

Impact of Just-in-Time Inventory Management on Business Cycle Severity

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Overview

- 1 Motivation
- 2 Research Question
- 3 Literature Review and Hypotheses
- 4 Data
- 5 Methodology
- 6 Results
- 7 Conclusion

- Studying business cycles (fluctuations of GDP around trend) is important
- Inventory a part of GDP (inputs to production, goods ready for sale)
- Inventory accounts for half of GDP decline in an average recession [Romer 2006].

The importance of inventory fluctuations

"To a surprisingly large extent, business cycles *are* inventory fluctuations."
[Gordon 2007]

Research Question

Just-in-time and the business cycle

"The hope is often expressed that new methods of management will enable firms to keep tighter control over their inventories and thus the prospects for steadier growth can be improved" [Dorbnusch and Fischer 1990]

Likely the first study to test this empirically

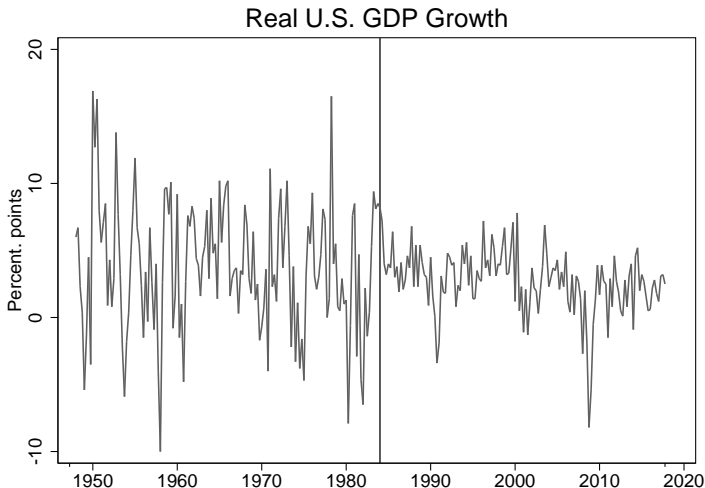
Research question

Does just-in-time (JIT) inventory management moderate the volatility of inventory and inventory reductions in recessions?

What is JIT?

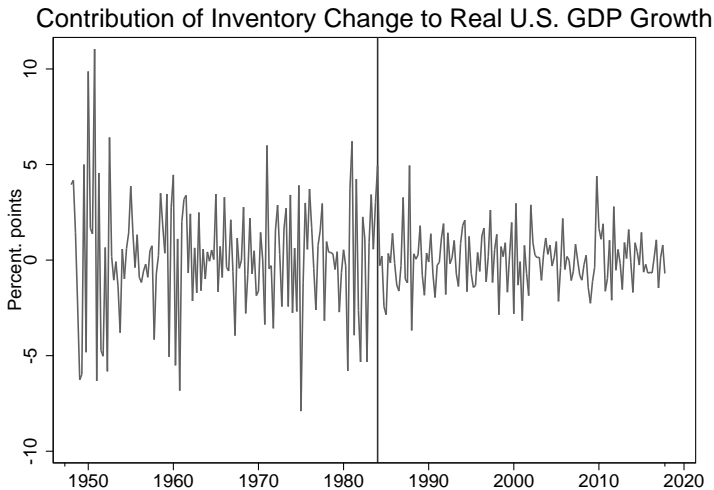
- Approach to managing production, inventory and supply chain [Morgan 1991]
- Extensive information sharing with suppliers and customers [Kannan and Tan 2005]
- Buying just-in-time to produce, producing just-in-time to sell [Morgan 1991]
- Reduces inventory relative to sales [Kahn et al. 2001]

The Great Moderation



Literature Review – Hypothesis 1

Reduction in volatility of inventory is a likely source of the Great Moderation [McConnell and Perez-Quiros 2000] [Irvine and Schuh 2005]



Why should JIT decrease inventory volatility?

- ① Smoother flow of inputs and outputs – smoother inventory changes [Kannan and Tan 2005]
- ② Indicative evidence: industries with lower inventory have less volatile inventory [Irvine and Schuh 2005]

Hypothesis 1

JIT decreases the volatility of inventory.

Why inventory falls in recessions?

- ① Lower sales – lower inputs and finished goods needed [Ramey 1989]
- ② Inventory acts as a liquidity buffer [Carpenter et al. 1994]

Why should JIT limit the reduction of inventory in recessions?

- ① Smaller I/S ratio – smaller response to sales fall [Morgan 1991]
- ② Limited liquidity buffer – lower sensitivity to internal cash flow [Carpenter et al. 1994]

Hypothesis 2

JIT limits the reduction of inventory occurring in recessions.

