Resurrecting the Role of the Product Market Wedge in Recessions

Mark Bils, University of Rochester and NBER
Pete Klenow, Stanford University and NBER
Ben Malin, Federal Reserve Bank of Minneapolis[1]

Federal Reserve Bank of San Francisco
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[1] Views expressed here are those of the authors and do not necessarily reflect the views of the Federal Reserve System.

Decomposing the Labor Wedge

Hours worked appear to be inefficiently low in recessions.

- Labor Wedge is high: $\mu \equiv \frac{mpn}{mrs}$

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Labor Wedge is the product of:

1. Labor Market Wedge: $\mu^w \equiv \frac{w/p}{mrs}$
2. Product Market Wedge: $\mu^p \equiv \frac{mpn}{w/p} \equiv \frac{p}{mc}$

The Standard Decomposition Approach

Uses (aggregate) wage data

- E.g., Gali, Gertler, Lopez-Salido (2007), Karabarbounis (2014)
- Measure of Price of Labor: w/p = average wage
- Key Assumption: all workers employed in spot markets.
- Conclusion: μ^w accounts for nearly all cyclicality of μ.

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- E.g., Gali, Gertler, Lopez-Salido (2007), Karabarbounis (2014)
- Measure of Price of Labor: $w/p =$ average wage
- Key Assumption: all workers employed in spot markets.
- Conclusion: μ^w accounts for nearly all cyclicality of μ.

BUT, conclusion depends critically on wage measure used.

- Alternative theories emphasize durable nature of employment and wage smoothing.
- w/p can be much more procyclical using other wage measures.

This Paper

Decomposes Labor Wedge μ without using wage data.

Recall: $\mu^p \equiv \frac{p}{mc}$

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1. Self-Employed
   - $\frac{p}{mc} = \frac{p}{p \cdot mrs/mpn} = \frac{mpn}{mrs}$,

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Recall: $\mu^p \equiv \frac{p}{mc}$

Consider 2 alternative inputs:

1. Self-Employed
   - $\frac{p}{mc} = \frac{p}{p \cdot mrs/mpn} = \frac{mpn}{mrs}$, or $\mu^p = \mu$
2. Intermediate Inputs
   - $\frac{p}{mc} = \frac{p}{p_m/mpm}$

Preview of Findings

Our point estimates: μ^p accounts for the cyclical variation in μ

- Self-Employed μ is just as cyclical as all-worker μ
- Intermediate Inputs μ^p is just as cyclical as μ

Thus, countercyclical price markups deserve a central place in business cycle research, alongside labor market frictions.

Outline for Remainder of Talk

Measuring the Labor Wedge

- Focus on Intensive Margin
- Decompose using Wage Data

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Our 2 Alternative Decompositions

1. Self-Employed
2. Intermediate Inputs

Intensive-Margin Wedge

$$\begin{aligned} ln(\mu_t) &\equiv ln(mpn_t) - ln(mrs_t) \\ &= ln\left(\frac{y_t}{n_t}\right) - \left[\frac{1}{\sigma} ln(c_t) + \frac{1}{\eta} ln(h_t)\right] \end{aligned}$$

- h_t = hours per *worker*
- $\eta = 0.5$
- $\sigma = 0.5$

Cyclicality of Intensive-Margin Labor Wedge

$$ln(\mu_t) = \alpha + \beta \cdot ln(cyc_t) + \epsilon_t$$

	Elasticity wrt GDP
Labor Wedge	-1.91 (0.13)
Labor Productivity	-0.10 (0.08)
Cons per capita	0.61 (0.03)
Hours per worker	0.30 (0.07)

- Quarterly data, 1987-2012 with $\sigma = 0.5$, $\eta = 0.5$

Decomposing the Wedge

Decomposition:

$$\begin{aligned} ln(\mu_t) &= \left[ln\left(\frac{y_t}{n_t}\right) - ln\left(\frac{w_t}{p_t}\right)\right] + \left[ln\left(\frac{w_t}{p_t}\right) - \frac{1}{\sigma}ln(c_t) - \frac{1}{\eta}ln(h_t)\right] \\ &= ln(\mu_t^p) + ln(\mu_t^w) \end{aligned}$$

Cyclicality:

$$\begin{aligned} ln(\mu_t) &= \alpha + \beta \cdot ln(cyc_t) + \epsilon_t \\ ln(\mu_t^p) &= \alpha^p + \beta^p \cdot ln(cyc_t) + \epsilon_t \\ ln(\mu_t^w) &= \alpha^w + \beta^w \cdot ln(cyc_t) + \epsilon_t \end{aligned}$$

Note: $\beta = \beta^p + \beta^w$.

Wedge Decomposition: Standard Approach

	Elasticity wrt GDP
μ	-1.91 (0.13)
$\mu^p \left(\frac{w}{p} = AHE\right)$	-0.04 (0.13)

Wedge Decomposition: Alternative Wage Measures

	Elasticity wrt GDP
μ	-1.91 (0.13)
$\mu^p \left(\frac{w}{p} = AHE\right)$	-0.04 (0.13)
$\mu^p \left(\frac{w}{p} = NH\right)$	-0.70 (0.16)
$\mu^p \left(\frac{w}{p} = UC\right)$	-1.89 (0.21)

Outline

Measuring the Labor Wedge

- Fous on Intensive Margin
- Decompose using Wage Data

Our 2 Alternative Decompositions

1. Self-Employed
2. Intermediate Inputs

Approach 1: Self-Employed

Idea:

- Compare the wedge for the self-employed (μ_{se}) to the wedge for all workers (μ).
- Assuming $\mu_{se} = \mu_{se}^{p} = \mu^{p}$, comparison yields μ^{p} vs. μ.

