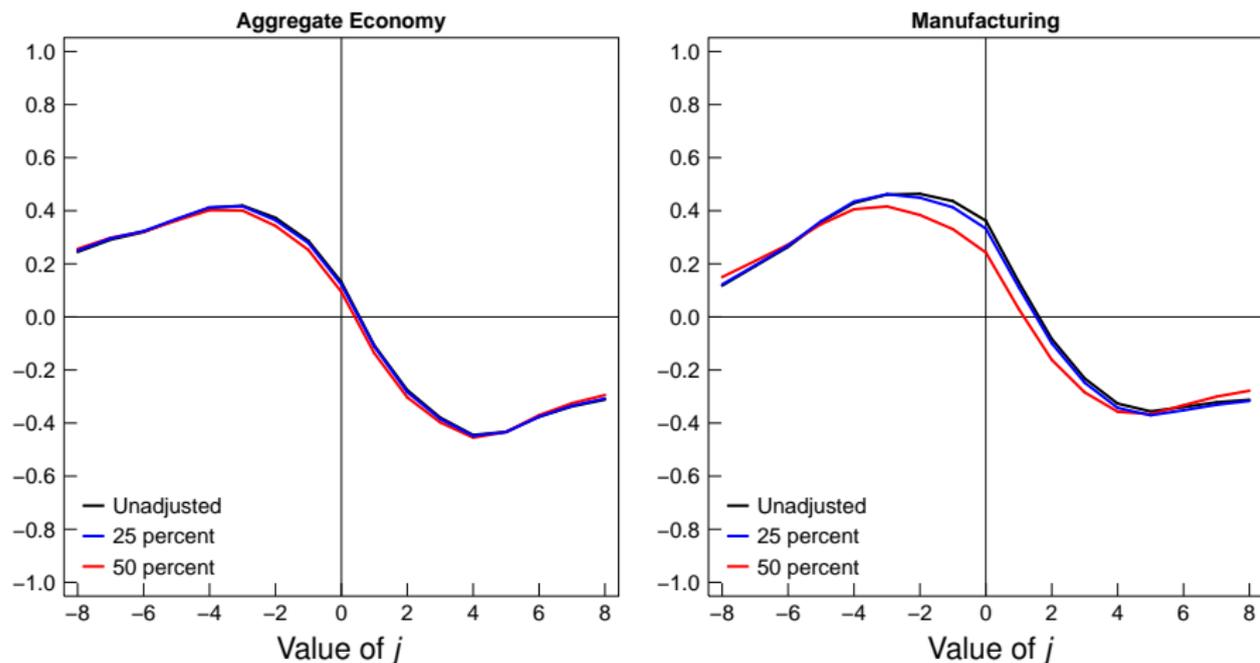
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<i>Marginal Markup</i>			
5. Private business, $\rho = 0.25$	-0.021***	0.137*	0.170**
6. Private business, $\rho = 0.50$	-0.020***	0.109	0.157**
7. Manufacturing, $\rho = 0.25$	-0.041***	0.342***	0.322***
8. Manufacturing, $\rho = 0.50$	-0.035***	0.252***	0.272***

Source: Authors' calculations using quarterly data from the BLS and NIPA for 1960:2–2009:4.

Notes: Marginal markup for private business uses NIPA measure of labor share.

Fig. 8. Cross-Correlations of Markups with Real GDP



Notes: Correlation of cyclical components of y_t and μ_{t+j} . Detrended using HP filter ($\lambda = 1,600$). Unadjusted is average markup in private business sector; remaining series are marginal markup with indicated overtime premium.

CES Production Function

- ▶ We also construct the markup under the assumption of a CES production function
- ▶ Markup using marginal wages and CES production function:

$$(12) \quad \mathcal{M}_M^{\text{CES}} = \frac{\alpha}{s(W_M/W_A)} \left(\frac{Y}{A \cdot hN} \right)^{\frac{1}{\sigma}-1}$$

- ▶ σ is the elasticity of substitution between K and L
- ▶ We use Chirinko's (2008) estimate of $\sigma = 0.5$ and estimate A using two different methods
- ▶ The estimated correlation of this markup is a little higher than the Cobb-Douglas case

