Monetary Policy, Firm Heterogeneity, and the Distribution of Investment Rates

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Motivation

- monetary policy transmits to the real economy via the investment decisions of firms
- which frictions or features of firm investment shape the investment channel of monetary policy?
- financial frictions
  - Ottonello & Winberry (2020), Jeenas (2019), Cloyne, Ferreira, Froemel & Surico (2020), ...
  - evidence: firms which are "likely financially constrained" react *on average* more strongly to monetary policy
- lumpy investment?
  - do the *average* effects reflect that all firms invest a little more or that a few firms invest a lot more?
  - investigate the effect of monetary policy on the entire *distribution* of investment rates

Overview

- empirically document the effect of monetary policy on the *distribution* of investment rates
  - after an expansionary monetary shock, there are fewer small/zero investment rates and more large investment rates ("spikes")
  - suggests that extensive margin investment decisions matter

- investigate the effect of monetary policy on the investment rate distributions of young and old firms
  - the investment rate distribution of young firms changes much more
  - about half of the observed higher sensitivity to monetary shocks of young firms can be explained by the extensive margin

Overview

- construct a heterogeneous-firm New Keynesian model with fixed & convex capital adjustment costs
  - $\rightarrow$ lumpy investment model
- calibrate model to match U.S. aggregate and firm-level data
- show that the model can replicate the effect of monetary policy on the distribution of investment rates & heterogeneous sensitivity of young and old firms
- use the model to understand more generally what determines a firm's sensitivity to interest rate changes

Related Literature

- empirical estimation of group-specific investment rate sensitivities to monetary policy shocks

  Ottonello & Winberry (2020), Jeenas (2019), Cloyne, Ferreira, Froemel & Surico (2020), Gertler & Gilchrist (1994), González, Nuño, Thaler & Albrizio (2021), Albrizio, González & Khametshin (2021), Jungherr, Meier, Reinelt & Schott (2022), ...

- relevance of lumpy investment for the transmission of macroeconomic shocks

  Bachmann, Caballero & Engel (2013), Winberry (2021), Koby & Wolf (2020), Reiter, Sveen & Weinke (2013), Fang (2021)

Empirical Evidence

Lumpy Investment

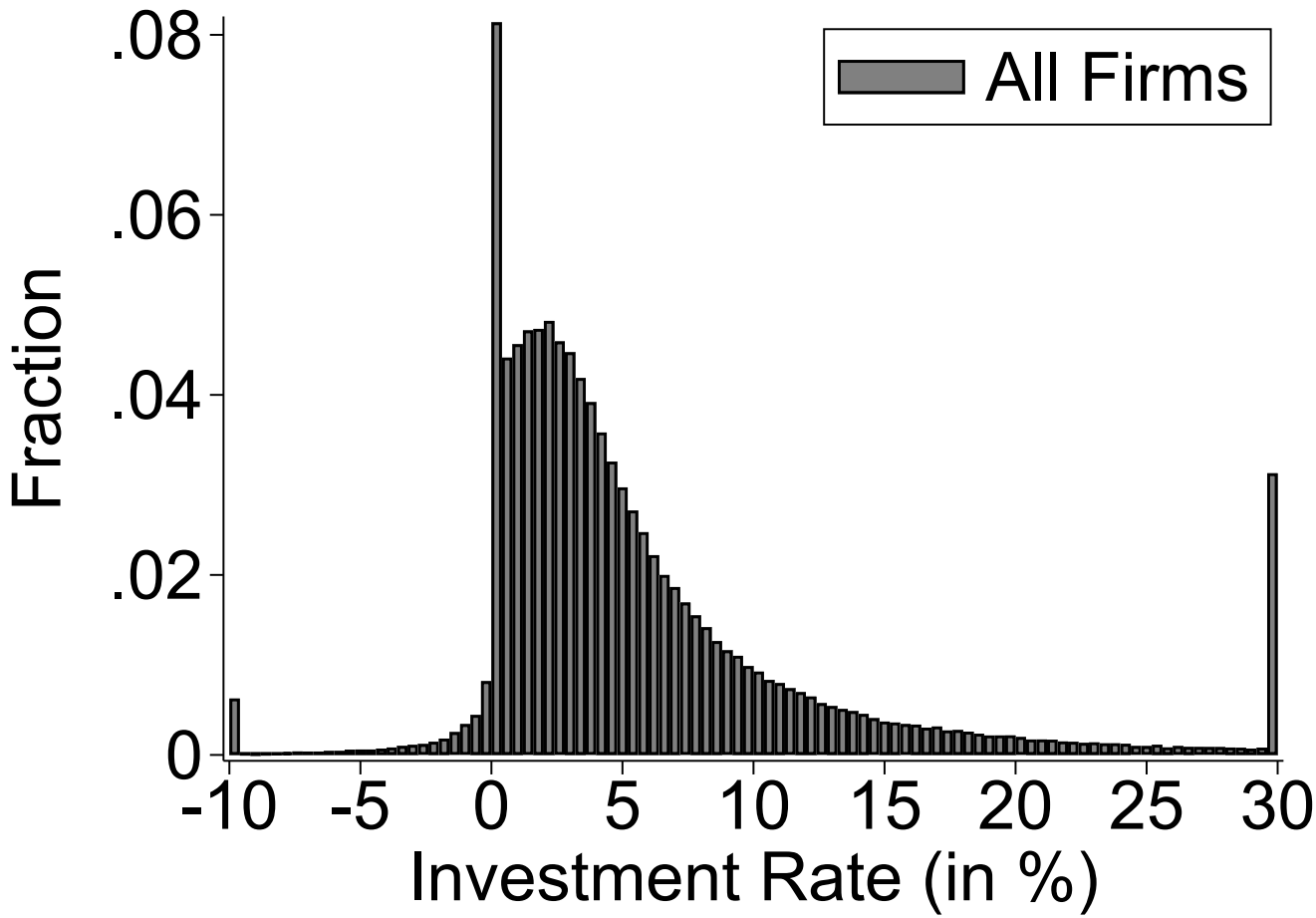
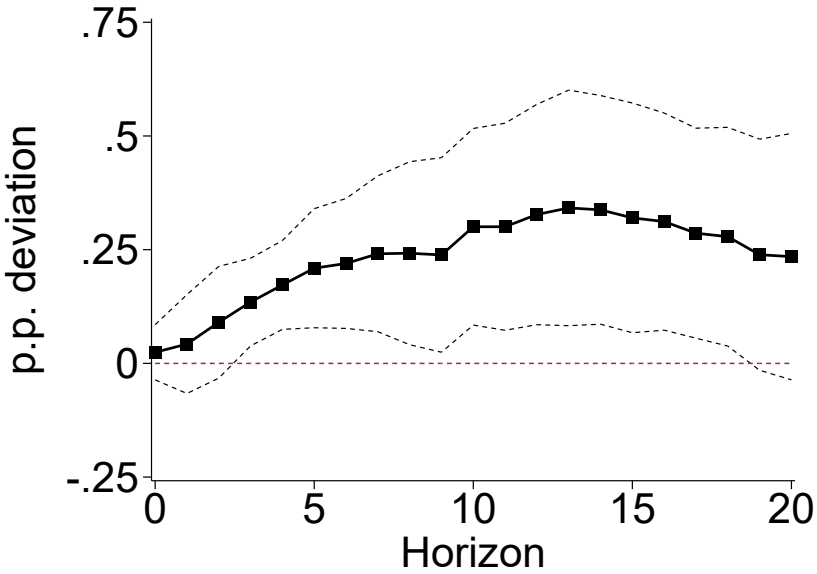


Figure 1: Cross-Sectional Distribution of Investment Rates

- investment is *lumpy*, i.e. there are many (almost) zero investment rates and also some very large ones (even in Compustat)