Focus on intensive (hours) margin

- Extensive movements could reflect costs of starting business

Data on Self-Employed

Hours and Earnings: March CPS

- "Self-employed"
  - Primary job is (nonag) self-employment.
  - 95% of earnings from primary job
- Trim sample to deal with top and bottom coding
- Hours: usual weekly hours (also total annual hours)
- Earnings from primary job
- Examine year-to-year changes for "matched" workers

Consumption: Consumer Expenditure Survey

- Construct *relative* consumption of self-employed

Cyclicality of the Labor Wedge: All vs. Self-Employed

	Labor Wedge			
Elasticity wrt	(1)	(2)	(3)	(4)
Real GDP	-1.87 (0.10)			
Hours	All			
MPN	Agg. y/n			
Consumption	NIPA PCE			

Cyclicality of the Labor Wedge: All vs. Self-Employed

	Labor Wedge			
Elasticity wrt	(1)	(2)	(3)	(4)
Real GDP	-1.87 (0.10)	-2.06 (0.17)		
Hours	All	SE		
MPN	Agg. y/n	Agg. y/n		
Consumption	NIPA PCE	NIPA PCE		

Cyclicality of the Labor Wedge: All vs. Self-Employed

	Labor Wedge			
Elasticity wrt	(1)	(2)	(3)	(4)
Real GDP	-1.87 (0.10)	-2.06 (0.17)	-1.97 (0.25)	
Hours	All	SE	SE	
MPN	Agg. y/n	Agg. y/n	SE earn/hr	
Consumption	NIPA PCE	NIPA PCE	NIPA PCE	

Cyclicality of the Labor Wedge: All vs. Self-Employed

	Labor Wedge			
Elasticity wrt	(1)	(2)	(3)	(4)
Real GDP	-1.87 (0.10)	-2.06 (0.17)	-1.97 (0.25)	-3.23 (1.00)
Hours	All	SE	SE	SE
MPN	Agg. y/n	Agg. y/n	SE earn/hr	SE earn/hr
Consumption	NIPA PCE	NIPA PCE	NIPA PCE	NIPA PCE + CE adj.

Labor Wedge for Self-Employed vs. All Workers

Self-Employed Conclusions

(Baseline) self-employed wedge is at least as countercyclical as all-worker wedge.

Robustness:

1. Use only *unincorporated* self-employed
2. Weight CPS observations by industry
3. Weight CPS observations by share of self-employed in industry-occupation that have employees

Conclusion: μ^p accounts for the bulk of cyclical variation in μ.

Outline

Measuring the Labor Wedge

- Focus on Intensive Margin
- Decompose using Wage Data

Our 2 Alternative Decompositions

1. Self-Employed
2. Intermediate Inputs

Approach 2: Intermediate Inputs

Production function:

$$y = \left[\theta m^{\frac{\varepsilon-1}{\varepsilon}} + (1-\theta)\left[z_v\left[\alpha k^{\frac{\omega-1}{\omega}} + (1-\alpha)(z_n n^{\frac{\omega-1}{\omega}})\right]^{\frac{\omega}{\omega-1}}\right]^{\frac{\varepsilon-1}{\varepsilon}}\right]^{\frac{\varepsilon}{\varepsilon-1}}$$

Marginal Product wrt Intermediates:

$$mpm_t = \theta\left(\frac{y_t}{m_t}\right)^{\frac{1}{\varepsilon}}$$

Product Market Wedge:

$$\mu_t^p = \frac{p_t}{mc_t} = \frac{p_t}{p_{mt}/mpm_t}$$

Constructing μ_i^p

Product Market Wedge

$$\mu_{it}^p = \frac{p_{it}\, y_{it}}{p_{m,it} m_{it}} \left(\frac{y_{it}}{m_{it}} \right)^{\frac{1}{\varepsilon}-1}$$

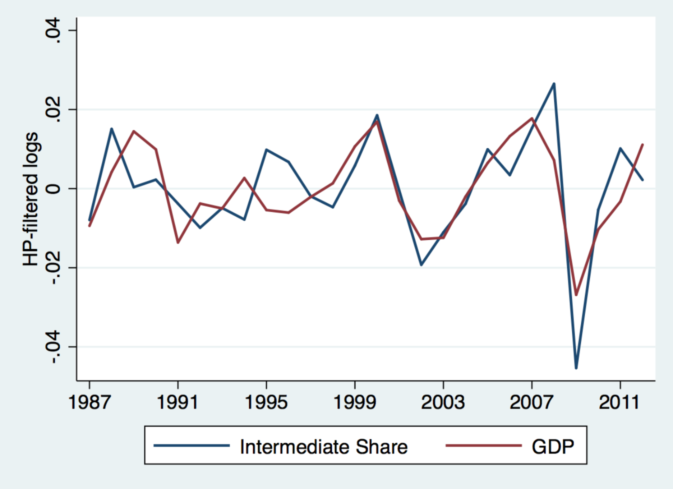
BLS Multifactor Productivity Database

- Annual data, 1987-2012
- 60 industries (18 manufacturing)
- Output and KLEMS inputs, nominal and real

Baseline: $\varepsilon = 1$

- Robustness: $\varepsilon < 1$

Cyclicality of Intermediate Share



Cyclicality of Intermediates-based μ^p

$$ln\left(\mu_{it}^{p}\right) = \alpha_i + \beta^p \cdot ln(cyc_t) + \epsilon_{it}$$

	Elasticity wrt GDP
All Industries	-0.94 (0.24)
Manufacturing	-0.95 (0.32)
Non-Manufacturing	-0.94 (0.24)

- Baseline estimates with $\varepsilon = 1$.

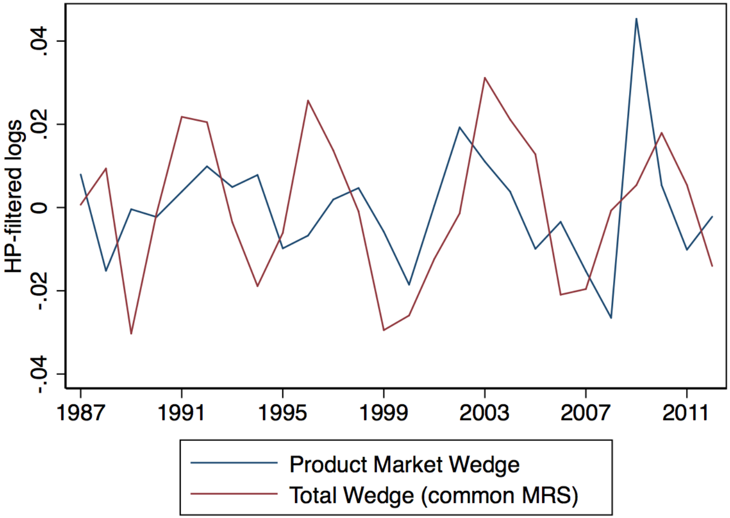
Cyclicality of *Industry-level* Labor Wedge (μ_i)

$$ln(\mu_i) = ln\left(\frac{p_i v_i}{p n_i}\right) + ln\left(\frac{y_i}{v_i}\right) - \left[\frac{1}{\sigma} ln(c) + \frac{1}{\eta} ln(h_i)\right]$$

	Elasticity wrt GDP
All Industries	-0.89 (0.26)
Manufacturing	-0.72 (0.39)
Non-Manufacturing	-0.93 (0.24)

- Baseline estimates with $\varepsilon = 1$.

