

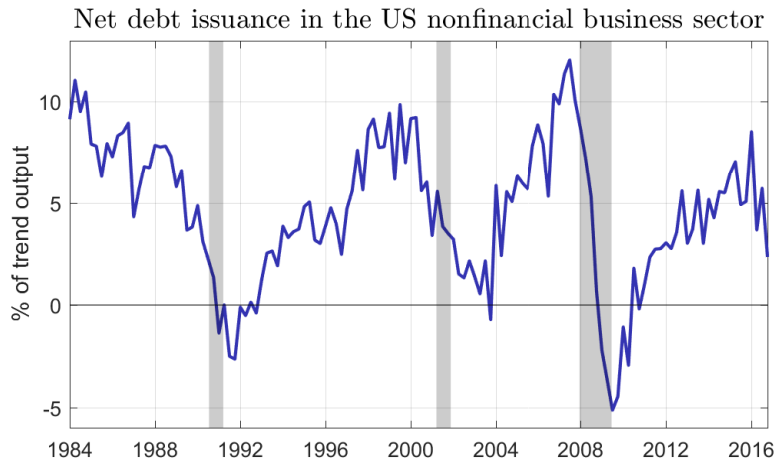
EARNINGS-BASED BORROWING CONSTRAINTS AND MACROECONOMIC FLUCTUATIONS

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**Federal Reserve Bank of Minneapolis
Virtual Seminar**

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MOTIVATION



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- ▶ Firm credit displays large swings over the business cycle
- ▶ Research studies how constraints to credit interact with economic activity
 - ▶ Collateral constraints are a prominent example

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- ▶ Firm credit displays large swings over the business cycle
- ▶ Research studies how constraints to credit interact with economic activity
 - ▶ Collateral constraints are a prominent example
- ▶ This paper: macro consequences of earnings-based constraint on firm debt
 - ▶ Motivated by direct microeconomic evidence
 - ▶ Generates more plausible firm credit dynamics than collateral constraints, both in macro data and in micro data
 - ▶ Affects fundamental conclusions about macro fluctuations and policy tradeoffs

OVERVIEW: 1 & 2 OUT OF 4

1. Micro evidence on covenants in US corporate loans

- ▶ Pervasive use of loan covenants linked to earnings (EBITDA)
- ▶ Firms can borrow more/less when current earnings high/low

2. Formalize earnings-based borrowing constraint in simple model

- ▶ Debt dynamics different than with collateral constraint
- ▶ Focus on responses to investment shocks
- ▶ Firm debt \uparrow with earnings-based constraint, as earnings \uparrow
- ▶ Firm debt \downarrow with collateral constraint, as capital value \downarrow

OVERVIEW: 3 & 4 OUT OF 4

3. Verify model predictions in aggregate and firm-level US data

- ▶ Study aggregate debt responses to investment shocks (SVAR)
- ▶ Study heterogeneous responses across borrower types (panel local projection)
- ▶ Aggregate debt \uparrow , earnings-based debt \uparrow , collateral debt \downarrow

4. Study quantitative macroeconomic consequences

- ▶ Formally derive direct link between earnings-based constraint and price markups
- ▶ Estimate medium-scale New Keynesian DSGE model
- ▶ Constraint implies procyclical markups, increases importance of supply shocks

MAIN CONTRIBUTIONS OF THIS PAPER

► Related work:

- Lian and Ma (2019) document prevalence of cash flow-based relative to asset-based firm borrowing empirically
- Greenwald (2018) studies income-based in addition to asset-based borrowing limits in mortgage contracts

► Key contributions of my paper:

1. Develop model-driven strategy to test for economic relevance of earnings-based constraints in both macro and micro data
2. Demonstrate that constraint alters fundamental conclusions about business cycles and macro policy through interaction with markups

OUTLINE FOR REST OF THE TALK

1. Micro evidence on earnings-based borrowing constraints
2. Framework to distinguish credit constraints
 - ▶ Derive differential predictions relative to collateral constraint in simple model
3. Distinguish credit constraints in macro and micro data
 - ▶ Investment shock responses in aggregate data (SVAR)
 - ▶ Investment shock responses in firm-level data (panel local projection)
4. Derive relation of constraint with sticky prices and markups
5. Estimate quantitative DSGE model
6. Conclusion

1. MICRO EVIDENCE

HOW DO US CORPORATIONS BORROW?

- ▶ LPC Dealscan: detailed loan-level data for $\approx 75\%$ of US commercial loan market Coverage
 - ▶ Roughly 50k loan issuances for 15k firms, 1994-2015
- ▶ Pervasive feature: **loan covenants**
 - ▶ Explicit restrictions on financial indicators
- ▶ Breaches of covenants are frequent and have large effects
 - ▶ Roughly 30% of firms in 10-year window
 - ▶ Sharp drops in investment, employment, borrowing
 - ▶ See e.g. Roberts and Sufi (2009a), Chodorow-Reich and Falato (2017)

THE IMPORTANCE OF EARNINGS

	Covenant type	Median	Mean	Freq. (%)
1	Max Debt to EBITDA	3.75	4.60	60.5
2	Min EBITDA to Interest	2.50	2.56	46.7
3	Min EBITDA to Fixed Charge	1.25	1.42	22.1
4	Max. Leverage ratio	0.60	0.64	21.3
5	Max. Capex	20M	194M	15.1
6	Net Worth	126M	3.2B	11.5

EBITDA is *earnings before interest, taxes, depreciation and amortization*
→ widely used measure of operational profitability

- ▶ Bottom line: covenants based on earnings very prevalent

WHY EARNINGS?

- ▶ Can borrowing constraint on earnings be rationalized from optimal behavior?
 - ▶ Mechanisms: (1) directly pledging earnings (2) contingent control and limited information (3) regulation
- ▶ I lay out a formal microfoundation based on limited contract enforcement and valuation by multiples
- ▶ I discuss how corporate finance literature conceptualizes covenants theoretically, provide details on regulatory aspects

TAKING STOCK OF MICRO EVIDENCE

- ▶ Micro evidence indicates environment in which movements in current earnings affect firms' access to debt
- ▶ How important is this link for aggregate fluctuations?
 - ▶ Formalize as earnings-based borrowing constraint on firm debt
 - ▶ Investigate whether earnings-based constraint changes transmission of shocks
 - ▶ Study quantitative consequences and implications for policy tradeoffs

Additional channels

Coll vs. cov

Other debt types

2. MACRO MODEL

BORROWING CONSTRAINT FORMULATION

- ▶ Debt access of firm is restricted by multiple of earnings:

$$\frac{b_t}{1 + r_t} \leq \theta_\pi \pi_t$$

- ▶ Consistent with definition of EBITDA: $\pi_t = y_t - w_t n_t$

- ▶ Compare to traditional collateral constraint:

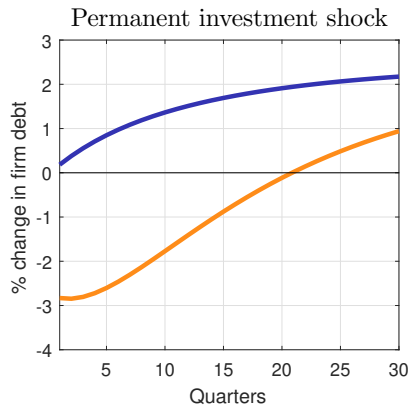
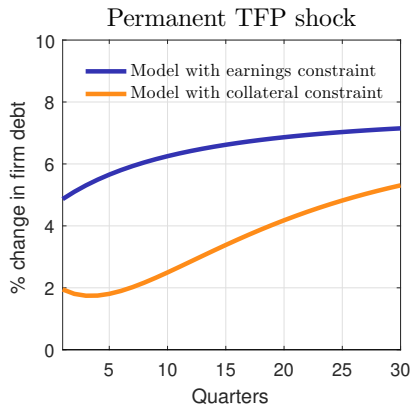
$$\frac{b_t}{1 + r_t} \leq \theta_k \mathbb{E}_t p_{k,t+1} (1 - \delta) k_t$$

- ▶ Study calibrations in which either one or the other constraint is present

MODEL ENVIRONMENT

- ▶ Neoclassical production economy
 - + Tax advantage for firm debt
(Hennessy and Whited, 2005)
 - + Dividend payout adjustment cost
(Jermann and Quadrini, 2012)
 - + Investment adjustment cost
(capital price affected by inv. shocks and varying Tobin's q)
 - + Borrowing constraint
(collateral or earnings-based)

MODEL IRFS OF FIRM DEBT



- ▶ Bottom line: same sign of IRF to TFP shock, opposite sign for investment shock
- ▶ First paper to use investment shocks as a tool to distinguish financial constraints