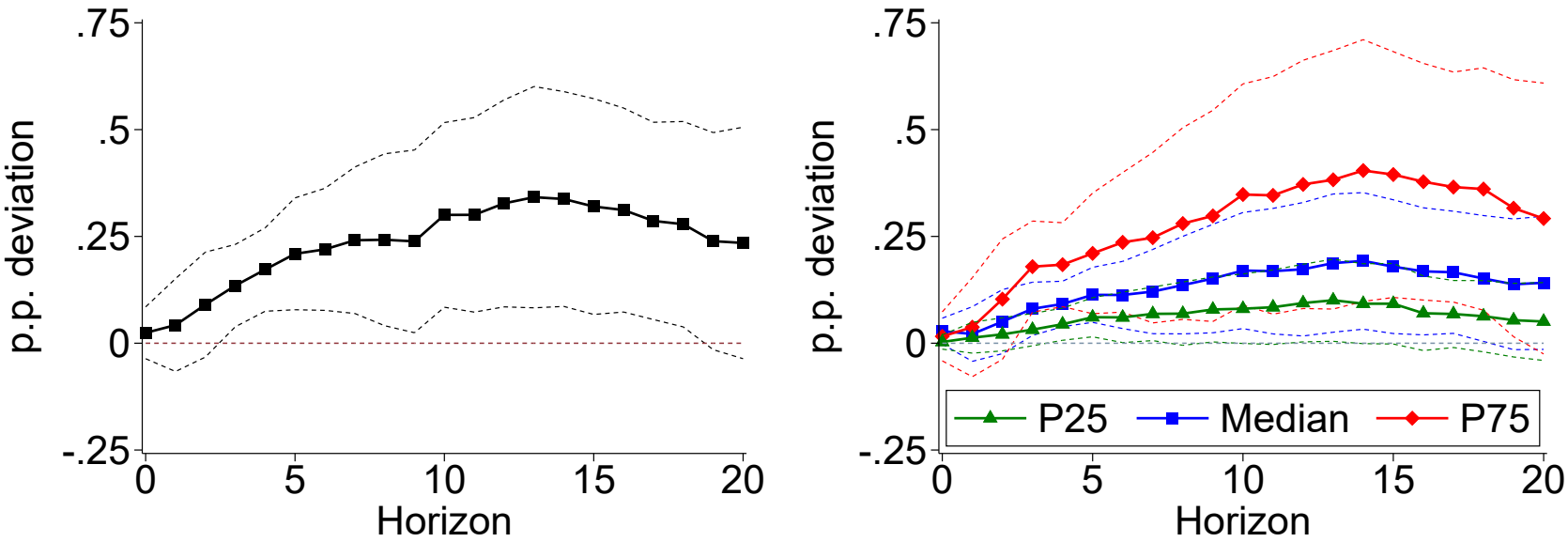
Monetary Policy – Mean & Quantiles



(a) Average Investment Rate

Figure 2: IRFs to MP Shock: Mean & Quantiles of Inv. Rate Distribution

Monetary Policy – Mean & Quantiles

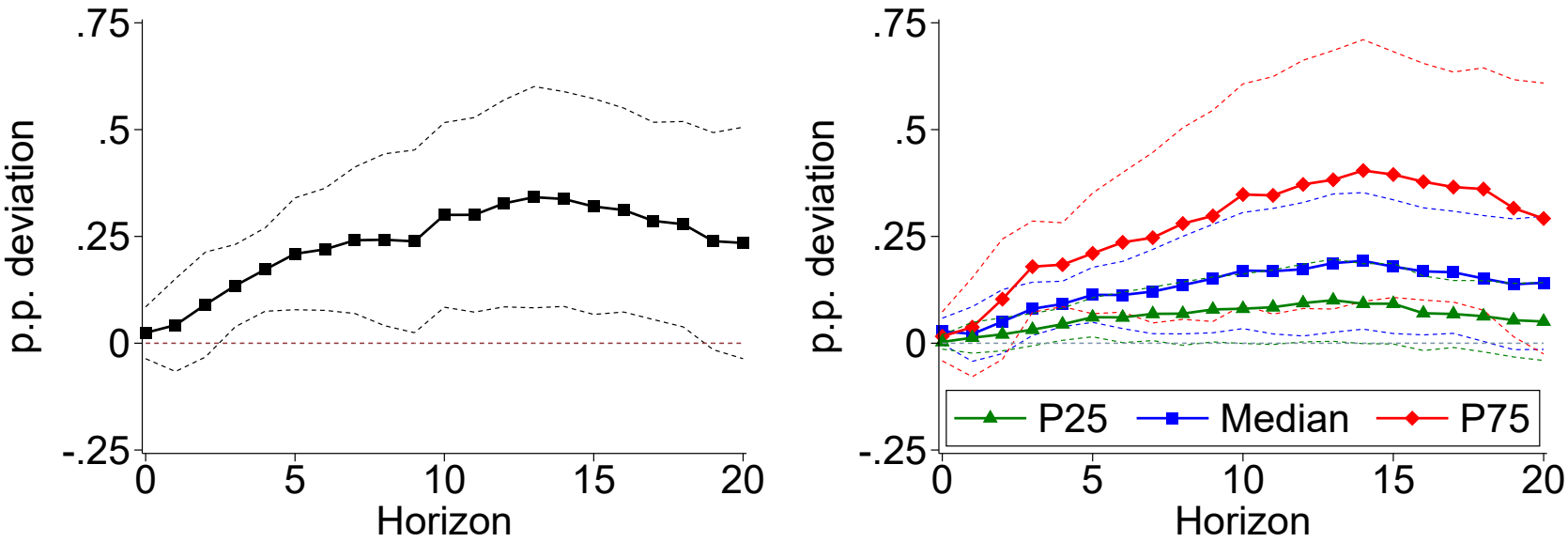


(a) Average Investment Rate

(b) Quantiles of Inv. Rate Dist.

Figure 2: IRFs to MP Shock: Mean & Quantiles of Inv. Rate Distribution

Monetary Policy – Mean & Quantiles



(a) Average Investment Rate (b) Quantiles of Inv. Rate Dist.

Figure 2: IRFs to MP Shock: Mean & Quantiles of Inv. Rate Distribution

- effect of monetary shock on average investment rate is driven by the right tail of the distribution

Monetary Policy – Parametric Approx. of Distribution

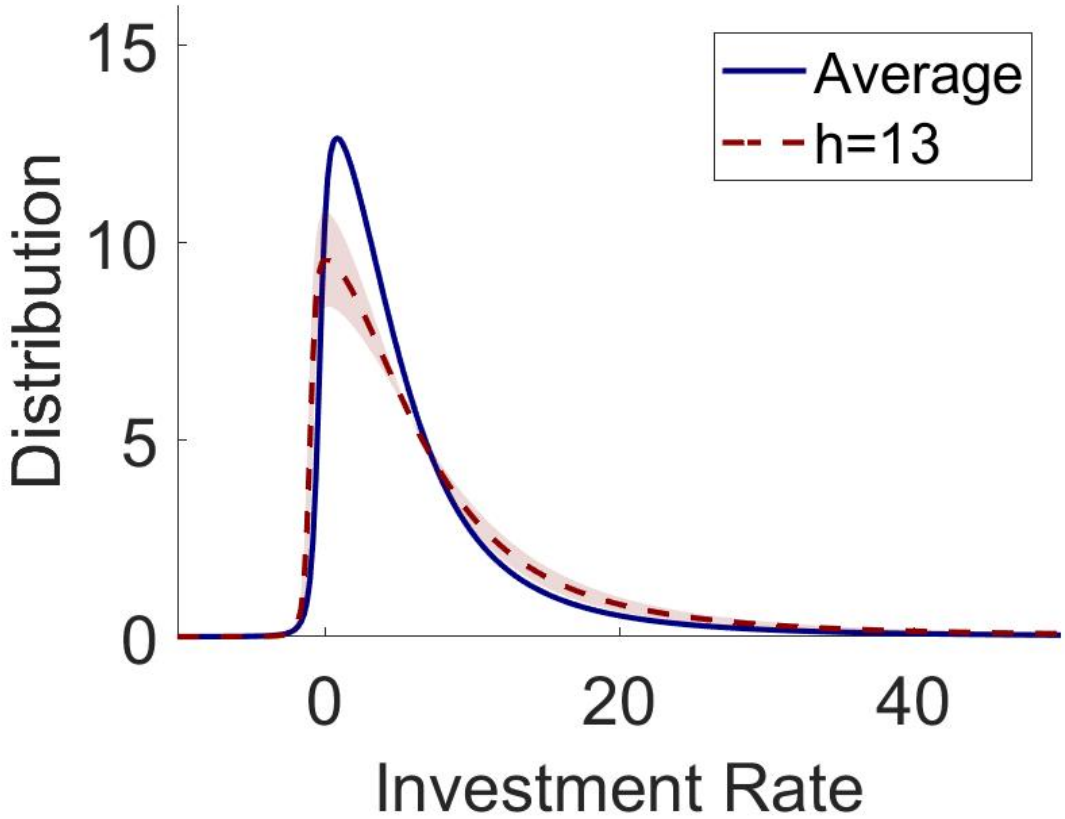


Figure 3: IRFs to MP Shock: Distribution

- after a monetary shock, there are fewer small/zero and more large investment rates