Outline

Theoretical Framework

Estimating the Marginal-Average Wage Adjustment

The Cyclical Behavior of Markups

Effect of a Monetary Policy Shock on Markups

Discussion of the Aggregate Results

Industry Analysis

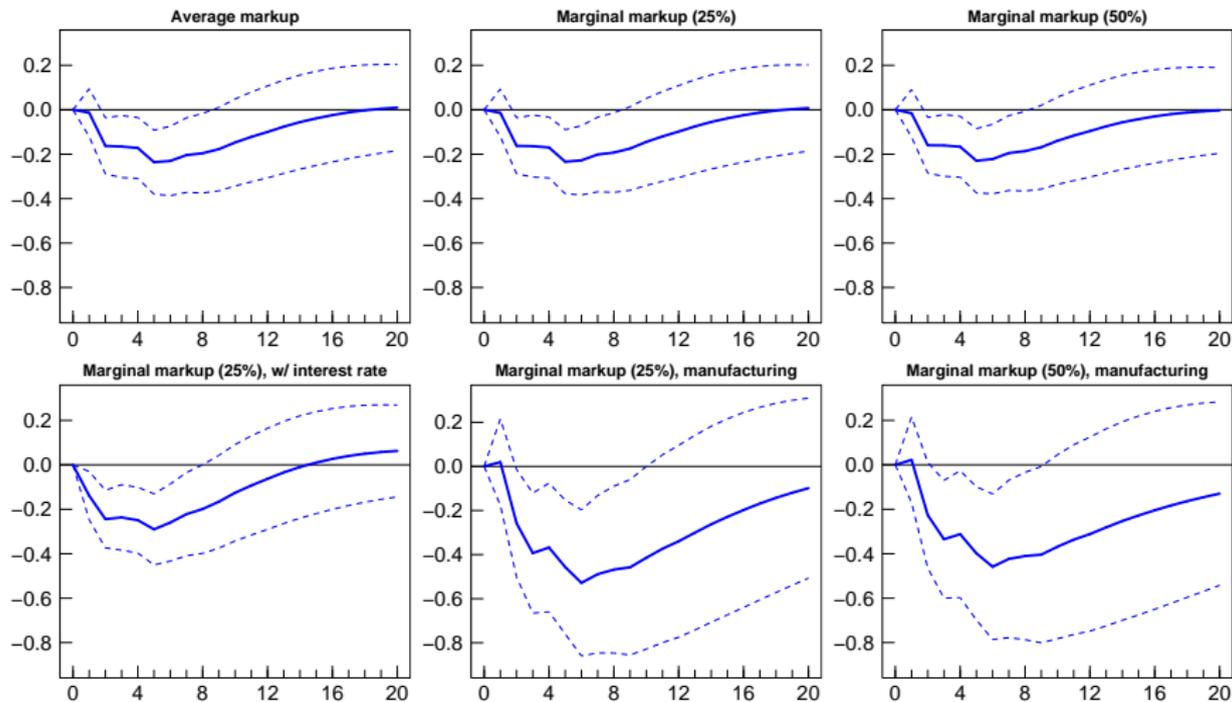
Implications of Procyclical Markups for NK Models

- ▶ The New Keynesian (NK) model predicts markup moves procyclically in response to a technology shock, but countercyclically in response to a demand shock
- ▶ Our finding of procyclical markups may be consistent with the NK model if technology shocks are the main source of cyclical fluctuations
- ▶ Therefore, we assess the cyclicity of the markup conditional on a demand shock

Effect of a Monetary Policy Shock on Markups

- ▶ We estimate a standard VAR on quarterly data from 1960:Q3–2009:Q4
- ▶ Variables: log real GDP, log commodity prices, log GDP deflator, log markup, federal funds rate
- ▶ A shock to the federal funds rate (ordered last) is the contractionary monetary policy shock
- ▶ We also consider the cost channel: include prime rate in marginal cost

Fig. 10. Response of Markup to Contractionary Monetary Policy Shock



Notes: Impulse responses estimated from VAR(4) with log real GDP, log commodity prices, log GDP deflator, markup measure, and federal funds rate; also includes a linear time trend. Monetary policy shock identified as shock to federal funds rate when ordered last. Specification with interest rate includes the prime rate in marginal cost. Dashed lines indicate 95-percent confidence interval.

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Relationship to Bils (1987)

- ▶ Our marginal markup is an extension of Bils's novel conceptual framework, but we reach the opposite conclusion
- ▶ The key is the details of implementation
- ▶ In particular, our technological innovations were not available in the 1980s
 - ▶ Higher-frequency data and longer sample
 - ▶ Richer data
 - ▶ Conditional estimation based on monetary policy shocks

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 - ▶ Conditional estimation based on monetary policy shocks
- ▶ **Time aggregation is especially important**

Tab. 3. Effect of Time Aggregation on Markup

<i>Frequency of dv/dh</i>	<i>Frequency of markup</i>	<i>Correlation of markup with</i>		
		<i>Real GDP</i>	<i>Industrial production</i>	<i>Total hours</i>
<i>2-digit industry data, 1956–83, 50 Percent Premium</i>				
1. Quarterly	Quarterly	0.307	0.140	0.069
2. Quarterly	Annual	0.200	0.010	–0.047
3. Annual	Annual	–0.004	–0.205	–0.245
<i>2-digit industry data, 1956–2002, 50 Percent Premium</i>				
4. Annual	Annual	0.011	–0.049	–0.084
<i>2-digit industry data, 1956–2002, 25 Percent Premium</i>				
5. Annual	Annual	0.208	0.153	0.003

Notes: Contemporaneous correlation of cyclical components of log markup and cyclical indicator, where cyclical component is extracted using HP filter. Industrial production and total hours are for manufacturing.