Intermediates-based μ^p vs. Total Labor Wedge μ



Role of μ^p in μ, with $\varepsilon < 1$

- $\varepsilon < 1 \Rightarrow \mu_i^p$ *more* countercyclical

$$ln\left(\mu_{it}^p\right) = ln\left(\frac{p_{it}\ y_{it}}{p_{m,it}m_{it}}\right) + \left(\frac{1}{\varepsilon} - 1\right) ln\left(\frac{y_{it}}{m_{it}}\right)$$

- $\varepsilon < 1 \Rightarrow \mu_i$ *less* countercyclical

$$ln\left(\mu_{it}\right) = ln\left(\frac{p_{it}}{p_t}\frac{y_{it}}{n_{it}}\right) + \left(\frac{1}{\varepsilon} - 1\right) ln\left(\frac{y_{it}}{v_{it}}\right) - ln\left(mrs_{it}^h\right)$$

- $\therefore \varepsilon < 1 \Rightarrow \mu^p$ accounts for > 100% of cyclicality of μ.

Conclusion

Our point estimates: μ^p accounts for the cyclical variation in μ

- Self-Employed μ is just as cyclical as all-worker μ
- Intermediate Inputs μ^p is just as cyclical as μ

Countercyclical price markups deserve a central place in business cycle research, alongside labor market frictions.

- Sticky prices
- Customer base and/or learning-by-doing + financial shocks
- Countercyclical risk or risk-aversion

Representative-Agent Labor Wedge

Preferences:

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left\{ \frac{c_t^{1-1/\sigma}}{1-1/\sigma} - \nu \frac{n_t^{1+1/\eta}}{1+1/\eta} \right\}$$

Production:

$$y_t = z_t k_t^{\alpha} n_t^{1-\alpha}$$

Labor Wedge:

$$\begin{aligned} ln(\mu_t) &\equiv ln(mpn_t) - ln(mrs_t) \\ &= ln\left(\frac{y_t}{n_t}\right) - \left[\frac{1}{\sigma} ln(c_t) + \frac{1}{\eta} ln(n_t)\right] \end{aligned}$$

Extensive and Intensive Margin Labor Wedges

- Consider extensive and intensive margins of labor supply
- Why?
  - Can base Frisch elasticity on micro estimates using hours margin
  - Self-employed wedge will be on intensive margin only
  - Product market distortions should impact wedge on both margins
    - If wedge is only important on one margin, product market distortions must have little cyclical importance.

Theory with Both Extensive and Intensive Margins

Preferences:

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left\{ \frac{c_t^{1-1/\sigma}}{1-1/\sigma} - \nu \left(\frac{h_t^{1+1/\eta}}{1+1/\eta} + \psi \right) e_t \right\}$$

Production:

$$y_t = z_t k_t^{\alpha} (e_t h_t)^{1-\alpha}$$

Search Frictions:

- Matching Technology: $m_t = v_t^{\phi} f(u_t)$
- Vacancy-posting cost: κ
- Separation rate: δ

Extensive Margin Wedge

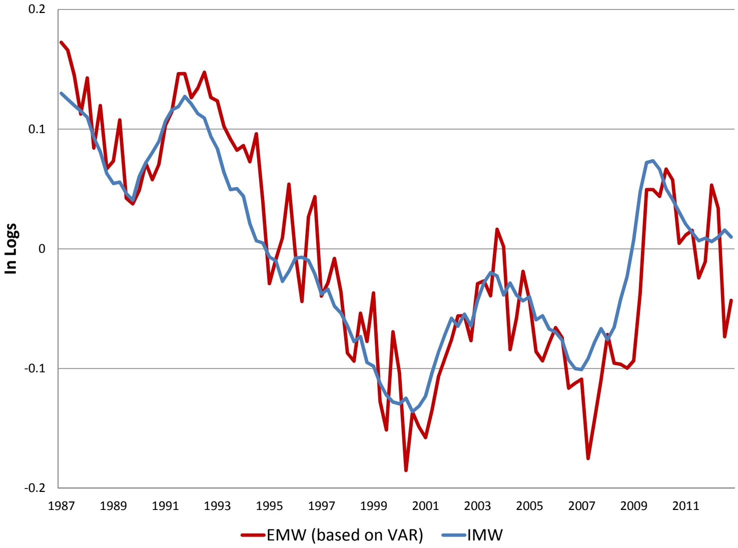
Consider spending today to generate one more matched worker, then reduce spending next period to cut matches by $1 - \delta$ workers:

$$EMW \approx ln(y/n) - 1/\sigma \cdot ln(c) - \textit{dynamic cost of vacancy matching}$$

So:

$$EMW - IMW = \frac{1}{\eta} ln(h) - \textit{dynamic cost of vacancy matching}$$

EMW vs. IMW


0.2
0.1
0
-0.1
-0.2
In Logs
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
EMW (based on VAR)
IMW

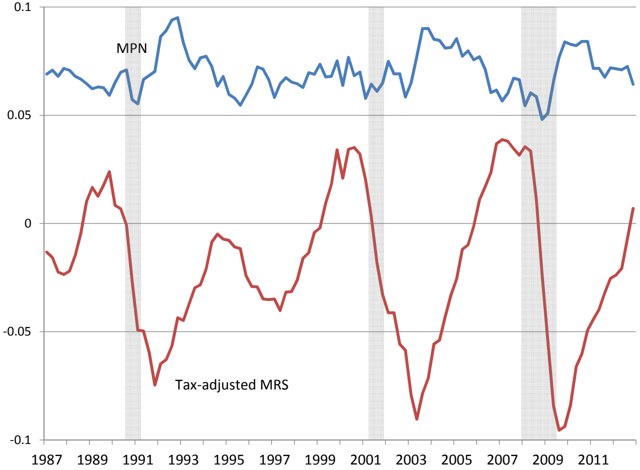
Alternative Wage Measures

Semi-elasticities wrt the Unemployment Rate (s.e.'s):

Average Hourly Earnings	-1.8 (0.7)
New-hire Wage	-3.0 (0.8)
User Cost of Labor	-5.2 (0.8)