Monetary Policy – Heterogeneous Sensitivity by Age

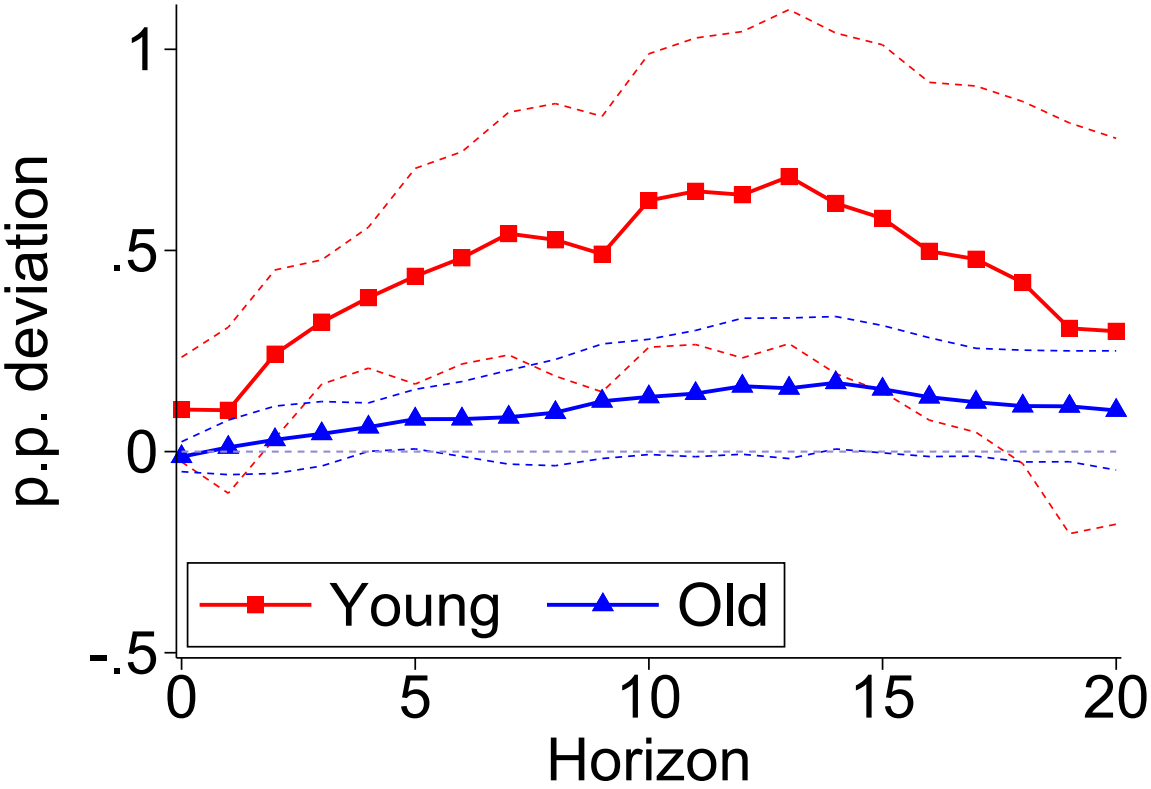
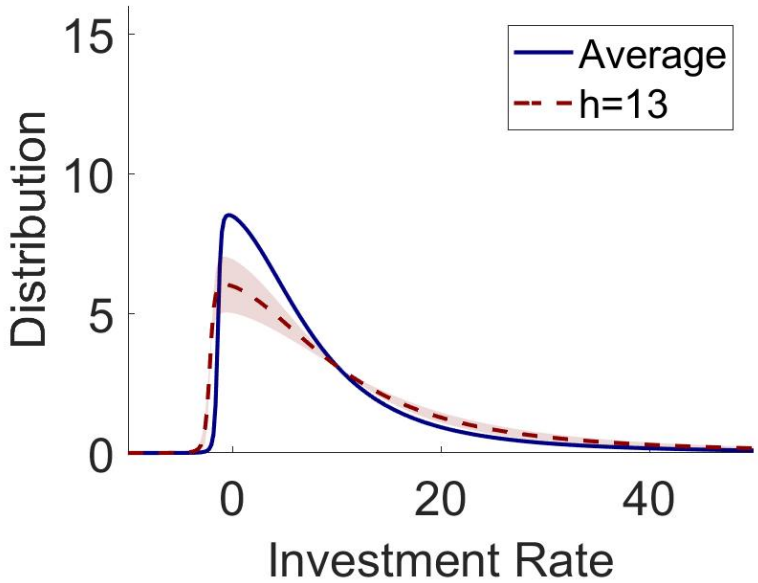


Figure 4: IRFs to MP Shock: Avg. Investment Rate by Age Group

- after a monetary shock, young firms increase investment rates (on average) by much more than old firms (Cloyne et al. 2020)

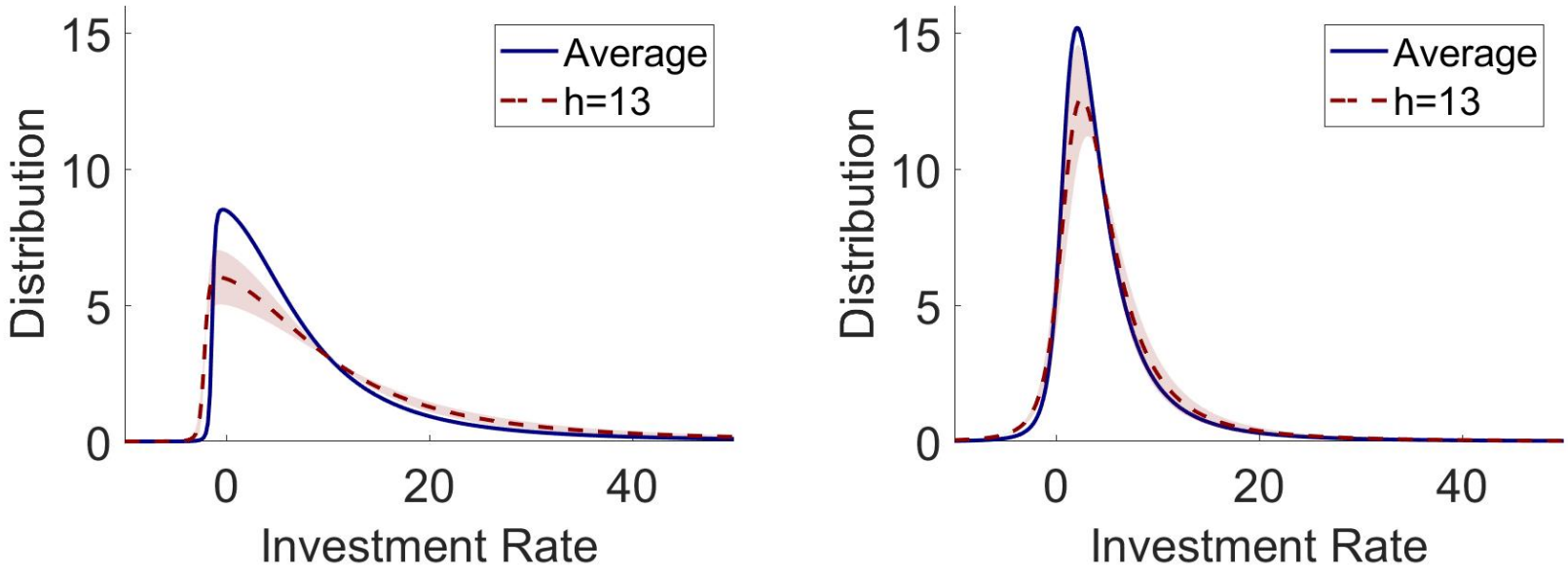
Monetary Policy – Distribution by Age Group



