The Working Capital Channel

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Motivation and Summary

1. **What is the working capital channel?**
   - The assumption that firms must pre-fund their wage bill before sales.

2. **Why is the working capital channel important?**
   - A standard explanation for the price puzzle in **VAR**.
   - Model the price puzzle in **DSGE**: Christiano, Eichenbaum and Evans (2005)
   - The only direct supply-side transmission mechanism.

3. **Is there any direct evidence for the working capital channel?**
   - DSGE calibration has been arbitrary: How much WC firms need?
   - **No**: indirect industry-level *(Barth and Ramey, 2001)* or pass-through from bank landing rates *(Gaiotti and Secchi, 2006)*.

4. **New direct micro-data evidence**:
   A firm that pre-funds all of its sales in a quarter **increases its price by around 1 % after 4-5 months** following a percentage unit increase in the policy rate.

Contribution

- **Firm-level evidence using policy rates**
  1. analogous to NKM, central bank models such as in UK, Sweden.
  2. credit spread shocks $\neq$ monetary policy shocks (Gilchrist and Zakrajsek, 2012).
- **Inform parameter calibration** in DSGE: WC holdings, price stickiness.
- The partial effect of a "total" interest rate change: **anticipated and unanticipated**. Not only MP shocks are important (Bernanke, Boivin and Eliasz, 2005).
- Micro-data evidence for the pass-through, **response time**.

Model framework

The **New Keynesian model** with Calvo price stickiness:

- Firms pay **interest** on the amount they borrow to **pre-fund** their wage bill
- Creates a supply-side monetary transmission mechanism.

A firm sets its optimal price according to

$$p^*_{i,t} = \mu + (1-\theta\beta)\sum_{k=0}^{\infty}(\theta\beta)^k E_{i,t}[\widetilde{mc}^n_{i,t+k|t}] \tag{1}$$

where $\widetilde{mc}^n$ is the firm's nominal marginal cost in logs.

$$\widetilde{MC}^n_{i,t} = \frac{(1+i_t)^{\delta_i} W_t}{A_t} \implies \widetilde{mc}^n_{i,t} = \delta_i R_t + mc^n_t \tag{2}$$

- **In CEE2005 $\delta_i = 1$ in a quarterly model.**

Inflation

Let a group of firms have price stickiness ($\boldsymbol{\theta}$) and pre-funding ($\boldsymbol{\delta}$)

$$\pi_t \equiv p_t - p_{t-1} = (1-\theta)(p_t^* - p_{t-1}), \tag{3}$$

$$p_{t-1} = (1-\theta)\sum_{\tau=0}^{\infty}\theta^{\tau} p_{t-1-\tau}^{*}. \tag{4}$$

Using p_t^*, mc_t and p_{t-1} rewrite (3) as

$$\pi_t = (1-\theta)(1-\theta\beta)\Big[E_t \sum_{k=0}^{\infty}(\theta\beta)^k(\delta R_{t+k} + mc_{t+k}^n) - (1-\theta)\sum_{\tau=0}^{\infty}\theta^{\tau} E_{t-1-\tau}\sum_{k=0}^{\infty}(\theta\beta)^k(\delta R_{t-1-\tau+k} + mc_{t-1-\tau+k}^n)\Big]. \tag{5}$$

Predictions

- Assuming that repo rate changes are fully **U**nanticipated:

$$\frac{\Delta \pi_t}{\Delta R_t} = (1-\theta)(1-\theta\beta)\,\delta\left[E_t \sum_{k=0}^{\infty} (\theta\beta)^k \frac{\Delta R_{t+k}}{\Delta R_t^{U}}\right]. \tag{6}$$

- Maybe repo changes are partly **A**nticipated (**Baseline Regression**):