INTUITION ON INVESTMENT SHOCK

Resource constraint and capital accumulation (no adjustments costs for simplicity)

$$\begin{aligned}c + i &= y \\ k' &= (1 - \delta)k + \mathbf{v}i\end{aligned}$$

Combine these equations $\Rightarrow 1/\mathbf{v}$ is the relative price:

$$c + k'/\mathbf{v} = y + (1 - \delta)k/\mathbf{v}$$

Borrowing in consumption units (collateral vs. earnings):

$$b' \leq \theta_k(1 - \delta)\frac{k'}{\mathbf{v}'} \quad vs. \quad b' \leq \theta_\pi \pi$$

\Rightarrow Boom with less debt vs. boom with more debt in response to permanent $\mathbf{v} \uparrow$

ILLUSTRATION OF INVESTMENT SHOCK

- ▶ Think about an **airline** that purchases and uses airplanes
- ▶ Imagine a shock that makes the production of **airplanes** more efficient and lowers their relative price
- ▶ Implication of this shock for borrowing differs sharply depending on constraint
- ▶ If airlines use airplanes as collateral, their falling relative value **tightens the collateral constraint**
- ▶ By contrast, the **earnings-based constraint is relaxed** as cheaper airplanes increase the airline's profitability

3.1. EMPIRICAL VERIFICATION OF MODEL PREDICTIONS: AGGREGATE DATA

SVAR: TWO IDENTIFICATION SCHEMES

1. Long-run restrictions following Fisher (2006)
 - ▶ Identify unique driver of long-run dynamics in relative investment price
 - ▶ Restrictions consistent with my model
 2. Medium-horizon restrictions following Francis et al. (2014)
 - ▶ Identify main driver of dynamics at chosen horizon, e.g. 5 years
- ▶ I also set up a Monte Carlo experiment in which I estimate the SVAR on data simulated from the model

SVAR SPECIFICATION

Consider the $MA(\infty)$ representation of an SVAR:

$$Y_t = B(L)^{-1}u_t,$$

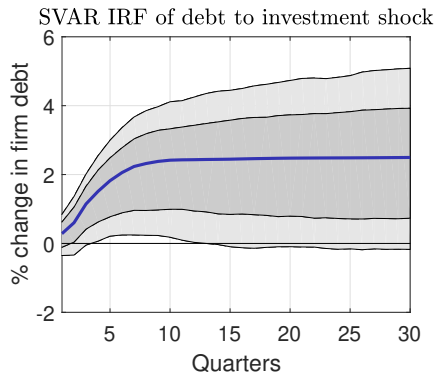
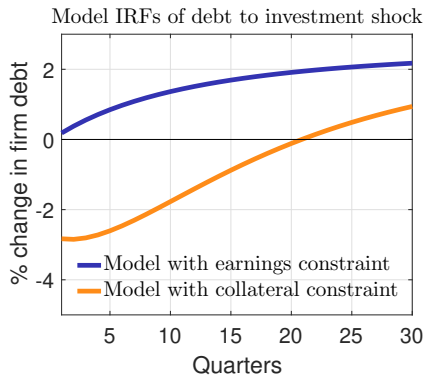
with $Y_t = [dlog(p_{kt}) \ dlog(y_t/n_t) \ log(n_t)]'$.

Long-run restrictions on $B(1)^{-1} = [B_0 - B_1 - \dots - B_p]^{-1}$:

1. p_{kt} only affected by first shock
2. y_t/n_t only affected by first and second shock

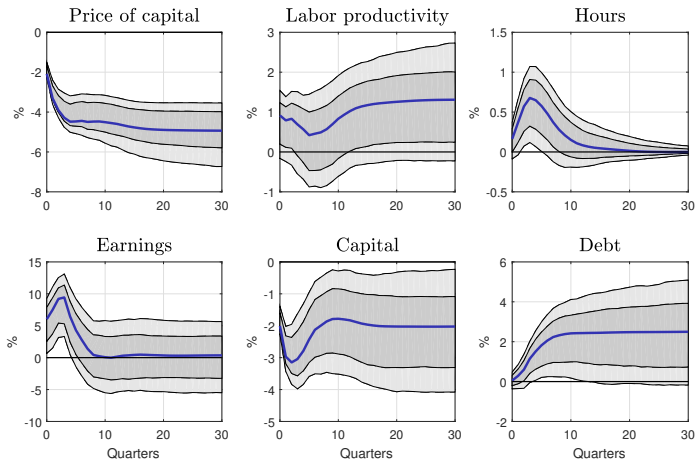
Add other variables of interest: earnings, capital, debt

SVAR: DEBT IRFS TO INVESTMENT SHOCK



- ▶ Bottom line: aggregate debt response consistent with earnings-based constraint, not with collateral constraint

SVAR: ALL IRFS TO INVESTMENT SHOCK



► Bottom line: other responses consistent with model and previous SVAR studies

Used equipment

TFP responses

Medium-horizon

Simulated data

Robustness

Hist decomp

3.2. EMPIRICAL VERIFICATION OF MODEL PREDICTIONS: FIRM-LEVEL DATA

IDEA OF FIRM-LEVEL ANALYSIS

- ▶ Merge Compustat and Dealscan:
~ 100,000 firm-quarter obs for ~ 4,000 distinct firms, 1994-2015
- ▶ Obtain micro responses to macro shock: Jordà (2005) method in a panel setting
- ▶ My paper is the first to do so for technological (rather than monetary) shocks
- ▶ To the extent that SVAR identification credible, the macro investment shock is an exogenous regressor
- ▶ Key idea: split responses across borrower types (earnings/collateral)

Summary stats

SPECIFICATION OF LOCAL PROJECTION

Estimate the horizon h IRF of total debt of firm i from running

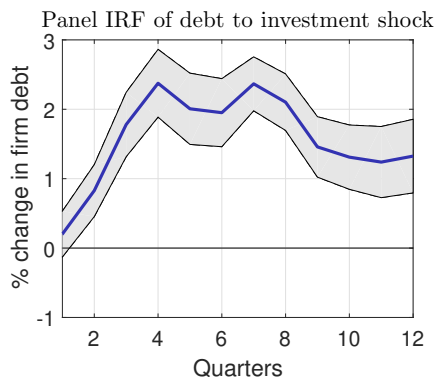
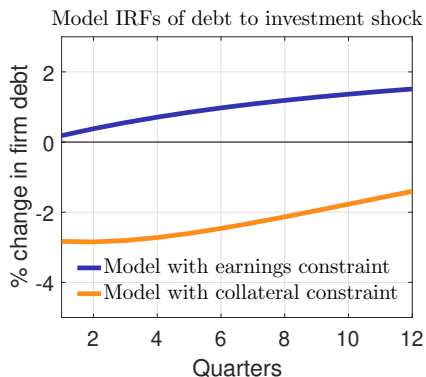
$$\log(b_{i,t+h}) = \alpha_h + \beta_h \hat{u}_{IST,t} + \gamma \mathbf{X}_{i,t-1} + \eta_{i,t+h}$$

and obtaining estimates of β_h , $h = 0, 1, 2, \dots, H$

Heterogeneous IRFs for ‘earnings borrowers’, ‘collateral borrowers’

$$\begin{aligned} \log(b_{i,t+h}) &= \alpha_h + \beta_h \hat{u}_{IST,t} + \gamma \mathbf{X}_{i,t-1} \\ &+ \beta_h^{earn} \mathbb{1}_{i,t,earn} \times \hat{u}_{IST,t} + \alpha_h^{earn} \mathbb{1}_{j,t,earn} \\ &+ \beta_h^{coll} \mathbb{1}_{i,t,coll} \times \hat{u}_{IST,t} + \alpha_h^{coll} \mathbb{1}_{i,t,coll} + \eta_{i,t+h} \end{aligned}$$

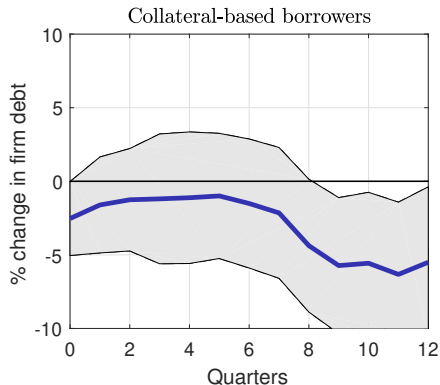
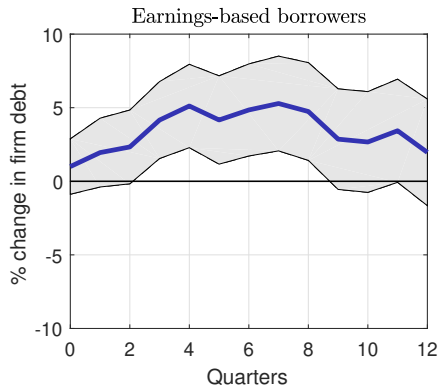
FIRM-LEVEL DEBT RESPONSE TO INVESTMENT SHOCK