(a) Young Firms

Figure 5: IRFs to MP Shock: Distribution by Age Group

Monetary Policy – Distribution by Age Group

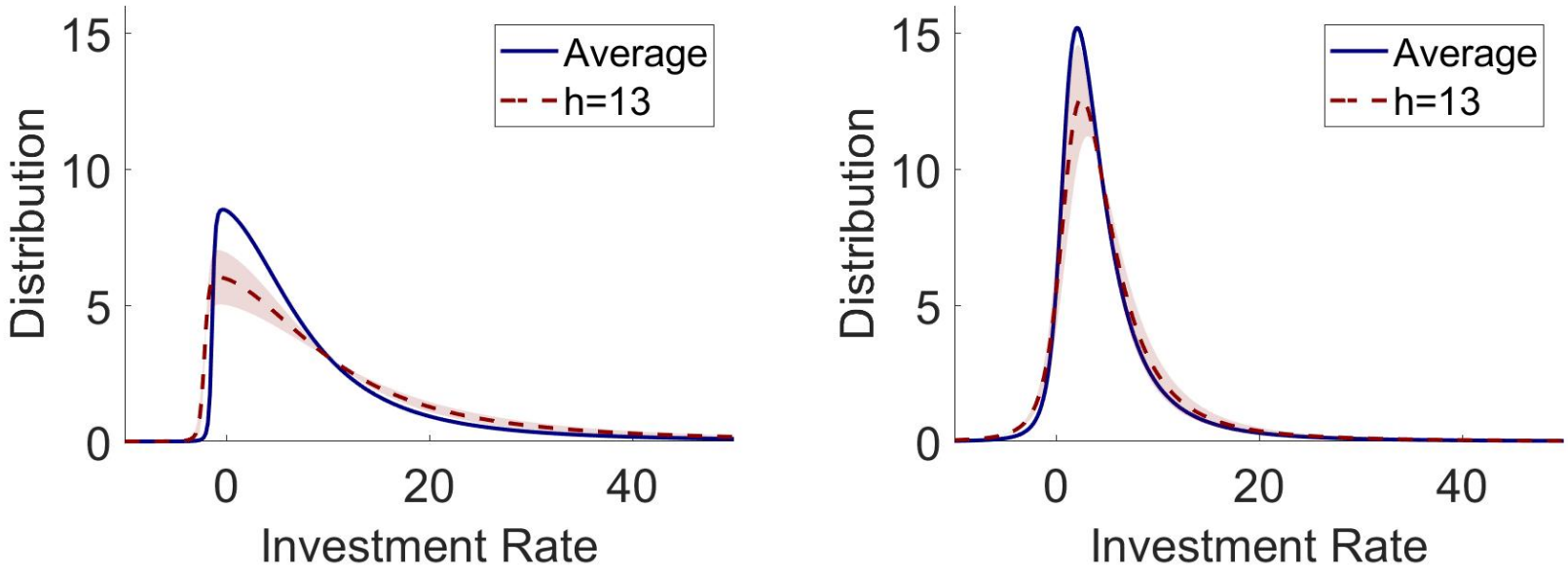


(a) Young Firms

(b) Old Firms

Figure 5: IRFs to MP Shock: Distribution by Age Group

Monetary Policy – Distribution by Age Group



(a) Young Firms (b) Old Firms

Figure 5: IRFs to MP Shock: Distribution by Age Group

- the shape of the distribution of investment rates of young firms changes much more in response to a monetary shock

▸ IRFs: Spike & Inaction Rates

Monetary Policy – Decomposition into Int. & Ext. Margin

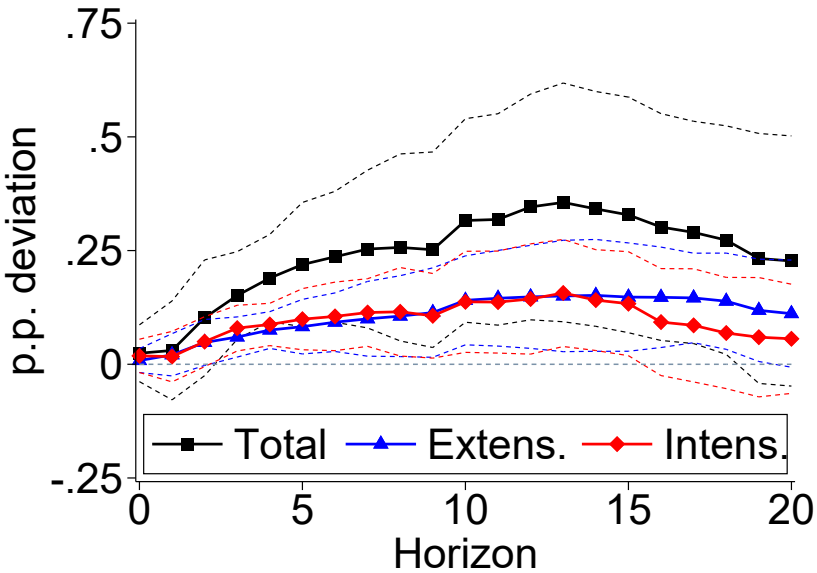
- classify investment rate observations into "spikes" ($i_{j,t} > 0.1$) and "normal" investments ($i_{j,t} \leq 0.1$)
- the average investment rate is

$$\overline{i_t} = \psi_t^s \overline{i_t^s} + (1 - \psi_t^s) \overline{i_t^n}$$

where ψ_t^s is the fraction of firms undertaking a "spike" in period t, $\overline{i_t^s}$ and $\overline{i_t^n}$ are the avg. inv. rates conditional on "spike" and "normal"

- consider changes in ψ_t^s as "extensive margin", changes in $\overline{i_t^n}$ & $\overline{i_t^s}$ as "intensive margin"

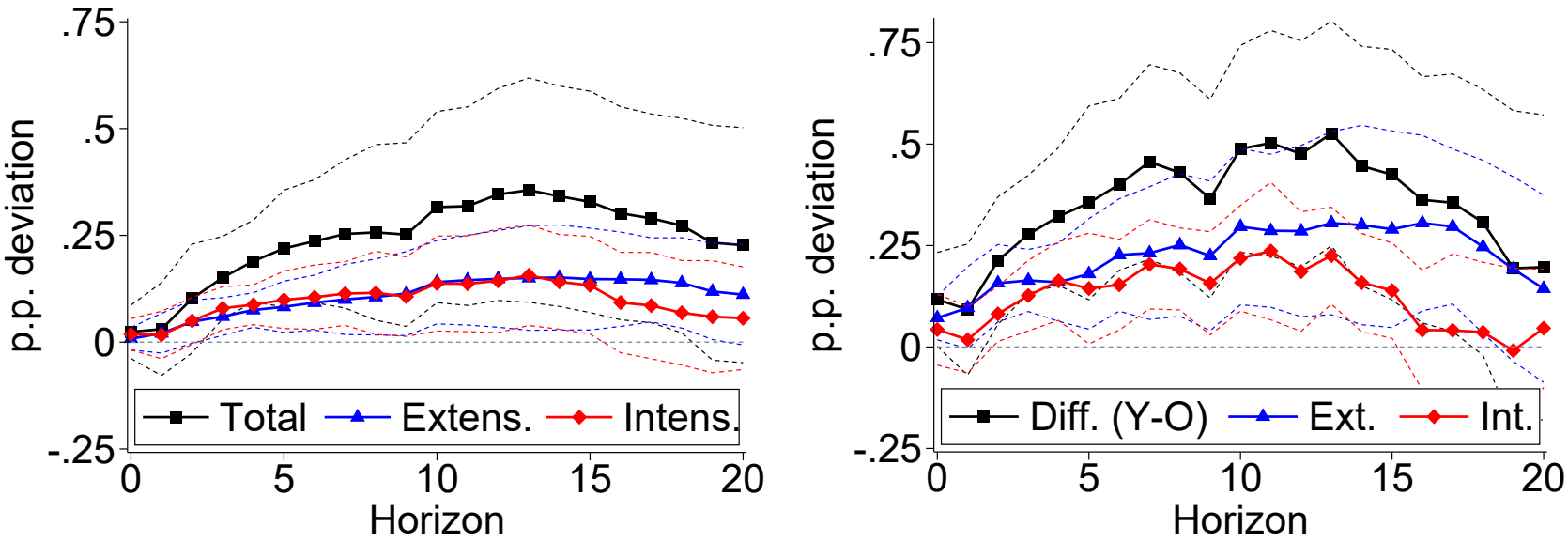
Monetary Policy – Decomposition into Int. & Ext. Margin



