Time-Varying Business Volatility, Price Setting, and the Real Effects of Monetary Policy

Rüdiger Bachmann
University of Notre Dame, CEPR, CESifo, IFO

Benjamin Born
University of Mannheim, CEPR, CESifo, IFO

Steffen Elstner
Staff of Council of Economic Experts

Christian Grimme
IFO Institute and University of Munich

Konferenz: Messung der Preise
June 16, 2015

Motivation – Research Question

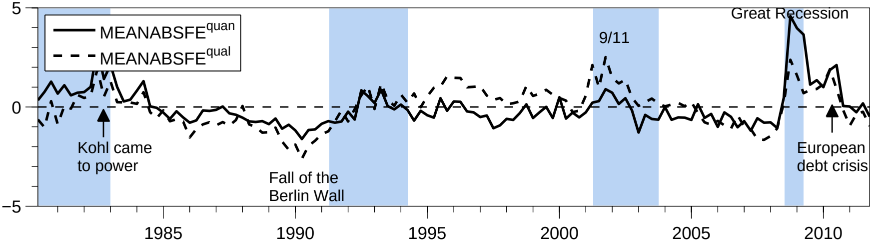
What is the (empirical) relationship between:

business volatility

$\Rightarrow$ frequency of price setting

$\Rightarrow$ effectiveness of monetary policy

Motivation



Great Recession in Germany:

- Average firm-level volatility tripled compared to pre-recession mean
- Average frequency of producer price changes increased from pre-recession mean of 31.6% to 38.6%

→ Link between firm-level volatility and price setting?

Why do we care?

- In a large class of monetary models:

  frequency of price adjustment / degree of nominal rigidity affects monetary non-neutrality

- If heightened business volatility leads to higher price flexibility in recessions

$\rightarrow$ Monetary policy might be less effective when needed most

Some rudimentary “theory”

- To the extent that heightened business volatility also leads to heightened business uncertainty

  → firms may want to “wait and see”

  → refrain from adjusting their prices

  → prices become endogenously more sticky

- Heightened business volatility

  → firms are hit by larger shocks

  → in certain imperfect information and learning environments a more volatile business situation might lead to more frequent information updating

  → price adjustment of firms more likely

- Sign of overall effect is an empirical question!

Outlook

1. Measuring firm-specific volatility
2. Empirical analysis
3. Model evidence
4. Conclusion
5. Robustness

Idiosyncratic volatility measures

- IFO Business Climate Survey (IFO-BCS): monthly firm survey for Germany
- Here: West-German manufacturing sector from 1980-2011 ($\sim$ 2500 firms of all sizes)
- 4 business volatility measures derived from IFO-BCS
  - 2 **"qualitative"** volatility measures
  - 2 **"quantitative"** volatility measures
- Based on Bachmann, Elstner and Sims (2013) and Bachmann and Elstner (2013)

Why the IFO survey?

- Survey of actual decision-makers, not, e.g., outside analysts

  $\rightarrow$ capture also uncertainty at the firm level

  $\rightarrow$ should also capture a "wait-and-see" effect

- Highly confidential: can only be accessed under strict non-disclosure agreements

  $\rightarrow$ less likely to suffer from strategic behavior

- Unique feature of German IFO-BCS:

  1. allows us to construct firm-specific volatility measures
  2. contains information on price setting of the same firms
  3. includes many firm-specific variables that allow us to control for first-moment effects

Construction of qualitative volatility measures

Use questions concerning firm-specific production expectations and realizations

1. Production expectation

   "Our domestic production activities with respect to product XY will: increase, roughly stay the same, decrease."

2. Production realization

   "Our domestic production activities with respect to product XY have: increased, roughly stayed the same, decreased."