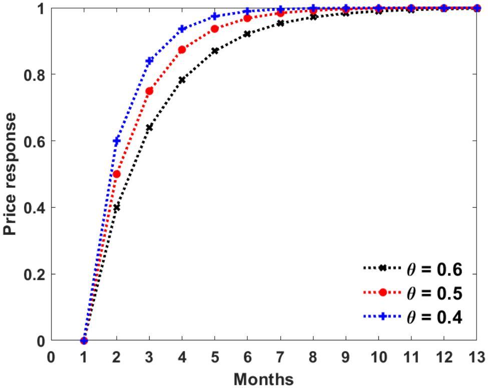
$$\frac{\Delta \pi_t}{\Delta R_t^A} = (1-\theta)(1-\theta\beta)\,\delta\left[E_t \sum_{k=0}^{\infty} (\theta\beta)^k \frac{\Delta R_{t+k}}{\Delta R_t^{A}} - (1-\theta)\sum_{\tau=0}^{\infty} \theta^{\tau} E_{t-1-\tau} \sum_{k=0}^{\infty} (\theta\beta)^k \frac{\Delta R_{t-1-\tau+k}}{\Delta R_t^{A}}\right], \tag{7}$$

Predictions of the model, varying price stickiness

Assume that ΔR_t and mc_t^n follow random walks, and $\delta = 1$

$$\Delta R_t = \epsilon_t \; ; \quad \epsilon_t \sim N(0, \sigma_\epsilon),$$
$$\Delta mc_t^n = v_t \; ; \quad v_t \sim N(0, \sigma_v),$$

so that the optimal reset price follows a random walk $p_t^* = p_{t-1}^* + \delta \Delta R_t + \Delta mc_t^n$.



Baseline Regression

$$p_{i,j,t+k} - p_{i,j,t-1} = \beta_{1,k}\left(\overline{\frac{W_i}{S_i}} \times \Delta R_t^A\right) + \beta_{2,k}\left(\overline{\frac{W_i}{S_i}} \times \Delta R_t^U\right)$$
$$+ \alpha_{i,k} + \gamma_{j,k,t} + \xi_{1,k}(\overline{S_i} \times \Delta R_t)$$
$$+ \sum_s^S \xi_{s,k}\left(\overline{\frac{W_i}{S_i}} \times D_s\right) + \epsilon_{k,i,t},$$

- **Working Capital**: receivables(= trade credit given) + inventories - payables - pre-payments
- $\overline{\frac{W_i}{S_i}}$: time-avg. WC/Sales ratio, variation across firms.

Identification challenge: changes in demand drive both π_t, W_t/S_t and ΔR_t

- Use allegedly exogenous high-frequency shocks for ΔR_t^U
- Firm and product-time FEs, control variable for size, DKraay SEs.

Data

Prices:

- **Firm-product group level** producer home price indices.
- **Representative** sample.
- **2,151 firms**, 1997-2016, manufacturing sector only.
- Allegedly **quality adjusted** series.
- **HS2 products** e.g.: "umbrellas, sun umbrellas, walking-sticks, seat-sticks, whips, riding-crops and parts thereof".

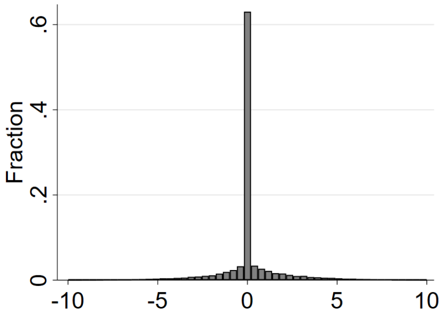
Working capital and sales:

- Firm-level balance sheets/income statements.

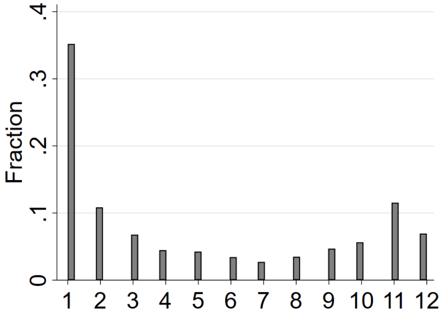
Repo rate:

- Riksbank - Swedish Central Bank.
- High-frequency Kuttner shocks, constructed using Stina 1-month rates.