(a) Average Effect

Figure 6: IRFs to MP Shock: Decomposition into Int. & Ext. Margin

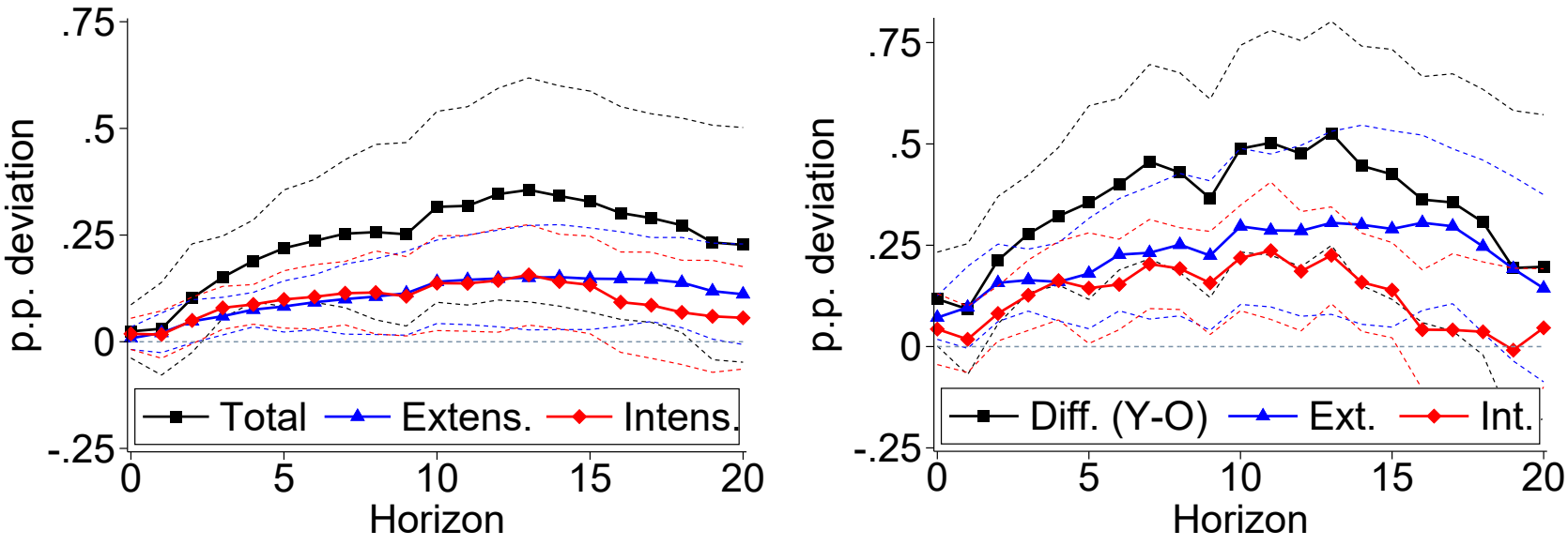
Monetary Policy – Decomposition into Int. & Ext. Margin



(a) Average Effect (b) Heterogeneous Effect (Young-Old)

Figure 6: IRFs to MP Shock: Decomposition into Int. & Ext. Margin

Monetary Policy – Decomposition into Int. & Ext. Margin



(a) Average Effect (b) Heterogeneous Effect (Young-Old)

Figure 6: IRFs to MP Shock: Decomposition into Int. & Ext. Margin

- the extensive margin explains around 50% of the *average* effect of monetary policy as well as of the *heterogeneous sensitivity* of young firms

Model

Model Overview

- continuum of heterogeneous production firms
- retailer firms with Rotemberg price adjustment costs & final good producer, generating a New Keynesian Phillips Curve
- capital good producer with external capital adjustment costs
- representative household
- central bank operating a Taylor rule

Production Firms

- production: $y_{jt} = z_{jt} k_{jt}^{\theta} n_{jt}^{\nu}$ with $\theta, \nu > 0$ and $\theta + \nu < 1$
- investment: $k_{jt+1} = \big(1 - \delta(1 - \chi)\big) k_{jt} + i_{jt}$
  - subject to a random fixed adjustment cost $w_t \xi_{jt}$, where ξ_{jt} is uniformly distributed between 0 and $\bar{\xi}$, to be paid if $i_{jt} \neq 0$
  - and a convex adjustment cost $\frac{\phi}{2} \frac{i_{jt}^2}{k_{jt}}$
  - maintenance investment of $\chi \delta k_{jt}$ as in Bachmann et al. (2013)
- entry & exit:
  - firms face i.i.d. exit shocks
  - at the beginning of each period, there is a mass of new firms which are endowed with initial capital k_0 and draw initial productivity from the ergodic distribution of z

Calibration - Fixed Parameters

Parameter	Description	Value
Household		
β	Discount factor	0.99
ψ	Labor Disutility	0.63
Investment Block		
θ	Capital Coefficient	0.21
ν	Labor Coefficient	0.64
δ	Depreciation Rate	0.026
ρ_z	Persistence of TFP Shock	0.95
π^{exit}	Exogenous Exit Probability	0.01625
New Keynesian Block		
φ	Price Adjustment Cost	90
γ	Elasticity of Substitution over Intermediate Goods	10
φ_π	Taylor Rule Coefficient on Inflation	1.5
ρ_r	Interest Rate Smoothing	0.75
κ	Aggregate Capital Adjustment Costs	8

Table 1: Fixed Parameters

Calibration - Fitted Parameters

Parameter	Description	Value
σ_z	Volatility of TFP Shock	0.060
k_0	Initial Capital of Entrants	3.500
$\bar{\xi}$	Upper Bound on Fixed Adjustment Cost	0.500
ϕ	Convex Adjustment Cost	0.750
χ	Maintenance Investment Parameter	0.350

Table 2: Fitted Parameters

Moment	Data	Model
Standard Deviation of Investment Rates	0.200	0.195
Average Investment Rate	0.119	0.111
Autocorrelation of Investment Rates	0.380	0.377
Relative Size of Entrants	0.253	0.254
Relative Spike Rate of Old Firms	0.740	0.725

Table 3: Empirical & Simulated Moments

Notes: Data moments related to investment rates are taken from Zwick & Mahon (2017) (Appendix, Table B.1, Unbalanced Sample). The relative spike rate of old firms is computed from Compustat data. Corresponding model moments are computed from a simulation of a large panel of firms. The first two moments are rescaled as described in the main text. The relative size of entrants is computed from Business Dynamics Statistics (BDS). In the model, this moment can be computed from the steady state distribution.