Construction of qualitative volatility measures

Let's consider a hypothetical one-month example

Table : Possible Expectation Errors - One Month Case

	Realization in t		
Expectation in $t-1$	*Increase*	*Unchanged*	*Decrease*
Increase	0	-1	-2
Unchanged	+1	0	-1
Decrease	+2	+1	0

- Production expectation is three months (one quarter) ahead; need to take this into account

Construction of qualitative volatility measures

1) Absolute forecast error as proxy for idiosyncratic volatility:

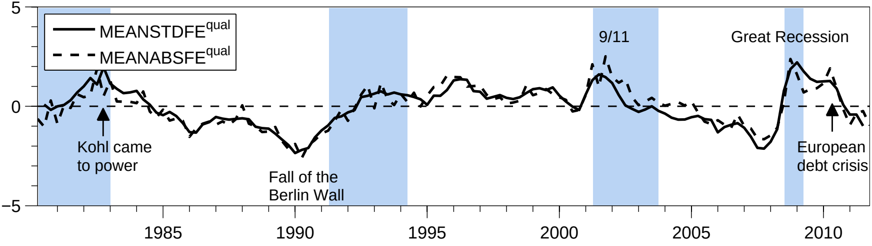
$$ABSFE_{i,t}^{qual} = |FE_{i,t+3}^{qual}|$$

2) 3-quarter rolling window standard deviation (Comin and Mulani, 2006; Davis, Haltiwanger, Jarmin, and Miranda, 2006)

$$STDFE_{i,t}^{qual} = \frac{1}{3}\sqrt{\sum_k \left(FE_{i,t+3+k}^{qual} - \overline{FE}_{i,t+3}^{qual}\right)^2}$$

- *Assumption:* Volatility means uncertainty at time of forecast (somewhat standard in the literature since Bloom, 2009)
- *STDFE* controls better for first moment effects (large shocks), but it leads to fewer observations
- Do robustness checks with respect to timing and window size

Evolution of qualitative volatility measures



- Time-series correlation coefficient: 0.89
- Pooled Spearman correlation coefficient (firm level): 0.52

Construction of the quantitative measures

- $u_{i,t}$: level of capacity utilization (quantitative)
- Production relation

$$y_{i,t}^{act} = u_{i,t} y_{i,t}^{pot}$$
$$\Delta \log y_{i,t}^{act} = \Delta \log u_{i,t} + \Delta \log y_{i,t}^{pot}$$

- Need: capacity utilization change is a production change, i.e. $\Delta \log y_{i,t}^{pot} = 0$

  $\rightarrow$ use only firms with no expected change in *technical capacity* and *employment* in prior period (two survey questions available)

- Now looking at firms with no expected change in *production*

  $\rightarrow$ $\Delta \log u_{i,t}$: production expectation error of firm i in t

- Can capture only volatility with respect to shocks that do not change the firms' potential output

Quantitative measures

- Production Expectation error of firm i in t:

$$FE_{i,t}^{quan} = \Delta \log u_{i,t}$$

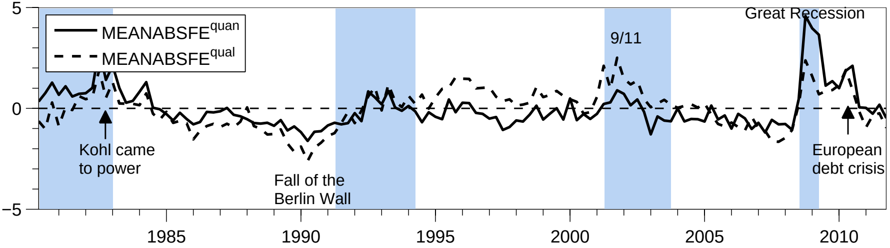
1) Absolute forecast error:

$$ABSFE_{i,t}^{quan} = |FE_{i,t+3}^{quan}|$$

2) 3-quarter rolling window standard deviation:

$$STDFE_{i,t}^{quan} = \frac{1}{3}\sqrt{\sum_k \left(FE_{i,t+3+k}^{quan} - \overline{FE}_{i,t+3}^{quan}\right)^2}$$

Comparison between quantitative and qualitative measures



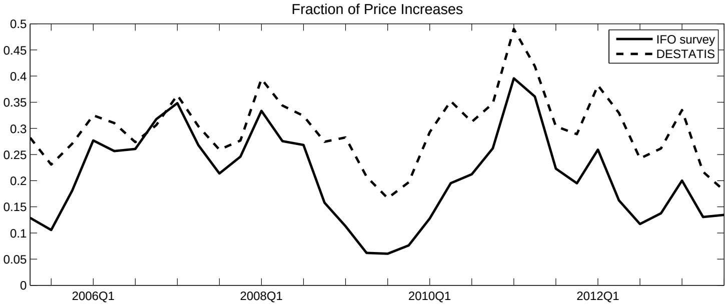
- Time-series correlation coefficient: 0.62
- Pooled Spearman correlation coefficient: 0.65