Prices



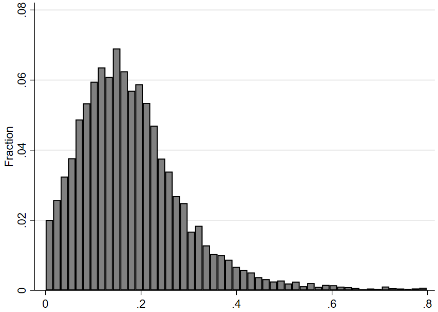
(a) Distribution of price changes



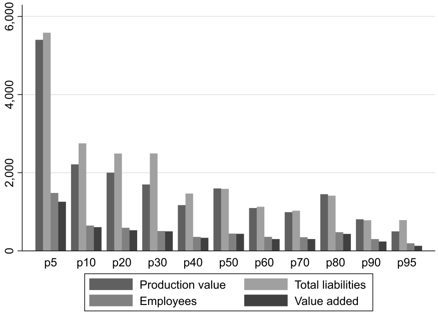
(b) Avg. number of non-zero changes

- (a) centres around zero price change
- (b) most firms change prices infrequently (some very frequently)
- Avg. frequency of price change is 4.6 times a year; 2-3 months avg. price duration.
- The median frequency of price change: Bils&Klenow (2004) 4 to 5 months, Klenow&Kryvtsov (2005) 4 to 7, Nakamura&Steinsson (2007) 8 to 11 months.

Working capital and other firm characteristics



(a) Distribution of W/S

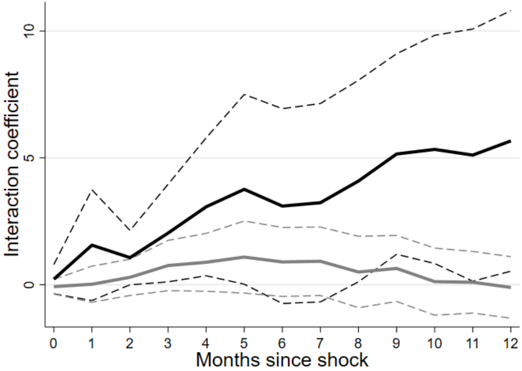


(b) Firm characteristics along W/S percentiles

- (a) identifying variation, avg WC holdings 0.2.
- (b) relative homogeneity between p10 and p90
- controlling for size and robustness w/o p10 and p90 is a good idea

Result I

$$p_{i,j,t+k} - p_{i,j,t-1} = \beta_{1,k}\left(\frac{\overline{W_i}}{S_i} \times \Delta R_t^A\right) + \beta_{2,k}\left(\frac{\overline{W_i}}{S_i} \times \Delta R_t^U\right) + \bar{X}_{i,j,k,t} + \epsilon_{k,i,t}$$

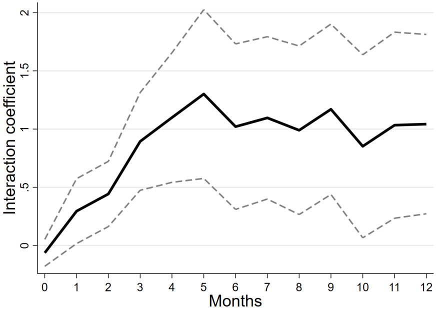


Results I table

Results I: pass-through via the working capital channel

- The short-run effect of the **unanticipated** change is **larger**.
- **Delay**: No concurrent price changes.
- An **avg** high-frequency **shock** of **0.03 %-unit** leads to a 0.09 (0.15) % increase in the price set by a firm with a WC/S ratio of 1 after 4 (9).
- Had there been a 1 %-unit increase in the repo rate, the **0.97 %-unit anticipated** component increases prices by 0.86 (0.62) percent.
- **The avg. price change is around 1 % after 4 months.**
- **1:1 transmission** after some time as theory predicts!