Aggregate Effects of Monetary Policy

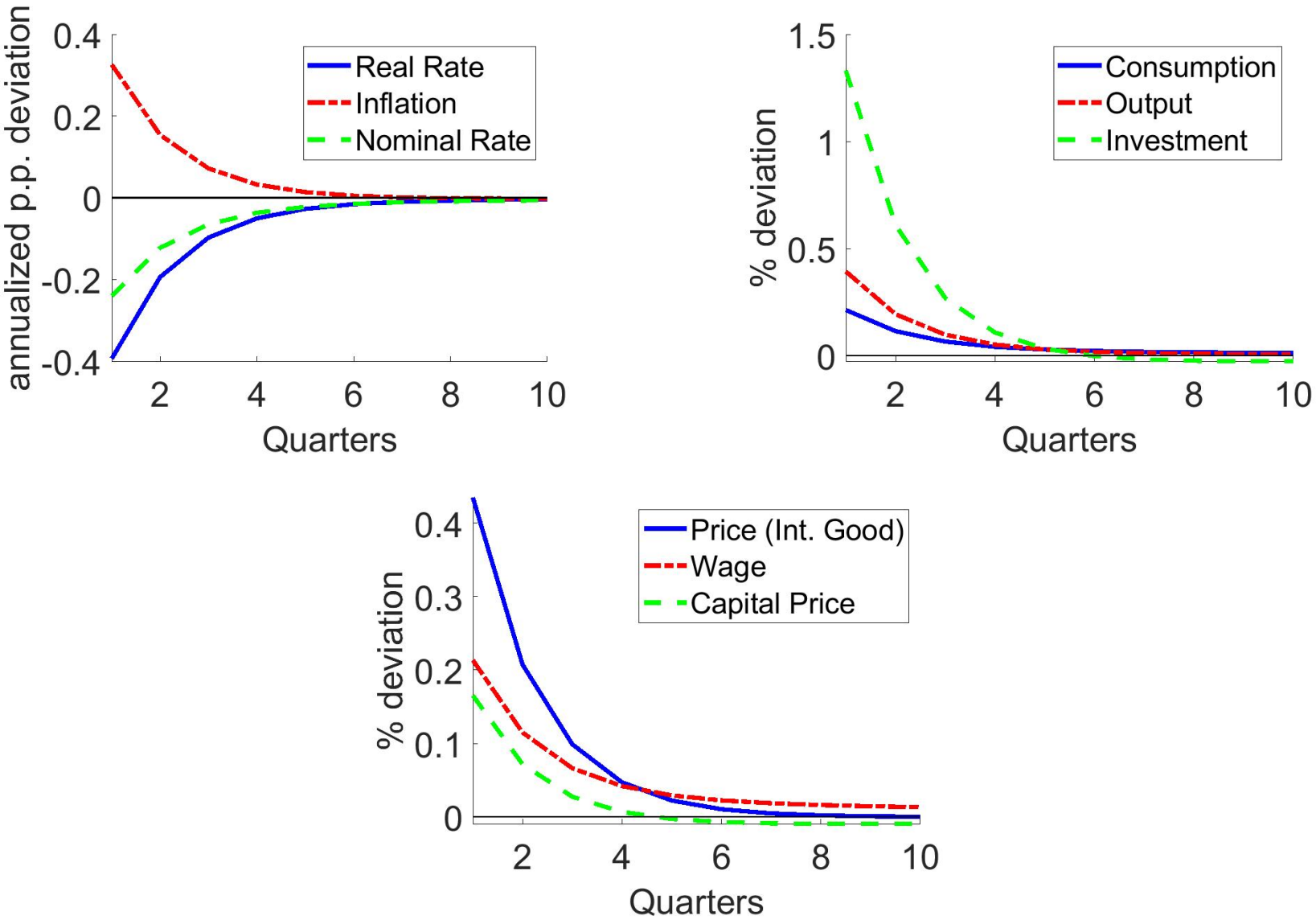
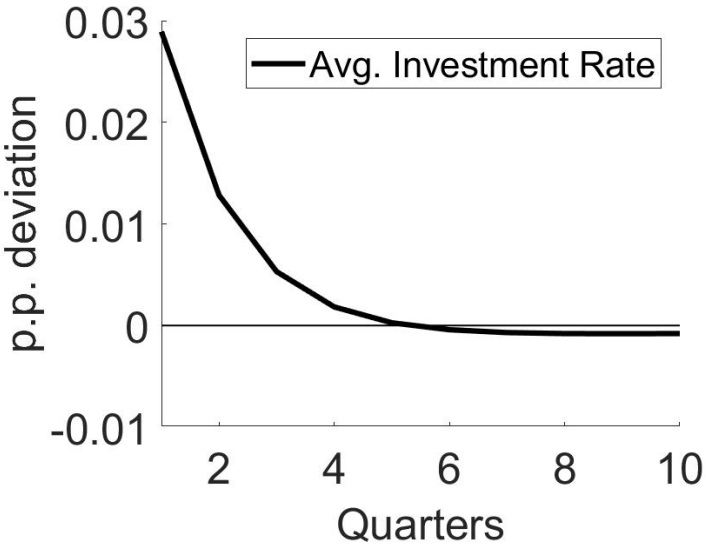


Figure 7: Aggregate Effects of an Expansionary Monetary Policy Shock

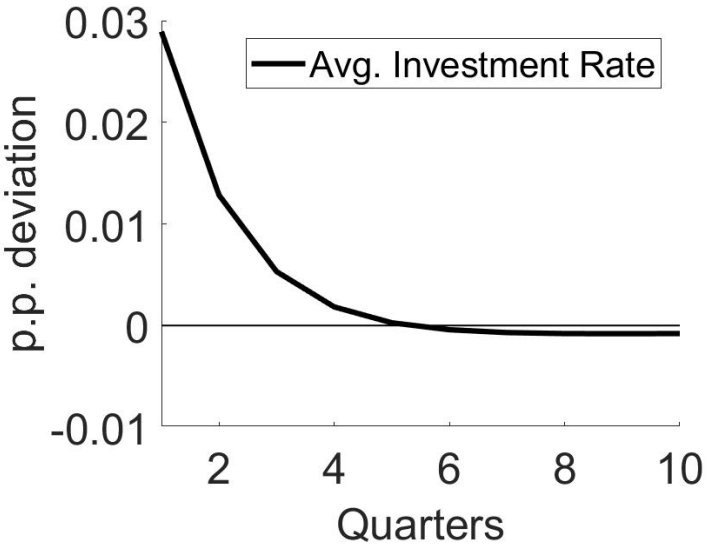
Effects of Monetary Policy on Investment Rates



(a) Avg. Investment Rate

Figure 8: Effects of Monetary Policy on Investment Rates

Effects of Monetary Policy on Investment Rates



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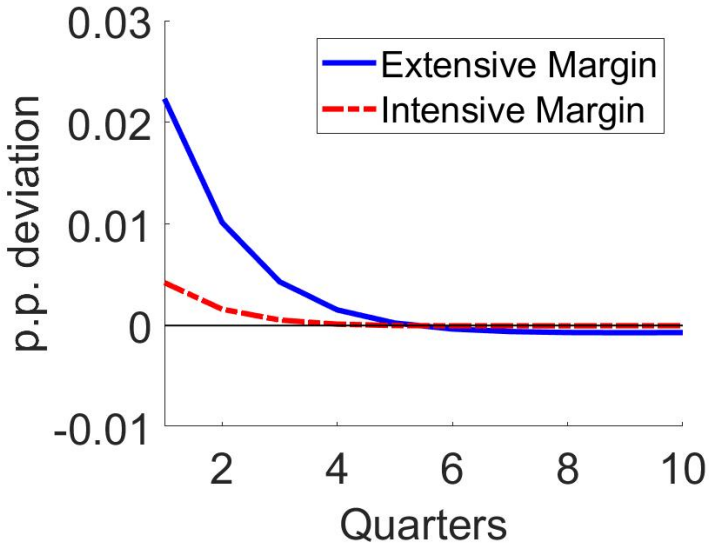
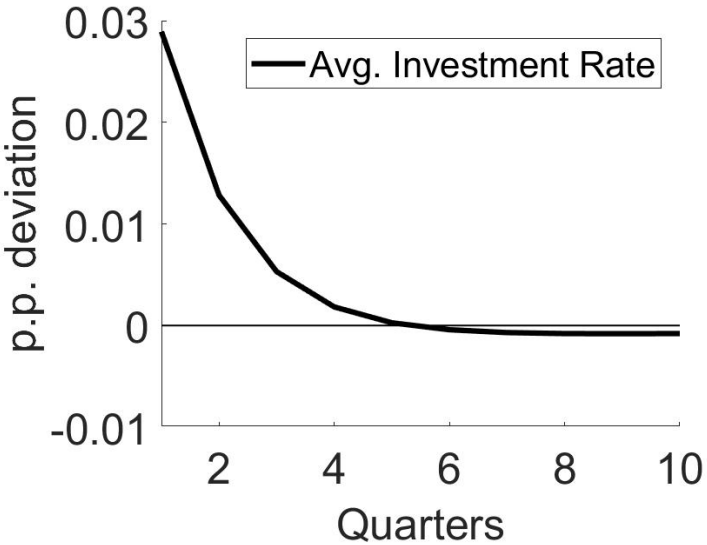