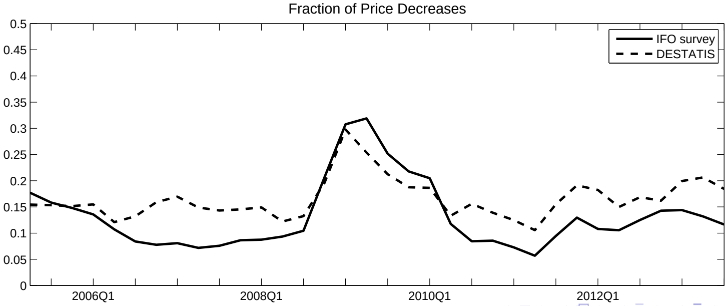
Empirical analysis

- Recall: want to analyze effects of heightened idiosyncratic volatility on price-setting of firms
- IFO-BCS: price statements at monthly frequency

  $\rightarrow$ transform to quarterly frequency
- Binary dependent variable: *price change*

  $\rightarrow$ equals 1 if firm i states at t that it changed its price in at least one of the last three months


Fraction of Price Increases
IFO survey
DESTATIS
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
2006Q1
2008Q1
2010Q1
2012Q1


Fraction of Price Decreases
IFO survey
DESTATIS
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
2006Q1
2008Q1
2010Q1
2012Q1

Business Cycle Properties of Frequency of Price Changes

Dependent variable: Share of price change		
	PPI	CPI
Non-Recession Mean	0.3128***	0.4366***
Recession Dummy	0.0271***	0.0459***

- *Countercyclicality of PPI*: non-recession mean 31.28%, recession mean 33.99%
- *Recession of 08/09*: Average frequency of producer price changes increased from 31.6% to 38.6%
- Confirm results in Vavra (2013) as well as Berger and Vavra (2011) for US CPI data

Empirical analysis

- Estimate probability of observing a price change
- Price-setting equation for firm
  - Taylor dummies
  - Sector dummies
  - Time-fixed effects
  - Firm-specific variables
- Quarterly pooled probit model (Benchmark)

$$P(y_{i,t} = 1 \,|\mathbf{x}_{i,t}) = \Phi(\mathbf{x}_{i,t}\mathbf{b})$$

Discussion of Controls

- Taylor dummies: capture (mechanical) time-dependent pricing
- Time-fixed effects: *aggregate demand* effects
- Costs, technical capacity: *supply side* effects
- Business expectations, expected employment: *news* effects
- Orders, capacity utilization: *idiosyncratic demand* effects

$\rightarrow$ Want to control as best as possible for first-moment effects!

Baseline empirical results

Table : Absolute production expectation error

Dependent variable: Price change				
	no firm-specific var.		incl. firm-specific var.	
$ABSFE^{qual}$	0.012***		0.008***	
$ABSFE^{quan}$		0.097***		0.092***
Observations	249,363	62,982	198,291	55,370
Pseudo R-squared	0.121	0.131	0.133	0.137

*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Baseline empirical results

Table : Rolling window standard deviation

Dependent variable: Price change				
	no firm-specific var.		incl. firm-specific var.	
$STDFE^{qual}$	0.040***		0.019***	
$STDFE^{quan}$		0.235***		0.182**
Observations	231,332	16,239	184,756	14,458
Pseudo R-squared	0.124	0.162	0.134	0.167

*** p<0.01, ** p<0.05, * p<0.1

Baseline empirical results

- Heightened volatility increases the probability of a price change, though the effect is small
- For $\text{ABSFE}^{\text{qual}}$ and $\text{STDFE}^{\text{qual}}$ only the sign is interpretable
- Prices are about 0.1 percentage points more likely to change when volatility changes by one percentage point ($\text{ABSFE}^{\text{quan}}$)
- To put this into perspective: volatility in the Great Recession increased by 7.6 percentage points, and so did (roughly) the frequency of price adjustment. The impact of volatility falls by an order of magnitude short!
- Cost changes matter for price changes, so do changes in demand and news