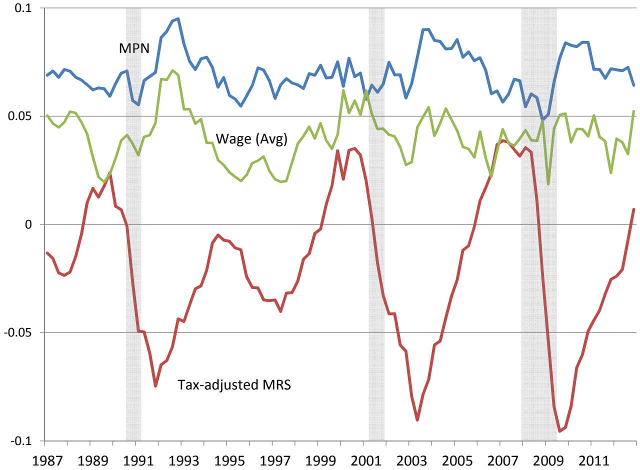
Source: Kudlyak (2015) using the NLSY

Wedge

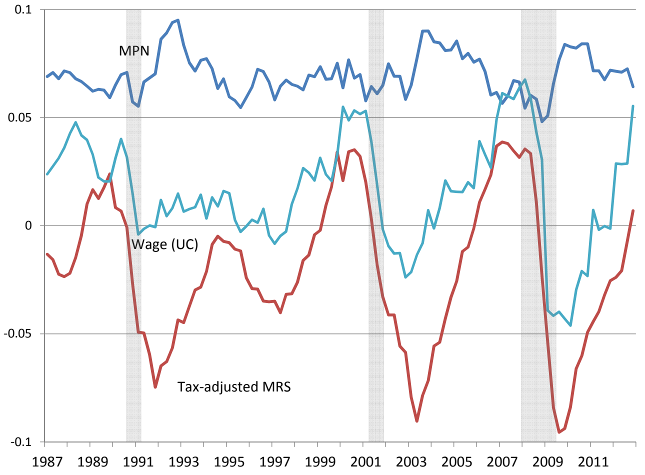


0.1
0.05
0
-0.05
-0.1
MPN
Tax-adjusted MRS
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011

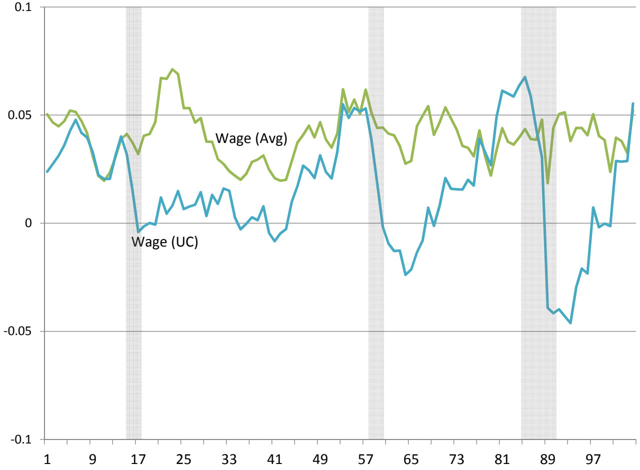
Wedge Decomposition: Avg Wage



Wedge Decomposition: User Cost of Labor



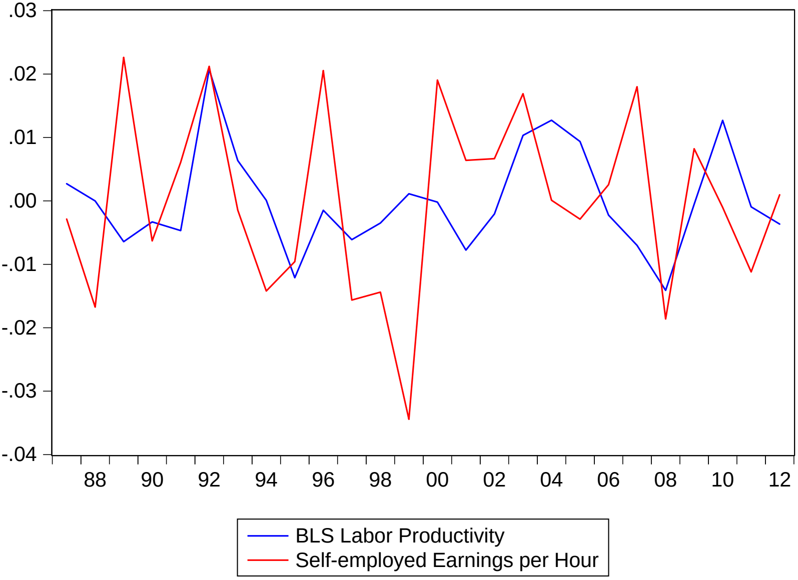
Alternative Wage Measures



Weekly Hours: Wage-Earn vs. Self-Emp (Matched)

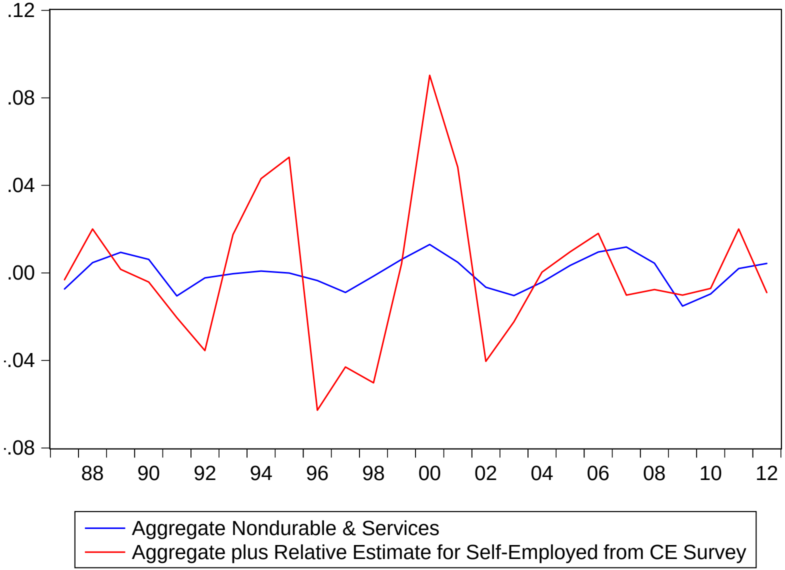
Cyclicality (wrt GDP): 0.17 (0.03), 0.28 (0.07)

Productivity: All Workers vs. Self-Emp



Cyclicality (wrt GDP): -0.21 (0.07), -0.13 (0.19)

Consumption: All Workers vs. Self-Emp



Cyclicality (wrt GDP): 0.64 (0.04), 1.27 (0.56)

Cyclicality of Labor Wedge: Robustness

Industry Composition of the Self-Employed

Construction	17.2	Personal Services	6.3
Retail Trade	15.9	Repair	5.0
Business	12.7	Manufacturing	6.0
Medical & Legal	8.6	Other	4.7
FIRE	8.5	Wholesale Trade	4.3
Other Professional	7.8	Recreation	3.0

Entries are percent of all self-employed.