- ▶ Bottom line: average firm debt response also consistent with earnings-based constraint, not with collateral constraint

HETEROGENEOUS IRFS ACROSS BORROWER TYPES

SPECIFICATION: 3-DIGIT INDUSTRY FE, SIZE, SALES GROWTH, OTHER MACRO SHOCKS



- Bottom line: split of debt response across borrower types consistent with model prediction across alternative constraints

Formal test

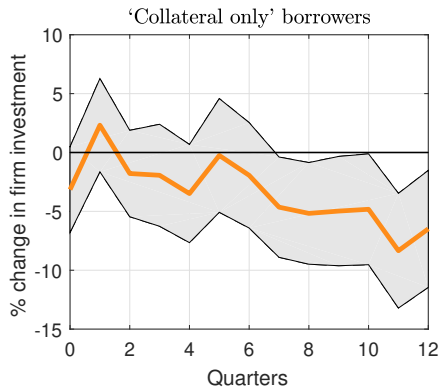
Alternative classification

IV setting

4 groups

HETEROGENEOUS IRFS ACROSS BORROWER TYPES

INVESTMENT RESPONSE



- ▶ Bottom line: similar pattern for firm investment (though volatile)

TAKING STOCK

- ▶ Proposed mechanism: positive investment shock raises debt levels if borrowing constraint is relaxed by the shock
 - ▶ Not the case with collateral constraint
 - ▶ True with earnings-based constraint
- ▶ Aggregate dynamics suggest that the earnings-based constraint more relevant for the economy as a whole
- ▶ Heterogeneous firm-level responses to the shocks are directly supportive of the suggested theoretical mechanism

4. EARNINGS-BASED CONSTRAINTS, STICKY PRICES & MARKUP CYCLICALITY

NEW KEYNESIAN MODELS AND PRICE MARKUPS

- ▶ Does constraint matter for “big questions”?
- ▶ Starting point: sticky prices key ingredient in quantitative macro models
- ▶ Consequence of price stickiness in NK models
 - ▶ Demand shocks \rightarrow countercyclical markups
 - ▶ Supply shocks \rightarrow procyclical markups
- ▶ See for example discussion by Nekarda and Ramey (2019)
- ▶ Distinction between supply and demand shocks key for stabilization tradeoffs

MARKUPS AND CREDIT CONSTRAINTS

- Consider the earnings-based borrowing constraint

$$\frac{b_t}{P_t(1 + r_t)} \leq \theta_\pi \pi_t$$

- Using the definition of earnings and assuming Cobb-Douglas production technology, this can be rewritten as

$$\frac{b_t}{P_t(1 + r_t)} \leq \theta_\pi y_t \left(1 - (1 - \alpha) \mathcal{M}_t^{-1} \right),$$

where \mathcal{M}_t is the markup, the ratio of price to marginal cost

MARKUPS AND CREDIT CONSTRAINTS

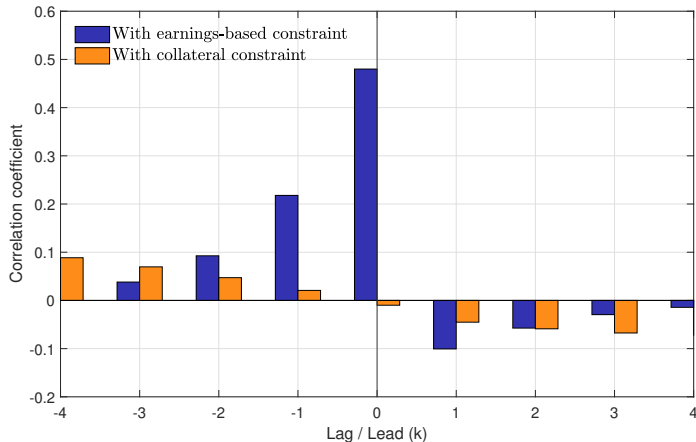
- ▶ *Direct* positive relation between markup and debt with earnings-based constraint (but not with collateral constraint)
- ▶ In the data, credit is highly procyclical, so procyclical markups make it easier for NK models to match the data
- ▶ Procyclical markups in NK models if ...
 1. Supply shocks more important than demand shocks
 2. Prices not meaningfully stickyor a combination of the two holds
- ▶ Relative strength of these forces? Quantitative question!
 - ▶ Answer by estimating a New Keynesian DSGE model

5. QUANTITATIVE DSGE MODEL WITH ADDITIONAL SHOCKS AND FRICTIONS

QUANTITATIVE MODEL

- ▶ Medium-scale NK model à la Smets and Wouters (2007) NK model details
- ▶ Estimate two versions with Bayesian methods on US data
 1. Earnings-based constraints
 2. Collateral constraints
- ▶ Potentially, many differences can be studied: parameters, moments, IRFS for many shocks, many variables ...
- ▶ Organize results around markups, sticky prices, supply vs. demand shocks
 - ▶ Directly relevant for policy tradeoffs
 - ▶ Highlights interaction with core NK transmission channel \Rightarrow many other applications

QUANTITATIVE MODEL: MARKUP CYCLICALITY



Model-implied correlation between output (t) and markup ($t+k$)

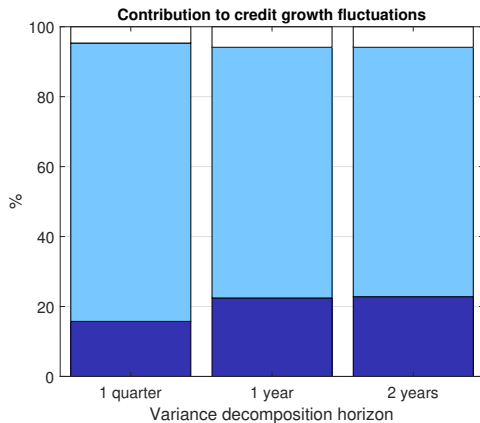
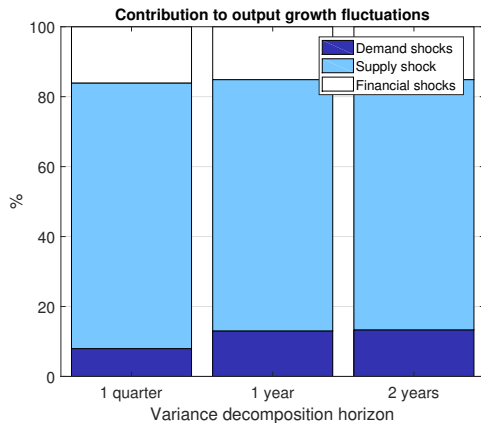
- Bottom line: earnings-based constraint implies procyclical markups

QUANTITATIVE MODEL: ESTIMATED RIGIDITIES

Credit constraint in model:	earnings-based	collateral
Rotemberg price adjustment parameter (90% HPD interval)	4.71 (4.51,4.95)	6.97 (4.97,8.50)
Calvo wage adjustment parameter (90% HPD interval)	0.84 (0.78,0.89)	0.69 (0.64,0.75)

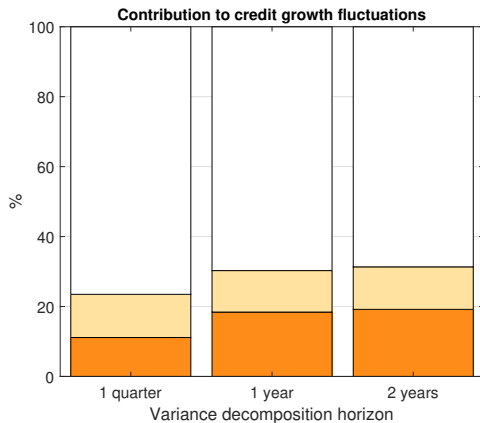
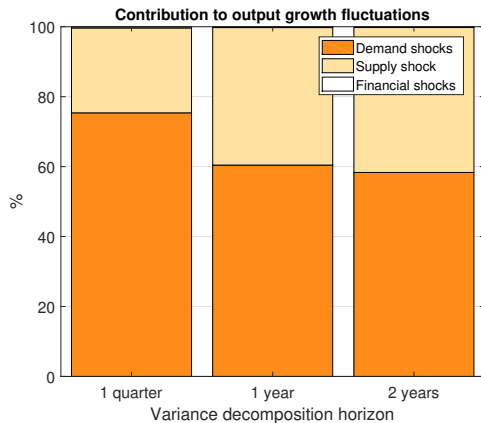
- ▶ Bottom line: earnings-based constraint implies lower price rigidities but higher wage rigidities than collateral constraint

QUANTITATIVE MODEL: SUPPLY VS. DEMAND SHOCKS



► Bottom line: supply shocks important with earnings-based constraint

QUANTITATIVE MODEL: SUPPLY VS. DEMAND SHOCKS



► Bottom line: demand shocks important with collateral constraint

QUANTITATIVE MODEL: BORROWING CONSTRAINT

- ▶ In comparison with a traditional collateral constraint, an earnings-based constraints implies
 1. Procyclical markups
 2. Lower price rigidity
 3. Supply shocks more important than demand shocks
- ▶ Constraint interacts *fundamentally* with the New Keynesian transmission mechanism and basic policy tradeoffs
- ▶ While scope of my analysis is to emphasize this interaction, it follows from these results that a variety of applications of NK DSGEs can be revisited!