- Panel of 232 mostly U.S. publicly traded firms
- Compustat
- Explicit JIT measure [Kinney and Wempe 2002] [Gao 2017]
- Matched sample – 116 adopters, 116 control firms
- Quarterly, 1975-2014
- 29,000 observations

Measure of volatility of inventory change

- Sample variance of scaled absolute inventory change (before and after adoption)
- Winsorized

Two methods

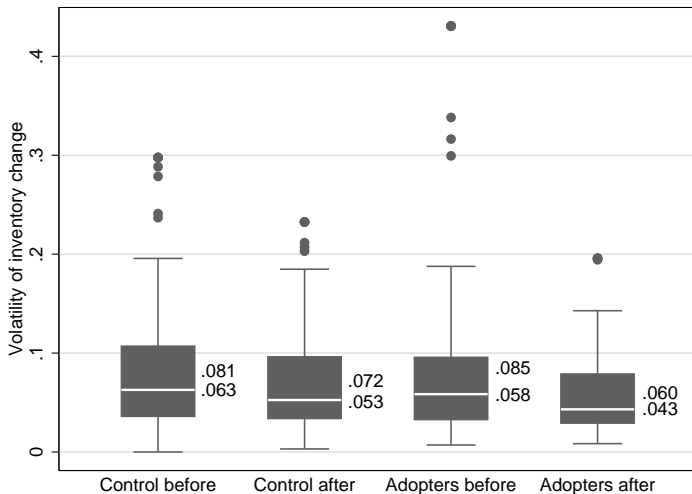
- 1 D-i-D regression of volatility of inventory change
 - $Volat_{j,t} = \beta_0 + \beta_1 Adopter_{j,t} + \beta_2 AfterA_{j,t} + \beta_3 Adopter_{j,t} * AfterA_{j,t} + \epsilon_{j,t}$
- 2 Wilcoxon sign-rank test, sign test

Two methods

- ① Optically study movements of median adopter's and median control's inventory during 5 recessions from 1975 to 2013
- ② Regression of inventory change
 - $\Delta N_{j,q} = \beta_0 + \beta_1 N_{j,q-1} + \beta_2 S_{j,q} + \beta_3 S_{j,q-1} + \beta_4 S_{j,q-2} + (1 + \pi \text{Adopter}_{1,q} + \rho \text{AfterA}_{j,q} + \tau \text{Adopter}_{j,q} * \text{AfterA}_{j,q}) * (\phi_0 \text{BsnsCcle}_{j,q} + \phi_1 \text{BsnsCcle}_{j,q-1} + \phi_2 \text{BsnsCcle}_{j,q-2}) + \theta_j + \theta_{i,t} + \epsilon_{j,q}$
 - Measure of business cycle – firm-level proxy using internal cash flow
 - Estimated in recessions

Results – Hypothesis 1 (volatility)

A. Optical comparison



Results – Hypothesis 1 (volatility)

B. Difference in difference regression of volatility of inventory change

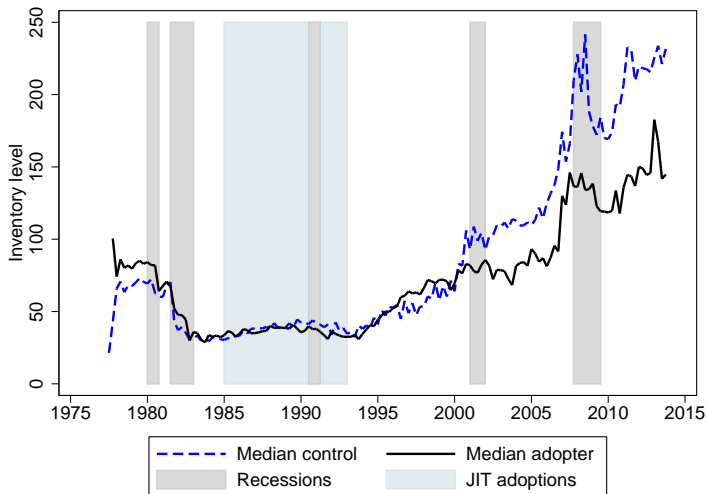
Independent variable	Coefficient	Standard error
Intercept	0.081***	0.01
Adopter	0.004	0.01
AfterA	−0.009	0.01
Adopter*AfterA	−0.016*	0.01
Observations	462	
R-squared	0.022	

C. Wilcoxon sign-rank test and sign test

- (comparison of whole distributions and paired differences)
- Between-groups results:
 - Before: Same volatility of adopters and controls
 - After: Adopters have lower volatility
- Within-group results:
 - Controls: Unchanged volatility
 - Adopters: Decreased volatility

Results – Hypothesis 2 (sensitivity to recessions)