Other = Transportation, Communications, Utilities and Mining.

Outline

Measuring the Labor Wedge

- Examine both Extensive and Intensive Margins
- Decompose using Wage Data

Our 2 Alternative Decompositions

1. Self-Employed
2. Intermediate Inputs

Discuss Other *Non-Wage* Decompositions

Other ways to get price markups without wage data

- Capital expenditures (Galeotti and Schiantarelli, 1998)
- Advertising (Hall, 2014)
- Inventories
  - Finished goods inventories
    - Bils and Kahn, 2000
    - Kryvtsov and Midrigan, 2012
  - Work-in-process inventories (appendix)

Summary of other ways to get price markups

- Capital expenditures $\Rightarrow$ countercyclical markups
- Advertising $\Rightarrow$ acyclical markups (maybe)
- Inventories $\Rightarrow$ countercyclical markups

All involve dynamics, requiring one to measure any adjustment costs and the stochastic discount factor.

Self-Employed and Intermediates require only static measurements.

Advertising Approach – Hall (2014)

Implication of simple theory:

- $\max_{p,A} \{(p - c)\, Zp^{-\epsilon}A^{\alpha} - \kappa A\} \quad \Rightarrow \quad \frac{\kappa A}{pQ} \propto \left[1 - \frac{1}{p/c}\right]$
- Thus, acyclical $\frac{\kappa A}{pQ} \Leftrightarrow$ acyclical $\frac{p}{c}$.

But this implication is not robust to reasonable alterations:

1. Advertising could affect the reservation price
   $\max_{p,A} \left\{(p - c)\, Z \left(\frac{p}{A^{\alpha}}\right)^{-\epsilon} - \kappa A\right\} \quad \Rightarrow$
   $\frac{\kappa A}{pQ}$ independent of *desired* markup movements.
2. Advertising could affect *future* demand – Bagwell (2007)

Campello, Graham and Harvey (2010)

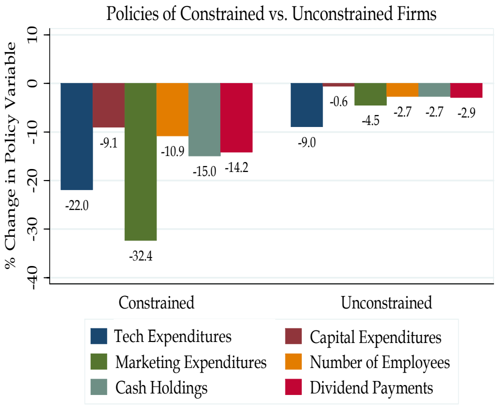


Figure 2: This figure displays U.S. firms' planned changes (% per year) in technology expenditures, capital expenditures, marketing expenditures, total number of domestic employees, cash holdings, and dividend payments as of the fourth quarter of 2008 (crisis peak period). Responses are averaged within sample partitions based on the survey measure of financial constraint. See text for additional details.

Constructing Extensive-Margin Wedge

Optimal vacancy creation:

$$\frac{\phi m_t}{v_t}\left[u'(c_t)\frac{y_t}{n_t}h_t - \Omega_t h_t\right] - u'(c_t)\kappa\frac{y_t}{n_t}h$$
$$+\beta(1-\delta)\mathbb{E}_t\left\{u'(c_{t+1})\kappa\frac{y_{t+1}}{n_{t+1}}h\frac{m_t/v_t}{m_{t+1}/v_{t+1}}\right\} = 0.$$

Can re-arrange to get

$$EMW_t = ln\left(\frac{y_t}{n_t}\right) - \left[\frac{1}{\sigma}ln(c_t) + ln\left(\Omega_t\right)\right] - S_t,$$

where

- $\Omega_t = \left(\frac{h_t^{1+1/\eta}}{1+1/\eta} + \psi\right)/h_t$
- $S_t = f(m_t, v_t, h_t, \mathbb{E}_t g(r_{t+1}, y_{t+1}/n_{t+1}, v_{t+1}, m_{t+1}))$

Cyclicality of EMW and IMW

	Elasticity wrt GDP
IMW	-1.91
	(0.13)
EMW	-1.89
	(0.28)

- Quarterly data, 1987-2012
- $\sigma = 0.5$, $\eta = 0.5$
- $\delta = 0.105$, $\phi = 0.5$, $\gamma = 0.16$
- $r_{ss} = 0.004$, $\left(\frac{\kappa v}{m}\right)_{ss} = 0.4$
- Expectational terms in EMW constructed using VAR approach

Cyclicality of EMW and IMW

	Elasticity wrt	
	GDP	Total Hours
EMW	-1.89	-1.54
	(0.28)	(0.15)
IMW	-1.91	-1.38
	(0.13)	(0.05)

- Quarterly data, 1987-2012
- $\sigma = 0.5$, $\eta = 0.5$
- $\delta = 0.105$, $r = 0.004$, $\phi = 0.5$, $\frac{\kappa v}{m} = 0.4$, $\gamma = 0.16$
- Expectational terms in EMW constructed using VAR approach