Relation to the New Keynesian Phillips Curve

- ▶ New Keynesian Phillips Curve: $\pi_t = \beta E_t(\pi_{t+1}) + \kappa \tilde{y}_t$
 - ▶ Problem: estimates of κ are negative
- ▶ Galí-Gertler (1999): use real marginal cost instead
 - ▶ $\pi_t = \beta E_t(\pi_{t+1}) + \lambda mc_t$
 - ▶ Estimates of λ are positive, consistent with theory
- ▶ The reason mc enters positively but \tilde{y} enters negatively is that they are negatively correlated in the data
- ▶ Note that $mc_t = -\ln \mathcal{M}_t$
 - ▶ Thus, the NKPC explains inflation well because the markup is procyclical!

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Evidence from Disaggregated Manufacturing Industries

- ▶ We now examine detailed 4-digit SIC industry data
- ▶ Advantages
 - ▶ We can determine whether results are from aggregation
 - ▶ We can construct a highly relevant demand instrument based on industry-specific govt demand
 - ▶ We can construct markups using gross output
 - ▶ Basu and Fernald (1997) argue value added is not a natural measure of output
 - ▶ Indeed, value added makes sense only when markup is unity

Data and Variable Construction

We merge information from:

1. NBER-CEcS Manufacturing Industry Database
 - ▶ Annual data on 458 4-digit SIC industries for 1958–2005
 - ▶ Data on hours, employment, payrolls, shipments, & capital
 - ▶ We use information from 2-digit CES data from 1958–2002 to create marginal-average wage factors
2. BEA benchmark input-output tables
 - ▶ Can trace direct and indirect shipments to the government using transactions and requirements matrices
 - ▶ Available quinquennially
 - ▶ We use 1963, 1967, 1972, 1977, 1982, 1987, and 1992

Industry-Specific Government Demand

- ▶ Nekarda and Ramey (2010) use the following government demand instrument:

$$\Delta g_{it} = \bar{\theta}_i \cdot \Delta \ln G_t,$$

- ▶ $\bar{\theta}_i$ is the average share of industry i 's total nominal shipments that go to the government
 - ▶ G_t is aggregate real federal purchases from the NIPA
- ▶ Since the distribution of government spending across industries may be correlated with industry-specific technological change, this instrument excludes those changes (after including industry and time fixed effects)
- ▶ The first-stage F statistic of industry shipments on this instrument is 193

Industry Regression Specification

- ▶ We regress the log change in the markup, $\Delta\mu_{it} = -\Delta \ln(s_{it})$, on the log change in real gross shipments, $\Delta \ln Y$:

$$(18) \quad \Delta\mu_{it} = \gamma_{0it} + \gamma_1 \Delta \ln Y_{it} + \varepsilon_{it},$$

- ▶ Instrument for $\Delta \ln Y_{it}$ using Δg_{it}
- ▶ Include industry and year fixed effects (γ_{0it})
- ▶ Sample contains 272 4-digit SIC industries from 1960–2002 for a total of 12,009 observations

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- ▶ Include industry and year fixed effects (γ_{0it})
- ▶ Sample contains 272 4-digit SIC industries from 1960–2002 for a total of 12,009 observations
- ▶ γ_1 describes how the markup responds to a demand-induced change in output

Tab. 4. Regression of Markup on Gross Shipments

Coefficient $\widehat{\gamma}_1$		
<i>Specification</i>	<i>Production workers</i>	<i>All workers</i>
Average	0.005 (0.052)	0.057 (0.046)
Marginal ($\rho = 0.25$)	0.018 (0.052)	0.066 (0.046)
Marginal ($\rho = 0.50$)	0.022 (0.052)	0.070 (0.047)

Notes: IV regression of $\Delta\mu_{it} = \gamma_{0it} + \gamma_1 \Delta \ln Y_{it} + \varepsilon_{it}$. $\Delta \ln Y_{it}$ is instrumented by Δg_{it} . Sample contains 272 4-digit SIC industries from 1960–2002 for a total of 12,009 observations. All regressions include industry and year fixed effects.

Conclusions

1. We find no evidence that the markup is countercyclical, in broad aggregates or detailed manufacturing industries
2. Our results are robust to adjustments of average wages to marginal wages
3. Our results hold unconditionally as well as conditional on demand shocks

Implications

- ▶ More research is needed to see whether the transmission mechanism of leading New Keynesian models actually holds
- ▶ Perhaps a return to models with sticky wages and fairly flexible prices can make the models consistent with the data