6. CONCLUSION

CONCLUSION

- ▶ Start from empirical insight that movements in current earnings affect firms' ability to borrow
- ▶ Develop model-driven strategy to show relevance of earnings-based constraint in macro and micro data
- ▶ Earnings-based borrowing constraint interacts fundamentally with the key framework for quantitative macro questions
- ▶ As a whole, evidence makes the case for macroeconomists to change the benchmark way of modeling firm credit constraints

APPENDIX SLIDES

RELATION TO THE LITERATURE

- ▶ **Literature on financial frictions in macroeconomic fluctuations**

Kiyotaki and Moore (1997, 2012), Bernanke, Gertler, and Gilchrist (1999), Geanakoplos (2010), Gertler and Karadi (2011), Liu, Wang, and Zha (2013), Jermann and Quadrini (2012), ...

- ▶ **Direct micro evidence → new type of friction in business cycle model**

- ▶ **Empirical corporate finance literature on loan covenants**

Dichev and Skinner (2002), Chava and Roberts (2008), Sufi (2009), Roberts and Sufi (2009b), Bradley and Roberts (2015), Falato and Liang (2017), Chodorow-Reich and Falato (2017), Lian and Ma (2019), ...

- ▶ **Borrowing against earnings → consequences for aggregate fluctuations**

- ▶ **Literature on investment shocks**

Greenwood, Hercowitz, and Huffman (1988), Greenwood, Hercowitz, and Krusell (2000), Fisher (2006), Justiniano, Primiceri, and Tambalotti (2010, 2011), Schmitt-Grohe and Uribe (2012), ...

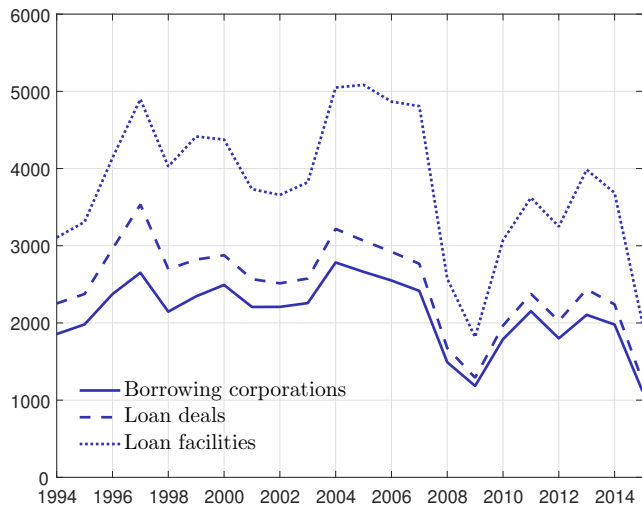
- ▶ **Examine borrowing dynamics that arise from investment shocks**

- ▶ **Existing papers in which flow variables restrict borrowing**

Kiyotaki (1998), Jappelli and Pagano (1989), Mendoza (2006), Bianchi (2011), Korinek (2011), Schmitt-Grohe and Uribe (2016a, 2016b), Greenwald (2018), ...

- ▶ **Study differences between flow and stock constraints in detail**

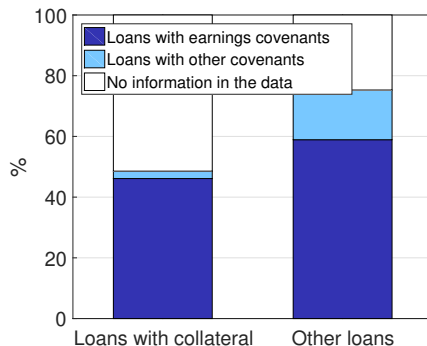
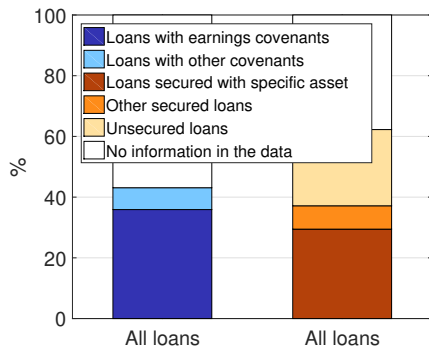
LOAN-LEVEL DATA: SAMPLE COVERAGE



ADDITIONAL WAYS IN WHICH EARNINGS MATTER

- ▶ Loan covenants not the only mechanism by which firms' borrowing ability is linked to their current earnings
- ▶ Examples:
 1. Credit ratings: S&P assesses 'risk profile' by evaluating 'core ratios'
→ strong emphasis on EBITDA
 2. Lenders' internal risk models
 3. Earnings multiples that lenders consider informally

COVENANTS VS. COLLATERAL IN THE DATA



► Bottom line: both are used in practice, jointly and individually

OTHER DEBT TYPES

- ▶ My analysis excludes debt securities (e.g. corporate bonds), which are often are not explicitly secured with collateral
- ▶ In the 2016 US flow of funds:
 - ▶ Outstanding loans: 7.6 tn USD
 - ▶ Outstanding debt securities: 5.8 tn USD
- ▶ Other studies find collateral to be unimportant in these debt types, see e.g. Azariadis, Kaas, and Wen (2016)
- ▶ I take this as additional motivation for considering other variables that may restrict debt access

MICROFOUNDATION: OVERVIEW

- ▶ In a detailed appendix to the paper I provide the following:
 1. An explicit formal rationalization, in which there is limited contract enforcement, that is, the borrower can divert funds
 - ▶ Collateral: lender can seize asset and sell it subject to **transaction cost**
 - ▶ Earnings-based constraint: lender can seize and operate the firm. Due to **limited information**, she values this contingency by applying a multiple
 2. A discussion of the literature on financial covenants and how this literature conceptualizes covenants from a theoretical point of view
 3. A discussion of regulatory aspects of earnings-based borrowing restrictions

FORMAL RATIONALIZATION: COLLATERAL

- ▶ Suppose that at the end of period t , when all transactions have been settled, the firm can default on its debt liabilities $\frac{b_{k,t}}{1+r_{k,t}}$
- ▶ Suppose legal environment is such that in the event of default the lender can address a court which grants it the right to seize the firm's collateral at the beginning of $t+1$. Lender sells collateral after depreciation at market prices, but incurs transaction cost which is a fraction $(1-\theta_k)$ of the resale value of capital
- ▶ Suppose lender and borrower are able to renegotiate. Borrower can offer a settlement payment $s_{k,t}$ to the lender, in combination with a promise to repay the amount of defaulted liabilities
- ▶ Settlement amount that lender agrees to needs to satisfy

$$s_{k,t} + \frac{b_{k,t}}{1+r_{k,t}} \geq \theta_k \mathbb{E}_t p_{k,t+1} (1-\delta) k_t.$$

- ▶ For firm to never choose to default, value of operating in absence of default must exceed the value of the firm after successful renegotiation.