EMW and IMW Decomposition

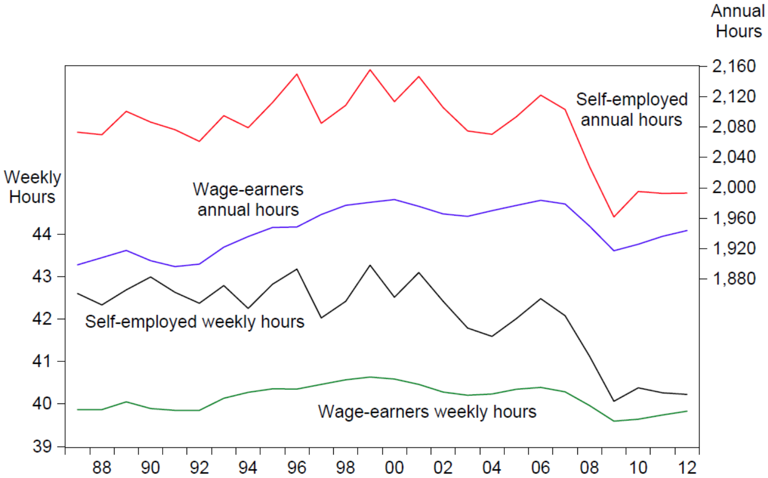
$$EMW = \left[ln\left(\frac{y/n}{w/p}\right) - \tilde{S}\right] + \left[ln\left(\frac{w}{p}\right) + \tilde{S} - S - \frac{1}{\sigma}ln(c) - ln(\Omega)\right],$$

where $\tilde{S} = S$, but with $\phi = 1$.

$$IMW = \left[ln\left(\frac{y/n}{w/p}\right)\right] + \left[ln\left(\frac{w}{p}\right) - \frac{1}{\sigma}ln(c) - \frac{1}{\eta}ln(h)\right]$$

Elasticity wrt GDP	EMW	IMW
μ	-1.89 (0.28)	-1.91 (0.13)
$\mu^p\left(\frac{w}{p} = AHE\right)$	-0.32 (0.13)	-0.04 (0.13)
$\mu^p\left(\frac{w}{p} = NH\right)$	-0.98 (0.16)	-0.70 (0.16)
$\mu^p\left(\frac{w}{p} = UC\right)$	-2.17 (0.21)	-1.89 (0.21)

Hours: Self-Emp vs. Wage-Earn (Repeated CPS)



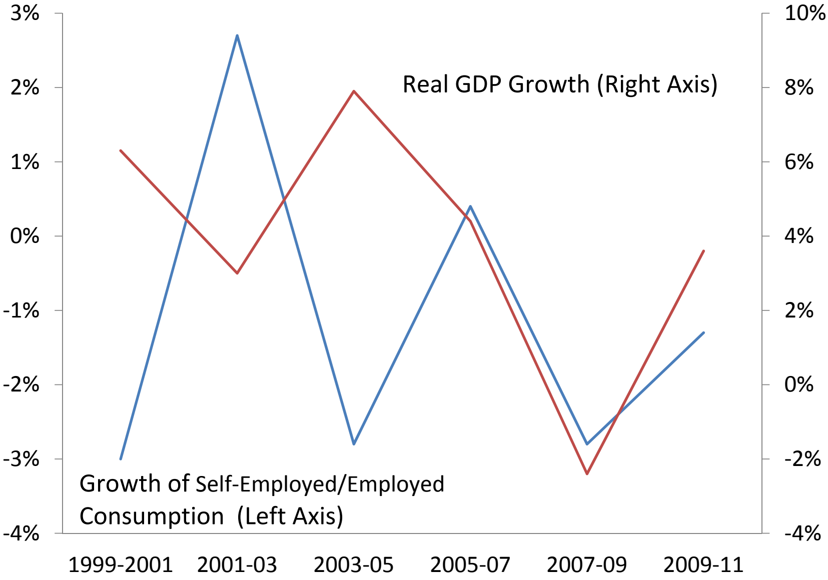
Weekly Hours cyclicality (wrt GDP): 0.37 (0.14), 0.20 (0.02)

Annual Hours cyclicality (wrt GDP): 0.57 (0.18), 0.39 (0.04)

Annual Hours: Self-Emp vs. Wage Earn (Matched)

Cyclicality (wrt GDP): 0.54 (0.13), 0.57 (0.07)

Self-Employed Consumption in the PSID



Industry-level Labor Wedge (μ_i)

Preferences:

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left\{ \frac{c_t^{1-1/\sigma}}{1-1/\sigma} - \nu \sum_i \left[\left(\frac{h_{it}^{1+1/\eta}}{1+1/\eta} + \psi \right) e_{it} \right] \right\}$$

Marginal Product wrt Labor (for $\varepsilon = \omega = 1$):

$$mpn_{it} = \frac{y_{it}}{n_{it}}$$

Labor Wedge (intensive-margin):

$$ln(\mu_{it}) = ln\left(\frac{p_{it}\, mpn_{it}}{p_t\, mrs_{it}}\right) = ln\left(\frac{p_{it}}{p_t}\frac{y_{it}}{n_{it}}\right) - \left[\frac{1}{\sigma} ln(c_t) + \frac{1}{\eta} ln(h_{it})\right]$$

Intuition for Intermediates Results

- If w and p_m reflect true shadow prices, then (for $\varepsilon = 1$)

$$\frac{w\,n}{p_m m} = const.$$

- But empirically, intermediate expenditures more procyclical than labor expenditures $\Rightarrow$ intermediates-based μ^p is more countercyclical.

$$ln(\mu^p) = ln\left(\frac{p\,y}{p_m m}\right) = ln\left(\frac{p\,y}{w\,n}\right) + ln\left(\frac{w\,n}{p_m m}\right)$$

- Possible reconciliation: w doesn't reflect true shadow price.

Finished Goods Inventories

(Simplified) Bils-Kahn and Kryvtsov-Midrigan first order condition:

$$\frac{mc}{p}u_c = \mathbb{E}\left[\phi\frac{s}{a}u_c + \beta\left(1 - \phi\frac{s}{a}\right)\frac{mc'}{p'}u_{c'}\right]$$