(b) Decomposition

Figure 8: Effects of Monetary Policy on Investment Rates

Effects of Monetary Policy on Investment Rates



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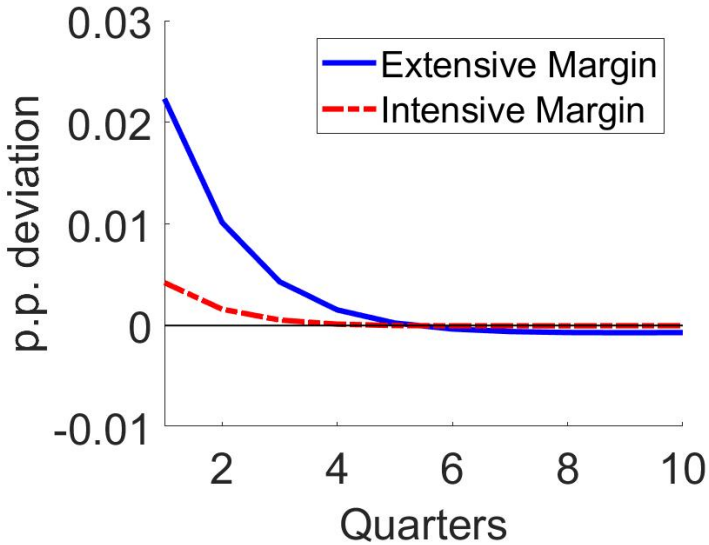


(b) Decomposition

Figure 8: Effects of Monetary Policy on Investment Rates

- the increase in the average investment rate is clearly driven by the extensive margin

Effect of Monetary Policy on Distribution of Inv. Rates

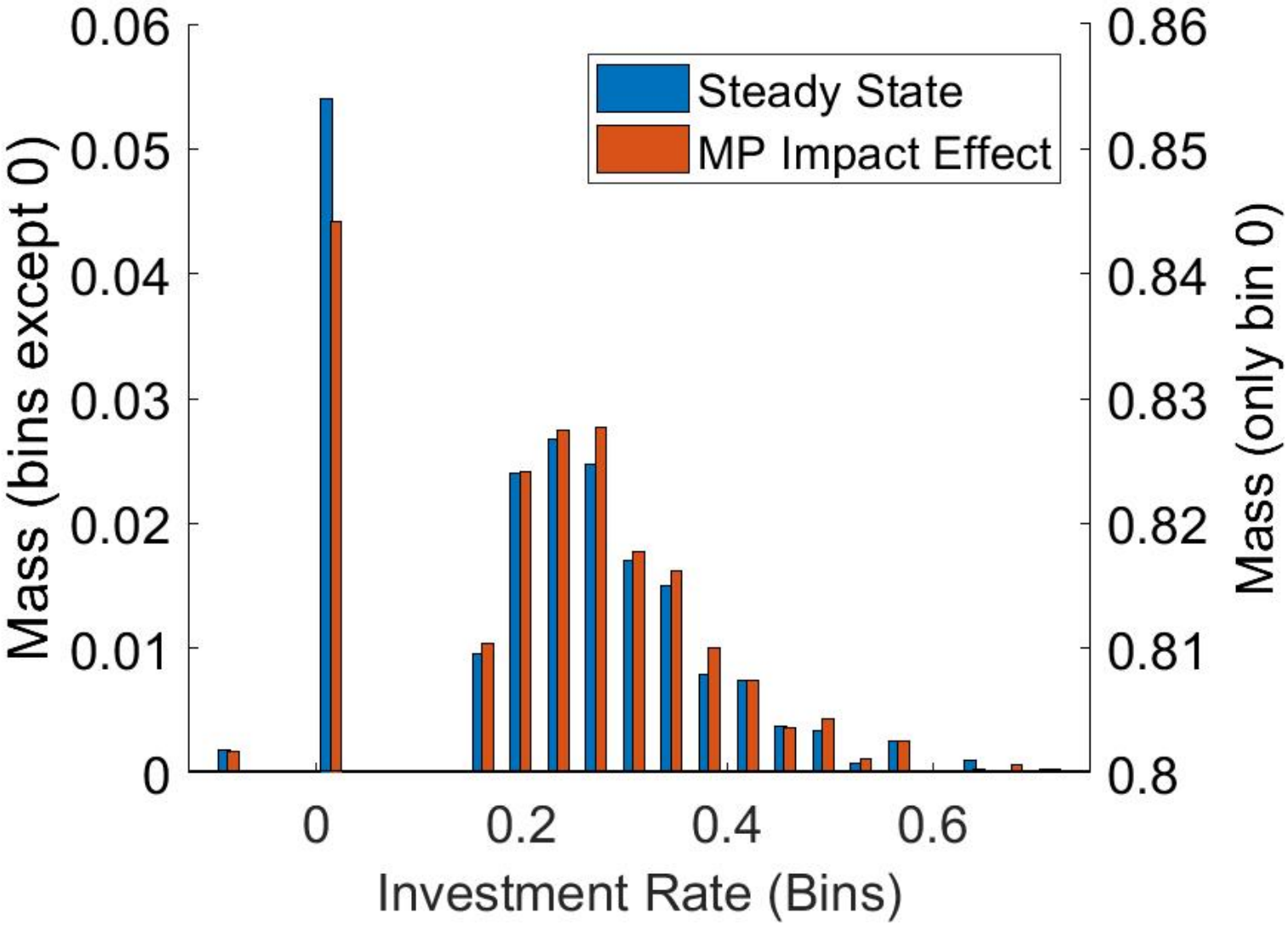
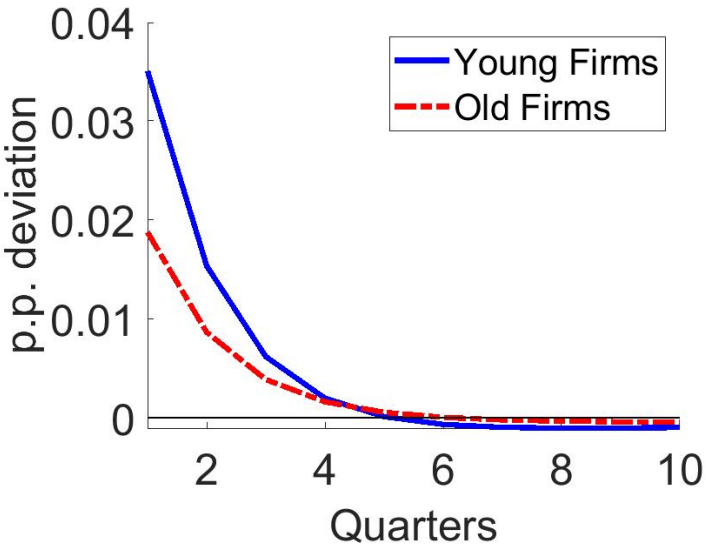


Figure 9: Effects of Monetary Policy on Investment Rates

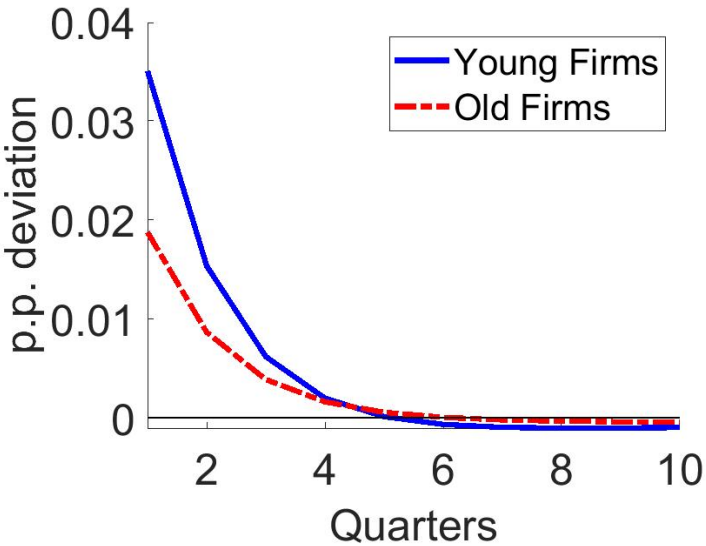
Heterogeneous Sensitivity of Young & Old Firms