A. Indicative results: recessions from 1975 to 2014

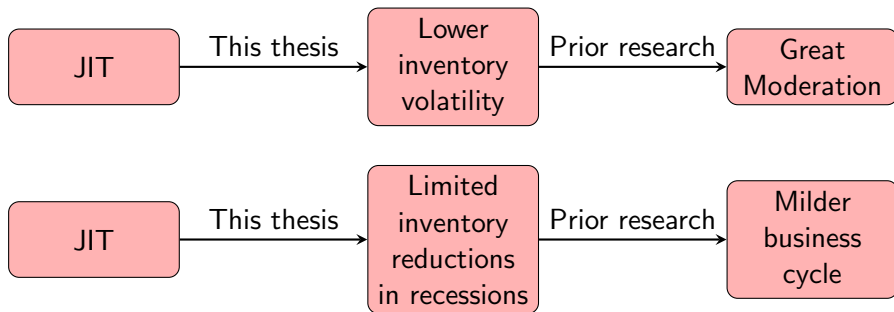


Results – Hypothesis 2 (sensitivity to recessions)

B. Regression of inventory change

Independent variable	Coefficient	Standard error
Intercept	0.008*	0.00
N (q-1)	-0.107***	0.01
S (q0)	-0.110***	0.02
S (q-1)	0.108***	0.02
S (q-2)	0.048***	0.02
BsnsCcle (sum)	0.115***	0.09
AfterA	-0.007**	0.00
Adopter*AfterA	0.001**	0.00
Adopter*BsnsCcle (sum)	0.255	0.14
AfterA*BsnsCcle (sum)	0.149*	0.11
Adopter*AfterA*BsnsCcle (sum)	-0.375*	0.16
Observations	3,167	
R-squared	0.266	

Conclusion



Understanding of the business cycle

A better understanding of inventory behavior is essential to achieving a better understanding (...) of the macroeconomics of business cycles.

[Blinder and Maccini 1991]

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Disadvantages of JIT

- Initial transition cost (production, IT, contracts)
- Maintaining intensive relationships with suppliers and customers [Kannan and Tan 2005]
- Need to limit issues in production chain (quality requirements) [Kannan and Tan 2005]
- Limited choice of suppliers (often JIT, quality requirements) [Kannan and Tan 2005]
- Need of more cash for higher flexibility [Gao 2017]
- Lower liquidity buffer in recessions (is it compensated by higher cash?) [Carpenter et al. 1994]

How is the matching performed?

- Inventory valuation method
- Firm size
- Industry

Firms' country of headquarters

- 114 out of 116 adopters are U.S. (+ 2 from Canada, Ireland)
- 107 out of 116 controls are U.S. (+ 9 from Canada, China, France, Ireland, Japan)

Winsorization

- Limiting effect of outliers
- At $p\%$ bottom = setting values below (p) th percentile to the (p) th percentile
- At $p\%$ top = setting values above $(1-p)$ th percentile to the $(1-p)$ th percentile
- Advantage to trimming: does not completely leave out the information contained in extreme values

Measure of volatility of inventory change

- Sample variance of scaled absolute inventory change (before and after adoption)
- Scaling by sales
- Winsorized at 3% top (right skew)

Two methods

- 1 D-i-D regression of volatility of inventory change
 - $Volat_{j,t} = \beta_0 + \beta_1 Adopter_{j,t} + \beta_2 AfterA_{j,t} + \beta_3 Adopter_{j,t} * AfterA_{j,t} + \epsilon_{j,t}$
 - Random effects
 - White SE
- 2 Wilcoxon sign-rank test, sign test

Detail – Methodology – Hypothesis 2 (sensitivity to recessions)

Two methods

- ① Optically study movements of median adopter's and median control's inventory during 5 recessions from 1975 to 2013
- ② Regression of inventory change
 - $\Delta N_{j,q} = \beta_0 + \beta_1 N_{j,q-1} + \beta_2 S_{j,q} + \beta_3 S_{j,q-1} + \beta_4 S_{j,q-2} + (1 + \pi \text{Adopter}_{1,q} + \rho \text{After}A_{j,q} + \tau \text{Adopter}_{j,q} * \text{After}A_{j,q}) * (\phi_0 \text{BsnsCcle}_{j,q} + \phi_1 \text{BsnsCcle}_{j,q-1} + \phi_2 \text{BsnsCcle}_{j,q-2}) + \theta_j + \theta_{i,t} + \epsilon_{j,q}$
 - Measure of business cycle – firm-level proxy using internal cash flow
 - Estimated in recessions
 - Seasonality: quarter-SIC dummies (1–4 for quarters, 2-digit SIC for industry)
 - Firm-specific heterogeneity: fixed effects
 - Heteroskedasticity and autocorrelation: scaling by total assets, White SE
 - Outliers: winsorization at 1% top and 1% bottom

C. Differences in inventory change volatility between the before and after periods

	Control firms	Adopters
p-value of Wilcoxon sign-rank test	.392	.000
Sign test		
Median change in volatility ¹	−.003	−.013
p-value	.151	.001

¹After minus before

C. Differences in inventory change volatility between adopters and control firms

	Before	After
p-value of Wilcoxon sign-rank test	.668	.035
Sign test		
Median change in volatility ²	— .002	— .006
p-value	.319	.082

²Adopters minus controls