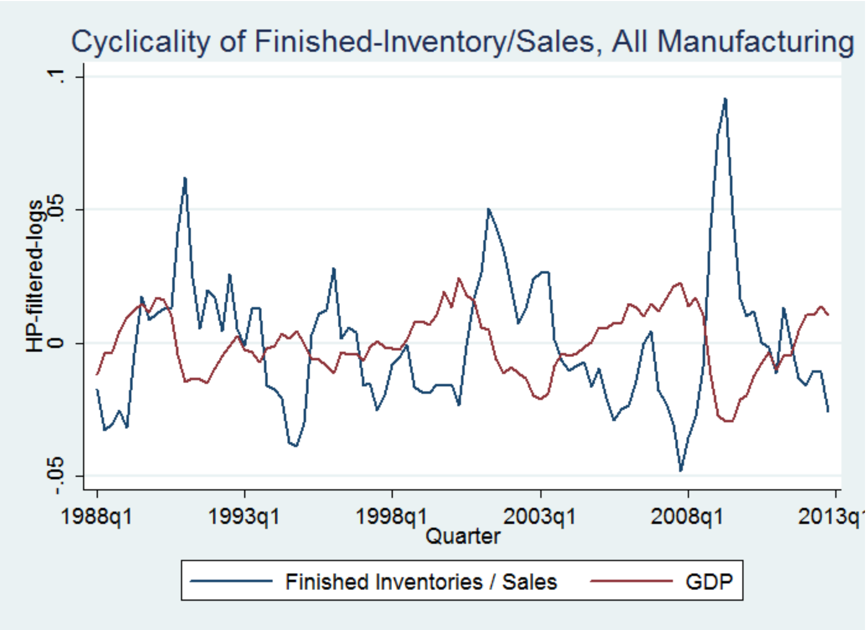
a = finished inventories, s = sales

Gives:

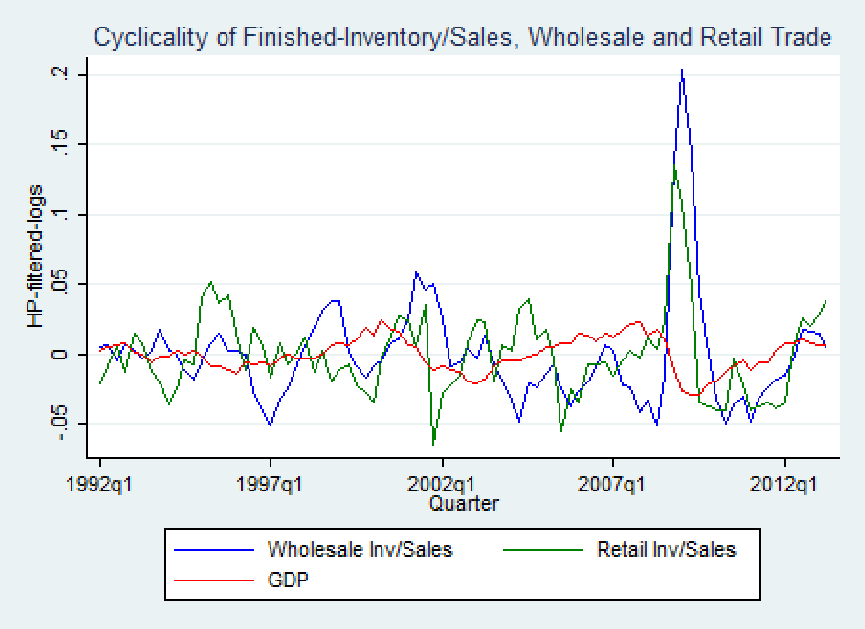
$$\mathbb{E}\left[\left(\phi\frac{s}{a}\Gamma + 1\right)\left(\frac{p/mc}{p'/mc'}\right)\frac{u_{c'}}{u_c}\right] = \frac{1}{\beta}$$

where

$$\Gamma = \frac{p - mc'/\left(\frac{p'}{p}\frac{u_c}{\beta u_{c'}}\right)}{mc'/\left(\frac{p'}{p}\frac{u_c}{\beta u_{c'}}\right)}$$



Cyclicality of Finished-Inventory/Sales, All Manufacturing
HP-filtered-logs
.1
.05
0
-.05
1988q1
1993q1
1998q1
2003q1
2008q1
2013q1
Quarter
Finished Inventories / Sales
GDP



Cyclicality of Finished-Inventory/Sales, Wholesale and Retail Trade
HP-filtered-logs
.2
.15
.1
.05
0
-.05
1992q1
1997q1
2002q1
2007q1
2012q1
Quarter
Wholesale Inv/Sales
Retail Inv/Sales
GDP

Issues with Finished Inventories

1. Could be scale effects for holding or ordering finished inventories.
2. Impact of inventories on sales could vary over cycle – i.e., expect lower elasticity in recessions if demand less elastic.

Work-in-Process Inventories

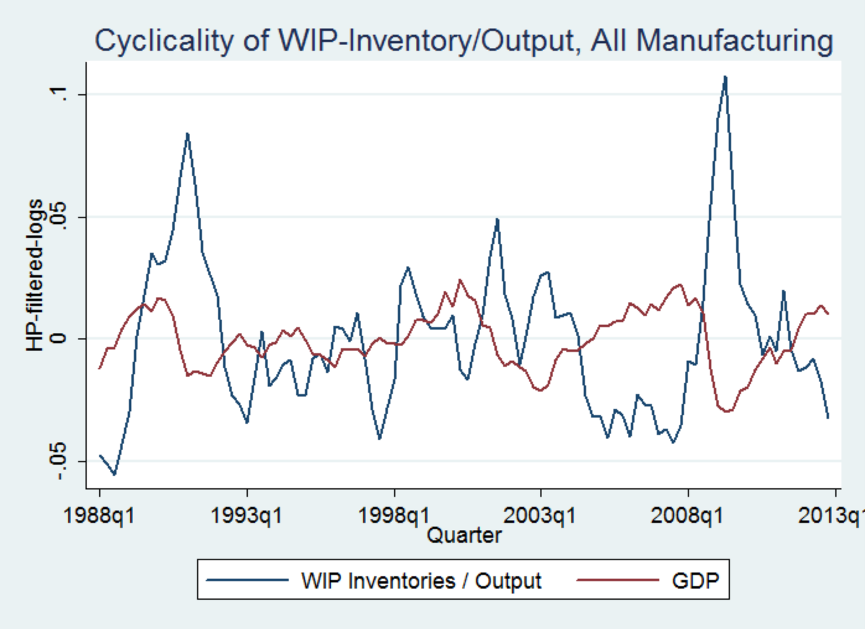
Follow Christiano (1988) in making work-in-process inventories a factor of production.