(a) Avg. Investment Rate

Figure 10: Heterogeneous Effect (by Age Group) of an Exp. MP Shock

Heterogeneous Sensitivity of Young & Old Firms



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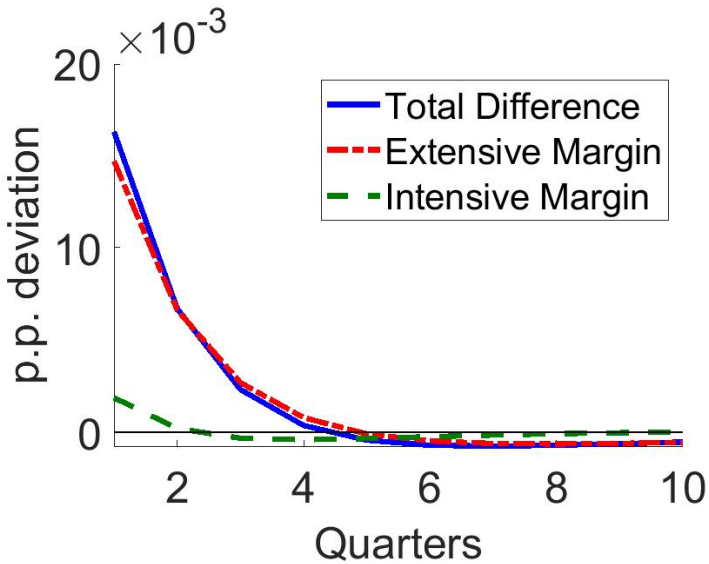

(b) Extensive vs. Intensive Margin

Figure 10: Heterogeneous Effect (by Age Group) of an Exp. MP Shock

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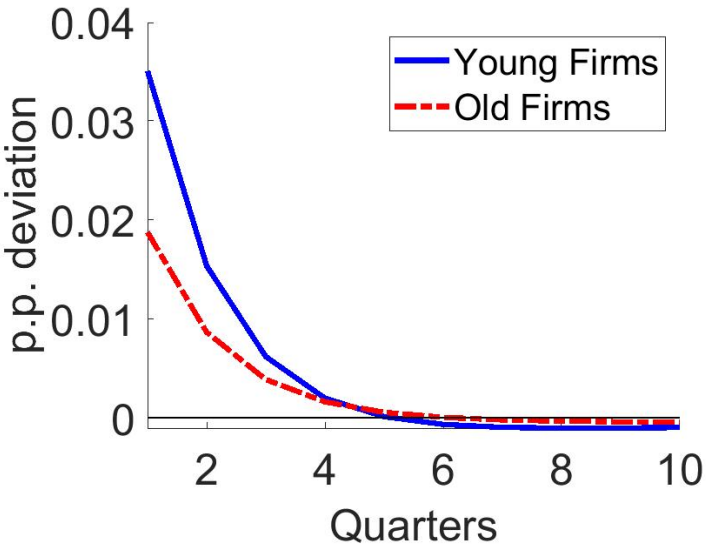

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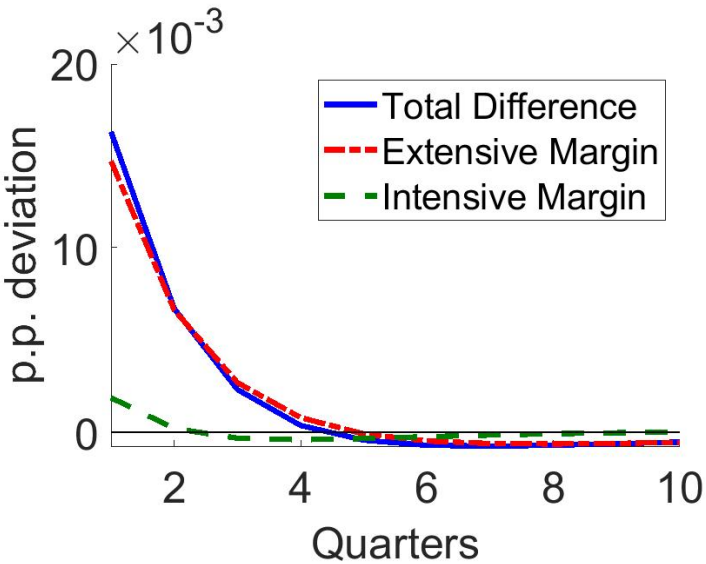


(b) Extensive vs. Intensive Margin

Figure 10: Heterogeneous Effect (by Age Group) of an Exp. MP Shock

- the relatively stronger increase in the average investment rate of young firms is driven almost exclusively by the extensive margin

Intuition for Het. Sensitivity at the Extensive Margin

- due to decreasing returns to scale, the value gain from adjusting to k^* (i.e. closing the capital gap) is convex
  - capital gap $= \log(k^*) - \log(k)$
- expansionary monetary policy increases the capital gap for all firms
  - $r \downarrow \rightarrow k^* \uparrow \rightarrow$ capital gap increases
- value gain from adjusting increases for all firms, i.e. all firms are more likely to adjust
- due to the convexity, the value gain from adjusting increases more strongly for firms with a large initial capital gap
- young firms have (on average) a larger capital gap and are therefore more sensitive to monetary policy at the extensive margin

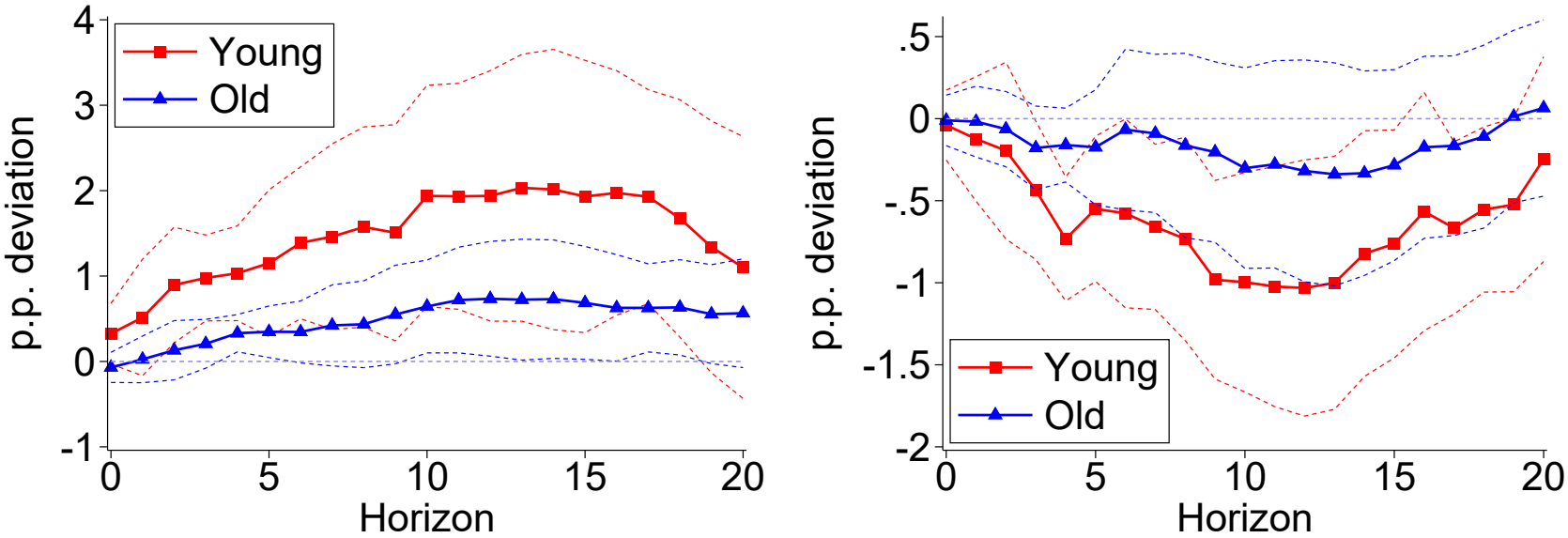
Conclusion

Conclusion

- lumpy investment is a feature of firm-level investment behavior that is relevant for the investment channel of monetary policy
- we document empirically that a monetary policy shock changes the distribution of investment rates in line with the predictions of a lumpy-investment-model
- lumpy investment can also explain about 50% of the stronger sensitivity of young firms, typically associated with a financial accelerator mechanism

Appendix

Spike Rate & Inaction Rate



(a) Spike Rate, by Age

(b) Inaction Rate, by Age

Figure 11: Effect of a Monetary Policy Shock on Spike & Inaction Rates

Notes: Young (old) firms are firms less (more) than 15 years old. Dashed lines indicate 90% confidence intervals.

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