$$\begin{aligned} s_{k,t} &\geq 0 \\ \theta_k \mathbb{E}_t p_{k,t+1} (1-\delta) k_t - \frac{b_{k,t}}{1+r_{k,t}} &\geq 0, \end{aligned}$$

which can be rearranged to the collateral constraint

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FORMAL RATIONALIZATION: EARNINGS CONSTRAINT

- ▶ Now environment is such that when the firm defaults on its liabilities $\frac{b_{\pi,t}}{1+r_{\pi,t}}$ at the end of $t + 1$, the court grants the lender the right to seize ownership of the firm. She can either operate the firm herself or sell it.
- ▶ Importantly, however, the lender is uncertain about the value of the firm in this case. Denote $\tilde{V}_{d,t}^{end}$ the end-of-period value of the firm after ownership rights have been transferred to lender.
- ▶ In order to determine this uncertain value, the lender uses the common practice of valuation by multiples.
- ▶ Specifically, it evaluates firm ownership after default by using fixed multiple of the last available realization of a fundamental profitability indicator, EBIDTA:

$$\tilde{V}_{d,t}^{end} \approx \theta_{\pi} \pi_t.$$

- ▶ The required settlement amount in the renegotiation process needs to satisfy the inequality

$$\begin{aligned} s_{\pi,t} &\geq 0 \\ \theta_{\pi} \pi_t - \frac{b_{k,t}}{1 + r_{k,t}} &\geq 0, \end{aligned}$$

which can be arranged to the earnings-based constraint

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THE FIRM'S PROBLEM

$$\max \mathbb{E}_0 \sum_{t=0}^{\infty} \Lambda_t d_t$$

subject to

$$d_t + \frac{\psi}{2}(d_t - \bar{d})^2 + i_t = \pi_t + \frac{b_{\pi,t}}{R_{\pi,t}} + \frac{b_{k,t}}{R_{k,t}} - b_{\pi,t-1} - b_{k,t-1}$$

$$\pi_t \equiv y_t - w_t n_t$$

$$y_t = \mathbf{z}_t k_{t-1}^{\alpha} n_t^{1-\alpha}$$

$$k_t = (1 - \delta)k_{t-1} + \mathbf{v}_t \left[1 - \frac{\phi}{2} \left(\frac{i_t}{i_{t-1}} - 1 \right)^2 \right] i_t$$

as well as

$$\frac{b_{\pi,t}}{1 + r_{\pi,t}} \leq \theta_{\pi} \pi_t$$

or

$$\frac{b_{k,t}}{1 + r_{k,t}} \leq \theta_k \mathbb{E}_t p_{kt+1} (1 - \delta) k_t$$

MODEL DETAILS: MORE ON FIRM'S PROBLEM

- ▶ Λ_t in the objective function denotes the firm owner's stochastic discount factor between periods 0 and t .
- ▶ There is a tax advantage for debt, following e.g. Hennessy and Whited (2005):

$$R_{j,t} = 1 + r_{j,t}(1 - \tau_j), \quad j \in \{\pi, k\}$$

- ▶ Calibrate model so that either one or other constraint is present: each constraint can be shut off by parameterizing $\theta_j = \mu_{j,t} = \tau_j = 0$, for $j \in \{k, \pi\}$ and $\forall t$

MODEL DETAILS: FIRM OPTIMALITY CONDITIONS

The firm's optimality conditions with respect to n_t , $b_{k,t}$, $b_{\pi,t}$ and k_t and i_t are derived as follows ($\psi = 0$):

$$\begin{aligned} F_{n,t} &= w_t \\ R_{k,t} \mathbb{E}_t \left\{ \frac{\Lambda_{t+1}}{\Lambda_t} \right\} + \mu_{k,t} \frac{R_{k,t}}{1 + r_{k,t}} &= 1, \\ R_{\pi,t} \mathbb{E}_t \left\{ \frac{\Lambda_{t+1}}{\Lambda_t} \right\} + \mu_{\pi,t} \frac{R_{\pi,t}}{1 + r_{\pi,t}} &= 1, \\ Q_t &= \mathbb{E}_t \left\{ \frac{\Lambda_{t+1}}{\Lambda_t} [(1 - \delta)Q_{t+1} + F_{k,t+1} + \mu_{\pi,t+1}\theta_{\pi}F_{k,t+1}] + \mu_{k,t}\theta_k(1 - \delta)p_{k,t+1} \right\} \\ Q_t v_t [(1 - \Phi_t) - \Phi_{1,t}i_t] + \mathbb{E}_t \left\{ \frac{\Lambda_{t+1}}{\Lambda_t} Q_{t+1} v_{t+1} \Phi_{-1,t+1} i_{t+1} \right\} &= 1 \end{aligned}$$

MODEL DETAILS: HOUSEHOLD AND GOVERNMENT

The household's objective is to maximize expected discounted lifetime utility

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t (\log(c_t) + \chi \log(1 - n_t)),$$

subject to the budget constraint

$$c_t + \frac{b_{\pi,t}}{1 + r_{\pi,t}} + \frac{b_{k,t}}{1 + r_{k,t}} + p_t s_t + T_t = w_t n_t + b_{\pi,t-1} + b_{k,t-1} + s_{t-1}(d_t + p_t).$$

Government budget balance requires

$$T_t = \frac{b_{k,t}}{R_{k,t}} - \frac{b_{k,t}}{(1 + r_{k,t})} + \frac{b_{\pi,t}}{R_{\pi,t}} - \frac{b_{\pi,t}}{(1 + r_{\pi,t})}.$$

MODEL DETAILS: HH OPTIMALITY CONDITIONS

The household's optimality conditions with respect to n_t , $b_{k,t}$, $b_{\pi,t}$ and s_t are

$$u_{c_t} w_t + u_{n_t} = 0$$

$$u_{c_t} = \beta(1 + r_{k,t})\mathbb{E}_t u_{c_{t+1}}$$

$$u_{c_t} = \beta(1 + r_{\pi,t})\mathbb{E}_t u_{c_{t+1}}$$

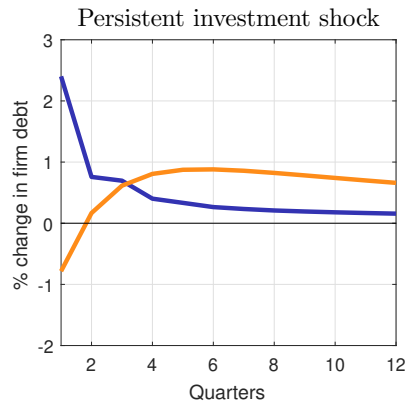
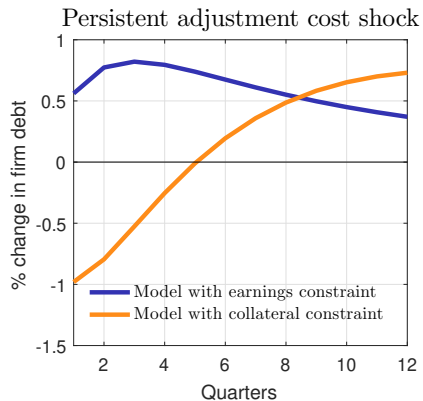
$$u_{c_t} p_t = \beta \mathbb{E}_t (d_{t+1} + p_{t+1}) u_{c_{t+1}},$$

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MODEL CALIBRATION

Parameter	Value	Comment on parameterization
<i>(a) Structural parameters</i>		
α	0.33	Capital share of output of 1/3
δ	0.025	Depreciation rate of 2.5% per quarter
$\bar{\phi}$	4	Prior of Smets and Wouters (2007)
β	0.9752	Target steady state annualized interest rate of 6.6%*
χ	1.87	Target $n = 0.3$ in steady state
ψ	0.46	Jermann and Quadrini (2012)
<i>(b) Model with earnings-based constraint only</i>		
θ_k	0	Shut off collateralized borrowing
τ_k	0	Shut off collateralized borrowing
θ_π	4.6×4	Weighted average value of debt-to-EBITDA covenants*
τ_π	0.35	Following Hennessy and Whited (2005)
<i>(c) Model with collateral constraint only</i>		
θ_k	0.817	Match steady state debt of parameterization in Panel (b)
τ_k	0.35	Following Hennessy and Whited (2005)
θ_π	0	Shut off earnings-based borrowing
τ_π	0	Shut off earnings-based borrowing

MODEL IRFS TO OTHER INVESTMENT MARGIN SHOCKS

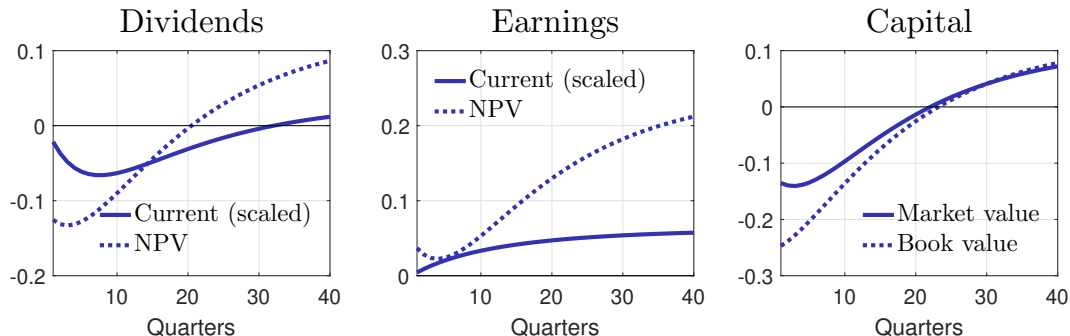


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MORE INTUITION: STOCKS VS. FLOWS