Gives:

$$\mathbb{E}\left[\left(\psi\frac{y'}{q'}+1\right)\left(\frac{p/mc}{p'/mc'}\right)\frac{u_{c'}}{u_c}\right]=\frac{1}{\beta}$$

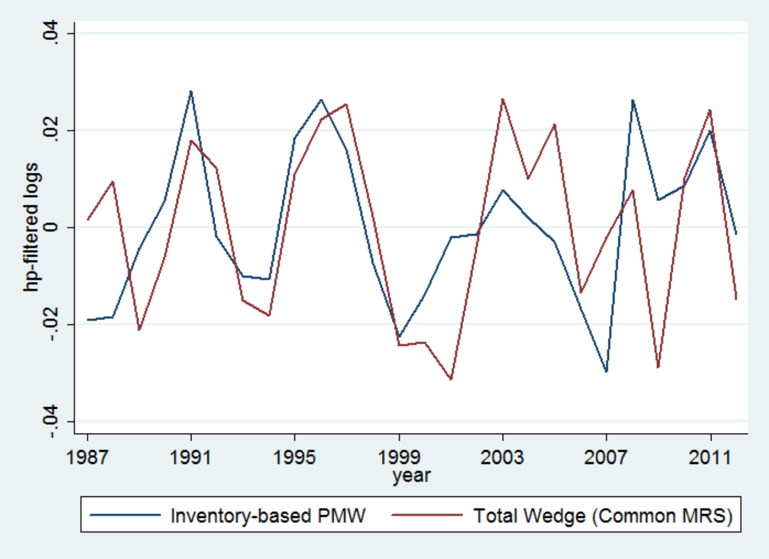
$q =$ work-in-process inventories

$y =$ production



Cyclicality of WIP-Inventory/Output, All Manufacturing
HP-filtered-logs
.1
.05
0
-.05
1988q1
1993q1
1998q1
2003q1
2008q1
2013q1
Quarter
WIP Inventories / Output
GDP

Inventory-based μ^p vs. Total Labor Wedge μ



Note: For Manufacturing Industries

Work-in-Process Inventories

Production Technology:

$$\begin{aligned} y_{it} &= g(z_{it}, k_{it}, n_{it})q_{it}^{\varphi_{it}} \\ q_{i,t+1} &= (1-\delta_q)q_{it} + y_{it} - s_{it} \end{aligned}$$

Marginal Product wrt Inventories:

$$mpq_{it} = \varphi_{it}\frac{y_{it}}{q_{it}}$$

Euler equation for shifting from WIP to sales (and back next period):

$$\frac{mr_{it}}{p_t} = \mathbb{E}_t\left[\frac{\beta u'(c_{t+1})}{u'(c_t)}\left(1-\delta_q+\varphi_{i,t+1}\frac{y_{i,t+1}}{q_{i,t+1}}\right)\frac{mr_{i,t+1}}{p_{t+1}}\right]$$

Constructing Inventory-based μ^p

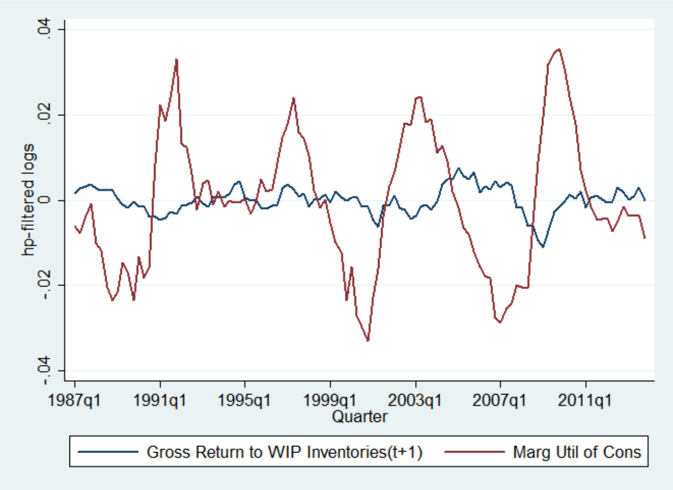
Iterate forward and take logs to get

$$ln\left(\mu_{it}^{p}\right) = -\frac{1}{\sigma} ln(c_t) + ln\left(\frac{p_{it}}{p_t}\right) - \mathbb{E}_t \sum_{s=1}^{\infty} \frac{\varphi_{i,t+s}}{1-\delta_q} \frac{y_{i,t+s}}{q_{i,t+s}}$$

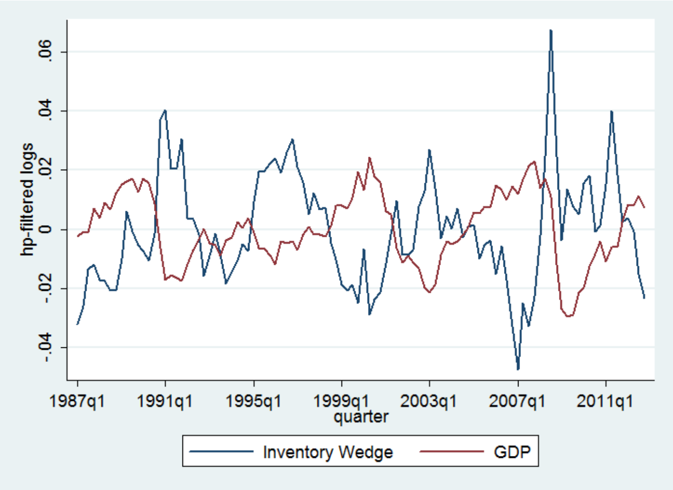
NIPA Underlying Detail Tables

- Quarterly data, 1987-2012
- 22 Manufacturing industries (aggregated to 14)
- q_{it}: Work-in-process inventories
- y_{it}: Sales plus change in (total) inventories
- p_{it}: Sales price deflator

Return to Inventories vs. MUC



Cyclicality of Inventory-based μ^p



Cyclicality of Inventory-based μ^p

$$ln\left(\mu_{it}^{p}\right) = -\frac{1}{\sigma}ln(c_t) + ln\left(\frac{p_{it}}{p_t}\right) - \mathbb{E}_t \sum_{s=1}^{\infty} \frac{\varphi_{i,t+s}}{1-\delta_q} \frac{y_{i,t+s}}{q_{i,t+s}}$$

	Elasticity wrt GDP
μ^p	-0.80 (0.12)
MUC	-1.23 (0.06)
Relative Price	0.67 (0.11)
Output/Inventory Path	0.25 (0.03)

Role of μ^p in μ, based on Inventories

$$\frac{\partial ln\left(\mu_{it}^p\right)}{\partial ln\left(cyc_t\right)} \Big/ \frac{\partial ln\left(\mu_{it}\right)}{\partial ln\left(cyc_t\right)}$$

	μ^p vs. μ
Manufacturing	109%