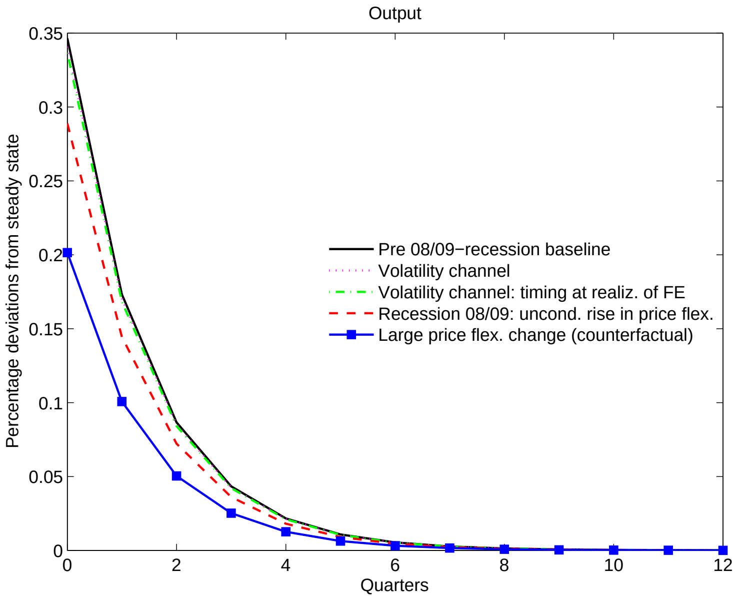
Model - Overview

- *Empirical results*: increase in firm-specific volatility leads to an increase in the probability of a price change
- What are the consequences for the effectiveness of monetary policy?
- Calibrated New Keynesian model as in Gali (2008)
- Price setting is constrained à la Calvo (1983)
- In this model: induced price rigidities as only source of monetary non-neutrality
- Really just meant as a (slightly more sophisticated) first-pass back-of-the-envelope calculation

Model experiments

- Study the output impulse response to a 25 basis point monetary policy shock (stimulative) in *five* scenarios:
- Baseline: Calvo parameter determined by pre-08/09-recession mean of 31.6%
- 4 experiments: unforeseen, once-and-for-all and permanent increase in the Calvo parameter
  1. Total Great Recession increase in average price setting frequency to 38.6%
  2. Conditional, volatility-induced increase in price setting frequency to 32.3% (re-estimate on the pre-crisis sample)
  3. Upper bound of conditional, volatility-induced increase in price setting frequency to 32.8% (maximum over all robust. checks)
  4. Counterfactual: Large price flexibility change between time of very low and very high price setting frequency in the sample ($\Delta \approx 18$ percentage points)

Results


Output
Percentage deviations from steady state
Quarters
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0
2
4
6
8
10
12
Pre 08/09−recession baseline
Volatility channel
Volatility channel: timing at realiz. of FE
Recession 08/09: uncond. rise in price flex.
Large price flex. change (counterfactual)

Model experiments – summary

- Total Great Recession increase in average price setting frequency: **17%** loss in output-stabilization effectiveness
- Conditional, volatility-induced increase in price setting frequency: **1.6%** loss
- Upper bound of conditional, volatility-induced increase in price setting frequency: **2.9%** loss
- Counterfactual: Large price flexibility change between time of very low and very high price setting frequency in the sample: **43%** loss

Current model extension

- Take the model more seriously
- Currently, building heterogeneous firm menu cost model

  $\rightarrow$ idiosyncratic volatility at firm level

  $\rightarrow$ more realistic price setting/rigidities
- Match the model to our estimated elasticity
- German Statistical Office gave us access to micro data underlying producer price index

  $\rightarrow$ allows moment matching to firm-level price data

Conclusion

- Heightened business volatility increases the probability of a price change, though the effect is small:
- We confirm the sign of the relationship predicted by the theoretical literature
- Deliver a new moment (elasticity) between volatility and price setting frequency that monetary models that study the effects of time-varying volatility should match
- Effects of this increase in firm-level volatility on monetary policy rather are small, at least for conventional monetary policy in a simple NK model