- ▶ Asset pricing theory: the value of an asset equals the net present value of flows derived from the asset
 - ▶ Hayashi (1982): $q_t k_t = \sum_{\tau}^{\infty} \Lambda_{t,\tau} d_{t+\tau}$
- ▶ “Asset-based” and “flow-based” borrowing the same?
- ▶ Two aspects are different in the constraint I propose
 1. **Timing**: current flows rather than NPV
 2. **Definition**: earnings rather than dividends
- ▶ *Definition* drives the different dynamics

MECHANICS BEHIND INVESTMENT SHOCK IRFS



- Bottom line: positive response driven by “earnings vs. dividends”, instead of “current flow vs. NPV of flow”

IST VS. MEI

- ▶ The term v_t can reflect two distinct exogenous disturbances:
 1. Investment-specific technology (IST): productivity at turning consumption into investment
 2. Marginal efficiency of investment (MEI): productivity at turning investment into capital
- ▶ In one-sector models, they collapse to the same wedge, but 1 corresponds empirically to inverse relative price of investment
- ▶ Detailed discussions in Justiniano, Primiceri, and Tambalotti, (2010, 2011), Schmitt-Grohe and Uribe (2012)
- ▶ In my model, both IST and MEI give rise to my predictions
- ▶ In my empirical verification, I identify IST shocks as I rely on the equipment investment deflator for identification

SVAR: DATA AND SAMPLE

- ▶ Use data for US nonfinancial business sector
- ▶ Nominal data deflated with consumption deflator for nondurable goods & services
- ▶ For investment price, use equipment deflator
 - ▶ In loan data, equipment category is largest one, three times larger than real estate
Collateral types
 - ▶ Use Gordon-Cummins-Violante price for robustness NIPA vs. GCV
- ▶ Show results for 1952:Q1 - 2016:Q4 sample, with 4 lags and 68% bands based on bootstrapping techniques

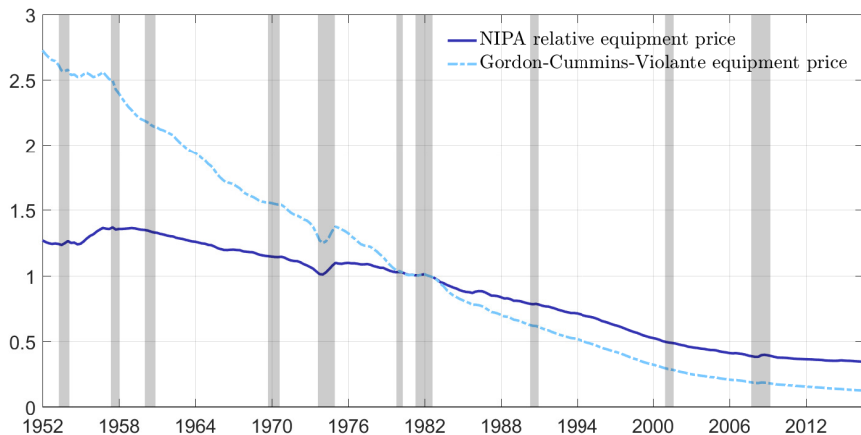
FREQUENCY OF COLLATERAL CATEGORIES

Collateral type	Number of loan facilities	Volume in bn USD
Property & Equipment	2292	353
Accounts Receivable and Inventory	1801	332
Intangibles	1367	238
Cash and Marketable Securities	989	328
Real Estate	737	142
Ownership of Options/Warrants	104	19
Patents	84	12
Plant	50	12
Agency Guarantee	25	6

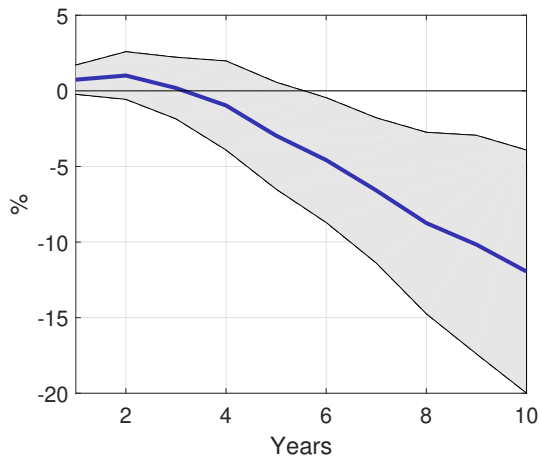
The table excludes the categories “unknown”, “all”, and “other”

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THE RELATIVE PRICE OF EQUIPMENT

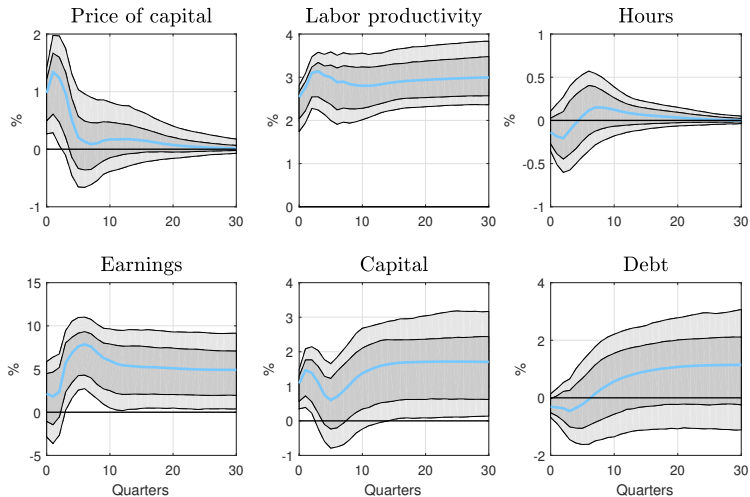


RESPONSE OF USED EQUIPMENT PRICES (AIRPLANES)



► Bottom line: shock also reduces price of *used* capital

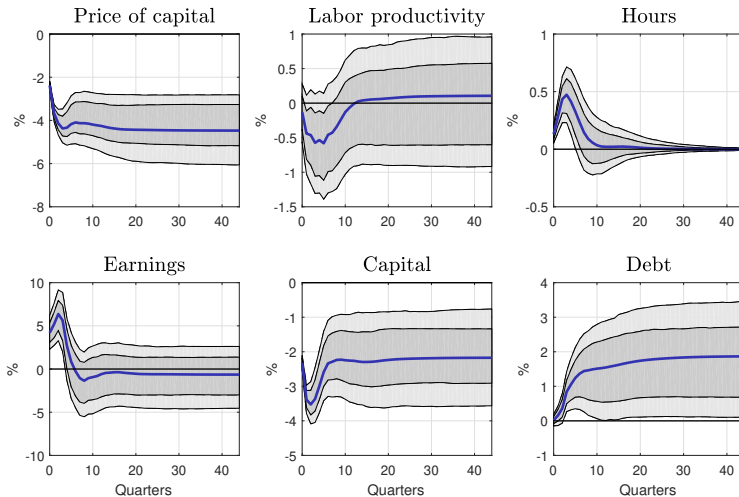
SVAR: IRFS TO TFP SHOCK



SVAR: MEDIUM-HORIZON RESTRICTIONS

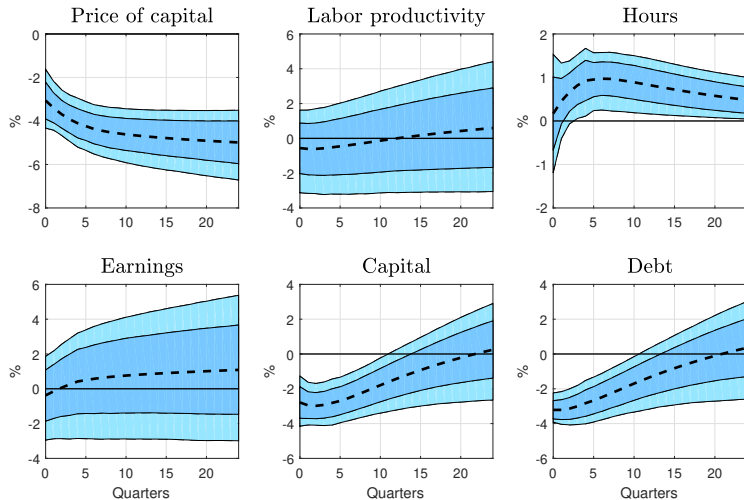
- ▶ Proposed to overcome weaknesses of the long-run identification method (see e.g. Faust and Leeper, 1997)
- ▶ Idea: Identify a shock such that its forecast error variance decomposition share for a the price of equipment at a specific finite horizon h is maximized
- ▶ Implementation: take initial estimate of B_0^{-1} (e.g. simple Choleski), then take an orthonormal rotation of this matrix such that the identifying restriction is satisfied
 - ▶ Specifically, I maximize the cumulated FEVD based on DB_0^{-1} up to horizon h by finding the optimal D , such that $D'D = I$