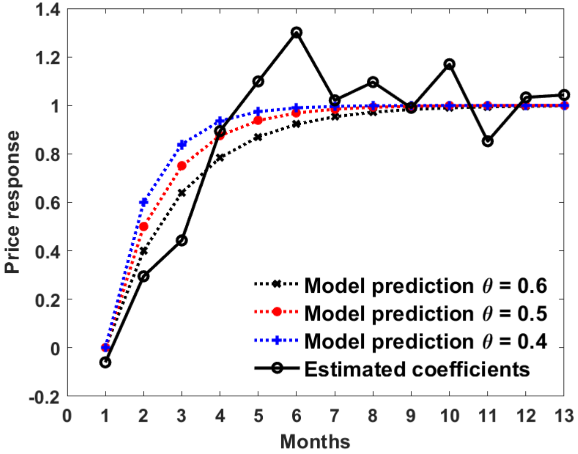
Result II: the WC effect of a **repo change**



- **The price effect stabilizes around 1 % after 4 months.**
- The average firm (WC/S=0.2) increases its price by 0.2 percent.
- The firm at the 10th (90th) percentile of the WC/S distribution increases its price by 0.03 (0.35) percent 3 months after the change.

Results II table

Predicted response and estimated coefficients



Conclusion

- Theory predicts that
  - the pass-through of interest rate changes to prices is 1:1
  - unanticipated changes have larger short-run effects
- Regressions using firm-level data confirm these predictions
- Robustness checks confirm them too: 2 other measures of shocks, multiple interaction variables for control capturing size, indebtedness etc
- Calibration and relevance for DSGE models:
  - Assuming a quarter of pre-funding is in line with annual WS/S $= 0.2$
  - Price-stickiness $\theta = 0.6$ or higher may capture short run price response better.
  - Takes 4-6 months for producer prices to adjust.

THANKS!

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Results I Anticipated and Unanticipated changes

Table: The transmission of interest rate changes using Stina1M based high-frequency shocks

	p(t)-p(t-1)	p(t+1)-p(t-1)	p(t+2)-p(t-1)	p(t+3)-p(t-1)	p(t+4)-p(t-1)
avg.W/S × dR^{U}	0.217	1.558	1.066^{+}	2.034*	3.071*
	(0.295)	(1.114)	(0.547)	(0.982)	(1.387)
avg.W/S × dR^{A}	-0.0783	0.0164	0.290	0.754	0.883
	(0.147)	(0.363)	(0.365)	(0.506)	(0.582)
avg. S # dR	x	x	x	x	x
Firm FE	x	x	x	x	x
Time-Product FE	x	x	x	x	x
FC dummies	x	x	x	x	x
Observations	124865	122363	119844	117348	114870

	p(t+5)-p(t-1)	p(t+6)-p(t-1)	p(t+7)-p(t-1)	p(t+8)-p(t-1)	p(t+9)-p(t-1)
avg.W/S × dR^{U}	3.759^{+}	3.098	3.231	4.087*	5.151*
	(1.909)	(1.960)	(1.995)	(2.027)	(2.017)
avg.W/S × dR^{A}	1.088	0.896	0.922	0.499	0.640
	(0.725)	(0.694)	(0.689)	(0.718)	(0.664)
avg. S # dR	x	x	x	x	x
Firm FE	x	x	x	x	x
Time-Product FE	x	x	x	x	x
FC dummies	x	x	x	x	x
Observations	112382	109890	107390	104888	102387

	p(t+10)-p(t-1)	p(t+11)-p(t-1)	p(t+12)-p(t-1)	p(t+13)-p(t-1)	p(t+14)-p(t-1)
avg.W/S × dR^{U}	3.759^{+}	3.098	3.231	4.087*	5.151*
	(1.909)	(1.960)	(1.995)	(2.027)	(2.017)
avg.W/S × dR^{A}	1.088	0.896	0.922	0.499	0.640
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avg. S # dR	x	x	x		
Firm FE	x	x	x		
Time-Product FE	x	x	x		
FC dummies	x	x	x		
Observations	112382	109890	107390	104888	102387