Robustness I

Dependent variable: Price change								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Volatility proxy at time of realization (pooled probit model)							
$ABSFE^{qual}$	0.022***				0.008***			
	(0.001)				(0.001)			
$ABSFE^{quan}$		0.187***				0.111***		
		(0.021)				(0.020)		
$STDFE^{qual}$			0.017***				0.006***	
			(0.002)				(0.001)	
$STDFE^{quan}$				0.031				0.006
				(0.019)				(0.012)
	Unexpected price changes (pooled probit model)							
$ABSFE^{qual}$	0.008***				0.005***			
	(0.001)				(0.001)			
$ABSFE^{quan}$		0.083***				0.068***		
		(0.015)				(0.016)		
$STDFE^{qual}$			0.028***				0.019***	
			(0.002)				(0.002)	
$STDFE^{quan}$				0.218***				0.202***
				(0.064)				(0.072)

*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Robustness Checks II

Dependent variable: Price change								
	Non-recession				Recession			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
$ABSFE^{qual}$	0.009***		0.004***		0.010***		0.005**	
	(0.001)		(0.001)		(0.002)		(0.003)	
$ABSFE^{quan}$		0.063***		0.047***		0.078**		0.064
		(0.015)		(0.014)		(0.032)		(0.041)
$STDFE^{qual}$	0.028***		0.012***		0.045***		0.023***	
	(0.003)		(0.002)		(0.004)		(0.004)	
$STDFE^{quan}$		0.228***		0.148**		0.120		0.106
		(0.077)		(0.069)		(0.137)		(0.136)

*** p<0.01, ** p<0.05, * p<0.1

Robustness Checks III

Dependent variable: Price change				
	(1)	(2)	(3)	(4)
Volatility based on production changes				
ABS^{quan}	0.100***		0.095***	
	(0.017)		(0.021)	
STD^{quan}		0.151***		0.108**
		(0.049)		(0.053)
Volatility based on capacity utilization changes				
ABS^{quan}	0.120***		0.101***	
	(0.010)		(0.012)	
STD^{quan}		0.211***		0.154***
		(0.018)		(0.019)
Qualitative production change				
ABS^{qual}	0.028***		0.016***	
	(0.001)		(0.002)	
STD^{qual}		0.049***		0.022***
		(0.003)		(0.003)

*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Robustness Checks IV

Dependent variable: Price change				
	(1)	(2)	(3)	(4)
(a) Control function approach				
$ABSFE^{qual}$	0.012***		–	
	(0.002)			
$ABSFE^{quan}$		0.099***		–
		(0.024)		
(b) 5-quarter rolling window standard deviation				
$STDFE^{qual}$	0.035***		0.016***	
	(0.003)		(0.002)	
$STDFE^{quan}$		0.191		0.032
		(0.132)		(0.132)

*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Robustness Checks V

Dependent variable: Price change				
	(1)	(2)	(3)	(4)
	Monthly model			
$ABSFE^{qual}$	0.004***		0.002**	
	(0.001)		(0.001)	
$STDFE^{qual}$		0.012***		0.004***
		(0.001)		(0.001)
	Volatility measure as dummy variable			
$ABSFE^{qual}$	0.017***		0.010***	
	(0.002)		(0.003)	

*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Asymmetric Price Response

	(1)	(2)	(3)	(4)
Dependent variable: Price increase				
$ABSFE^{qual}$	0.008***		0.007***	
	(0.002)		(0.002)	
$STDFE^{qual}$		0.017***		0.009**
		(0.003)		(0.002)
Dependent variable: Price decrease				
$ABSFE^{qual}$	0.008***		0.003***	
	(0.001)		(0.001)	
$STDFE^{qual}$		0.013***		0.004***
		(0.002)		(0.001)

*** p<0.01, ** p<0.05, * p<0.1

- Heightened volatility increases probability of price increases and price decreases
  - → individual prices are more dispersed in times of higher volatility
  - → another indication that what we measure is (mostly) volatility and not simply large first moment shocks