SVAR: IRFS WITH MEDIUM-HORIZON RESTRICTIONS



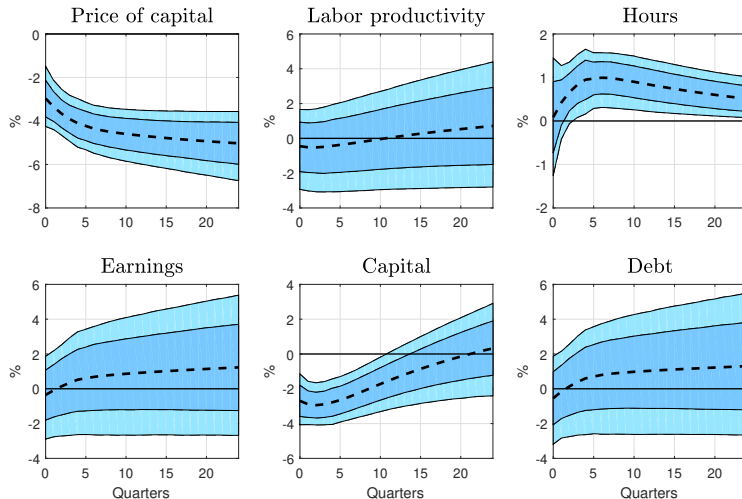
SVAR RESULTS FOR SIMULATED DATA

DATA GENERATED FROM COLLATERAL CONSTRAINT MODEL



SVAR RESULTS FOR SIMULATED DATA

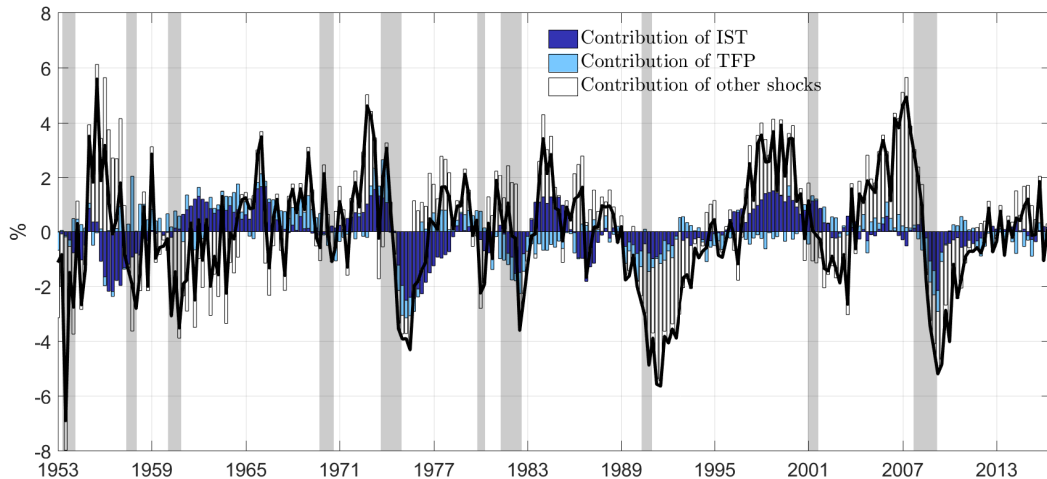
DATA GENERATED FROM EARNINGS-BASED CONSTRAINT MODEL



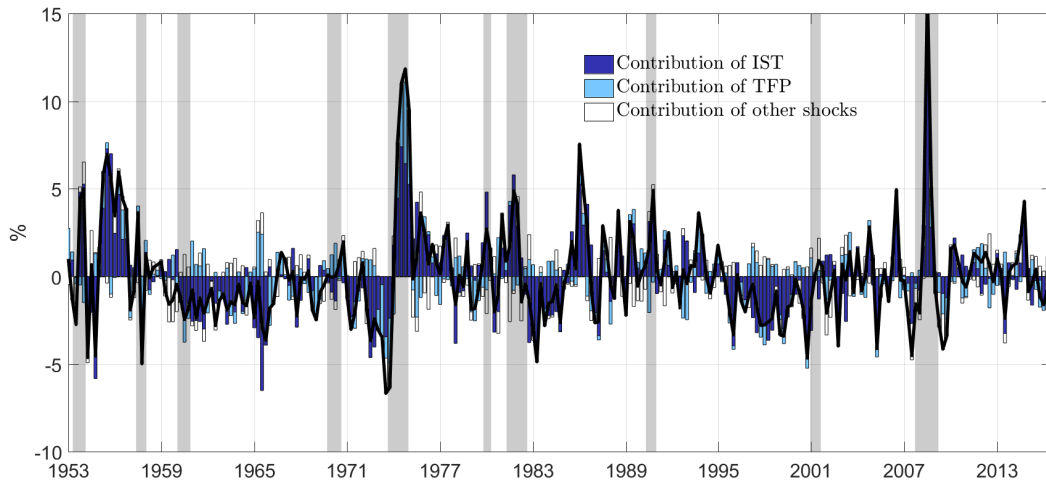
SVAR: GENERAL ROBUSTNESS CHECKS

- ▶ Split sample in the early 1980s
 - ▶ First part of the sample: shapes of the IRFs are preserved, while bands get wider
 - ▶ Second part of the sample: debt response again positive and significant, but somewhat more hump-shaped
- ▶ For firm debt, use loans and debt securities separately
 - ▶ Total debt IRF mainly driven by the loan dynamics, while response for debt securities is very noisy, and even negative for the first three quarters
- ▶ Use GVC equipment price instead of relative NIPA deflators
 - ▶ The results are very similar

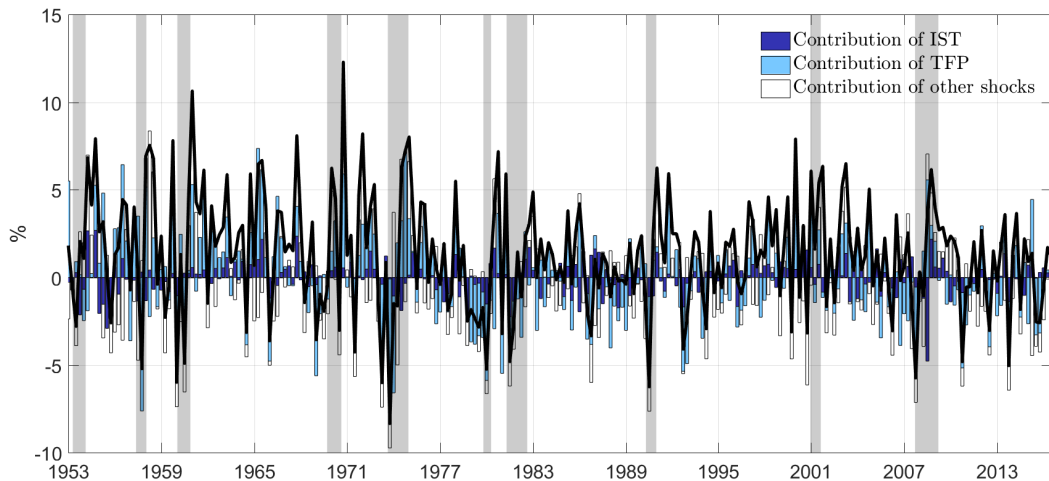
SVAR: HISTORICAL DECOMPOSITION OF DEBT



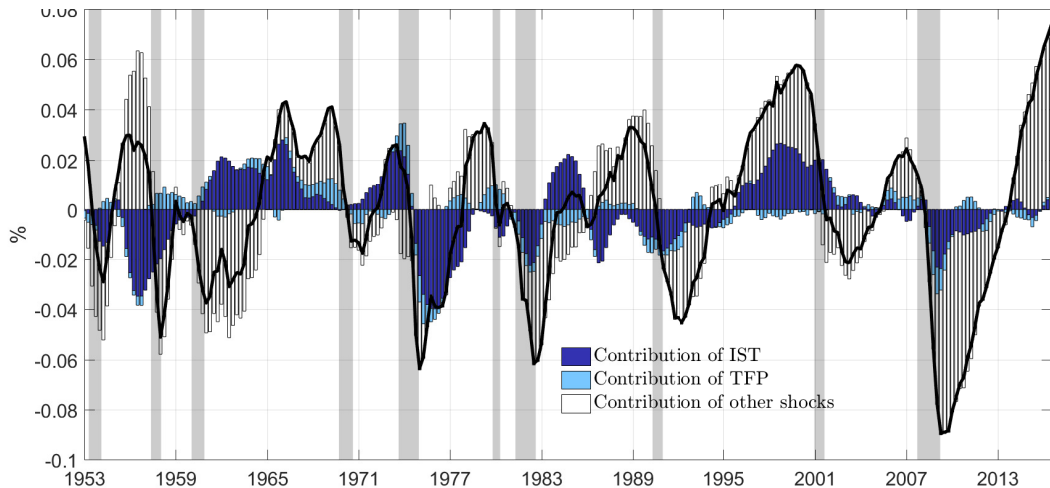
HISTORICAL DECOMPOSITION OF EQUIPMENT PRICE