Notes: Driscoll and Kraay standard errors with four lags are in parenthesis; significance levels $p < 0.05$; $p < 0.01$ $p < 0.001$; t are months. W is working capital, defined as receivables and inventories; and S is sales. The same control variables are used in each regression. These are the interaction of average sales and the change in the repo rate from $t-1$ to t, firm and time-product fixed effects, and the financial crises dummies for the months of the financial crises between 2008m10-2009m6.

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Results II Repo rate changes

Table: The transmission of repo rate changes via the working capital channel

	p(t)-p(t-1)	p(t+1)-p(t-1)	p(t+2)-p(t-1)	p(t+3)-p(t-1)	p(t+4)-p(t-1)
avg.W/S $\times$ dR	-0.0631	0.295	0.443	0.894*	1.099*
	(0.111)	(0.269)	(0.270)	(0.405)	(0.537)
avg. S # dR	x	x	x	x	x
Firm FE	x	x	x	x	x
Time-Product FE	x	x	x	x	x
FC dummies	x	x	x	x	x
Observations	154072	151337	148591	145852	143131
	p(t+5)-p(t-1)	p(t+6)-p(t-1)	p(t+7)-p(t-1)	p(t+8)-p(t-1)	p(t+9)-p(t-1)
avg.W/S $\times$ dR	1.301+	1.021	1.096	0.990	1.170+
	(0.699)	(0.686)	(0.673)	(0.698)	(0.706)
avg. S # dR	x	x	x	x	x
Firm FE	x	x	x	x	x
Time-Product FE	x	x	x	x	x
FC dummies	x	x	x	x	x
Observations	140397	137657	134909	132160	129410
	p(t+10)-p(t-1)	p(t+11)-p(t-1)	p(t+12)-p(t-1)		
avg.W/S $\times$ dR	0.852	1.033	1.043		
	(0.758)	(0.771)	(0.743)		
avg. S # dR	x	x	x		
Firm FE	x	x	x		
Time-Product FE	x	x	x		
FC dummies	x	x	x		
Observations	126281	123970	121860		

Notes: Driscoll and Kraay standard errors with four lags are in parenthesis; significance levels + $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$; t are months. W is working capital, defined as receivables and inventories net of payables and prepayments. S is sales. The same control variables are used in each regression. These control variables are the interaction of sales and the repo rate change between $t-1$ and t, firm and time-product fixed effects, and the financial crises dummies for the months of the financial crises between 2008m10-2009m6. The tables with all coefficients can be found in Appendix ??.

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References

Barth, III Marvin J. and Valerie A. Ramey, "The Cost Channel of Monetary Transmission," *NBER Macroeconomics Annual*, 2001, *16* (1), 184–240.

Bernanke, Ben S., Jean Boivin, and Piotr Eliasz, "Measuring the Effects of Monetary Policy: A Factor-Augmented Vector Autoregressive (FAVAR) Approach," *The Quarterly journal of economics*, 2005, *120* (1), 387–422.

Christiano, Lawrence J, Martin Eichenbaum, and Charles L Evans, "Nominal Rigidities and the Dynamic Effects of a Shock to Monetary Policy," *Journal of Political Economy*, 2005, *113* (1), 1–45.

Gaiotti, Eugenio and Alessandro Secchi, "Is There a Cost Channel of Monetary Policy Transmission? An Investigation into the Pricing Behavior of 2,000 Firms," *Journal of Money, Credit and Banking*, 2006, *38* (8), 2013–2037.

Gilchrist, Simon and Egon Zakrajsek, "Credit Spreads and Business Cycle Fluctuations," *The American Economic Review*, 2012, *102* (4), 1692–1720.