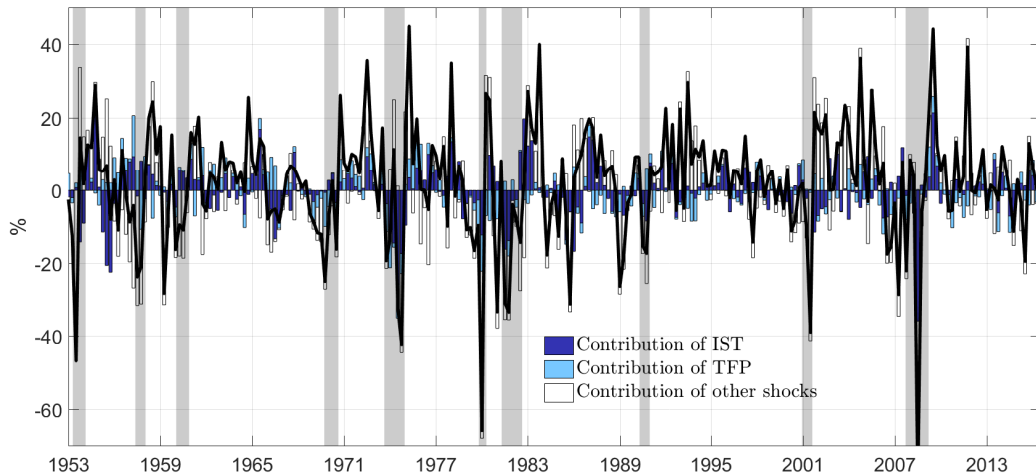
HISTORICAL DECOMPOSITION OF PRODUCTIVITY



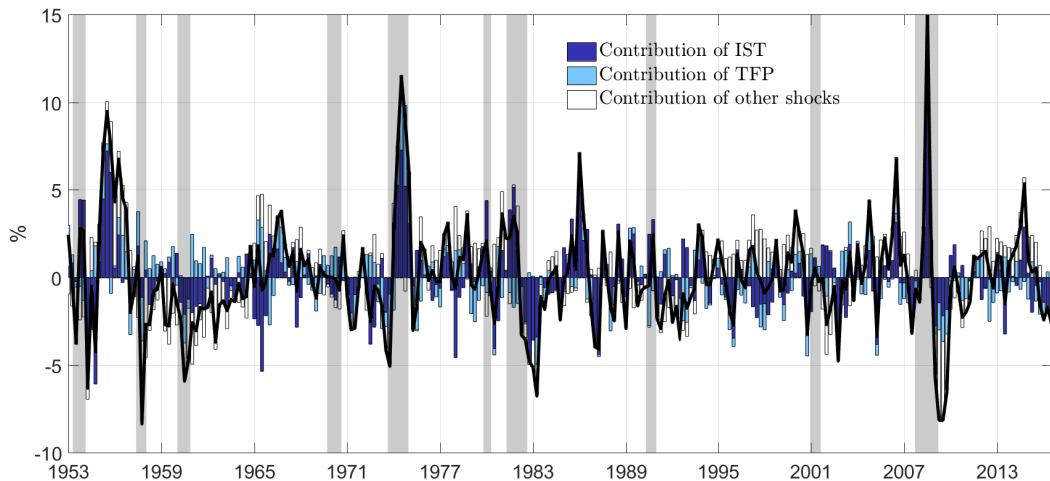
HISTORICAL DECOMPOSITION OF HOURS WORKED



HISTORICAL DECOMPOSITION OF CAPITAL



HISTORICAL DECOMPOSITION OF EARNINGS



SUMMARY STATISTICS: COMPUSTAT-DEALSCAN

TABLE: FULL COMPUSTAT-DEALSCAN PANEL ($N = 4,484$)

	Firm-qrt obs	Mean	SD	Min	Median	Max
Real total assets (bn 2009 USD)	153,554	4.6	16.2	0.0	0.8	542.7
Real sales (bn 2009 USD)	153,554	1.0	3.7	0.0	0.2	124.3
Real sales growth (percent)	149,049	3.4	16.6	-27.6	1.9	43.3
Employment (thousands)	136,575	14.3	53.5	0.0	2.8	2200.0
Real debt liab. (bn 2009 USD)	153,554	1.4	6.4	0.0	0.2	339.6
Cash ratio	153,543	0.1	0.1	0.0	0.0	0.9
Market-to-book ratio	140,325	1.8	1.8	0.5	1.4	45.0
Book leverage (broad)	153,543	0.6	0.2	0.1	0.6	1.3
Book leverage (narrow)	153,543	0.4	0.2	0.0	0.3	0.9

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SUMMARY STATISTICS: COMPUSTAT-DEALSCAN

	Firm-qrt obs	Mean	SD	Min	Median	Max
Panel (a): Borrowers with earnings-based covenants only ($N = 1,721$)						
Real total assets (bn 2009 USD)	46,680	5.4	17.2	0.0	1.6	455.6
Real sales (bn 2009 USD)	46,680	1.1	2.7	0.0	0.4	55.0
Real sales growth (percent)	46,044	4.9	16.3	-27.6	2.8	43.3
Employment (thousands)	43,164	17.7	40.8	0.0	5.4	707.9
Real debt liab. (bn 2009 USD)	46,680	1.8	6.1	0.0	0.4	251.9
Cash ratio	46,668	0.1	0.1	0.0	0.0	0.9
Market-to-book ratio	43,848	1.7	1.0	0.5	1.5	16.8
Book leverage (broad)	46,668	0.6	0.2	0.1	0.6	1.3
Book leverage (narrow)	46,668	0.4	0.2	0.0	0.3	0.9
Panel (b): Borrowers with collateral only ($N = 1,470$)						
Real total assets (bn 2009 USD)	28,128	3.5	10.2	0.0	0.6	192.8
Real sales (bn 2009 USD)	28,128	0.8	3.0	0.0	0.1	86.3
Real sales growth (percent)	26,652	4.7	17.6	-27.6	2.8	43.3
Employment (thousands)	25,860	12.5	52.6	0.0	2.1	1900.0
Real debt liab. (bn 2009 USD)	28,128	1.5	4.4	0.0	0.2	131.1
Cash ratio	28,128	0.1	0.1	0.0	0.0	0.9
Market-to-book ratio	25,428	1.7	1.5	0.5	1.3	45.0
Book leverage (broad)	28,128	0.7	0.3	0.1	0.7	1.3
Book leverage (narrow)	28,128	0.5	0.3	0.0	0.4	0.9

SUMMARY STATISTICS: COMPUSTAT-DEALSCAN

	Firm-qrt obs	Mean	SD	Min	Median	Max
Penal (c): Borrowers with both ($N = 1,855$)						
Real total assets (bn 2009 USD)	44,124	2.2	9.8	0.0	0.6	513.3
Real sales (bn 2009 USD)	44,124	0.5	1.3	0.0	0.1	51.9
Real sales growth (percent)	42,864	6.0	17.8	-27.6	3.5	43.3
Employment (thousands)	41,652	9.2	24.0	0.0	2.6	355.0
Real debt liab. (bn 2009 USD)	44,124	1.0	5.6	0.0	0.2	307.5
Cash ratio	44,124	0.1	0.1	0.0	0.0	0.9
Market-to-book ratio	40,764	1.6	0.9	0.5	1.3	12.0
Book leverage (broad)	44,124	0.6	0.2	0.1	0.6	1.3
Book leverage (narrow)	44,124	0.5	0.3	0.0	0.5	0.9
Panel (d): Borrowers without either ($N = 844$)						
Real total assets (bn 2009 USD)	20,424	12.8	26.4	0.0	4.2	375.8
Real sales (bn 2009 USD)	20,424	2.6	5.6	0.0	0.7	66.0
Real sales growth (percent)	20,040	4.7	17.8	-27.6	2.7	43.3
Employment (thousands)	14,724	39.4	83.9	0.0	10.3	1383.0
Real debt liab. (bn 2009 USD)	20,424	3.8	10.2	0.0	1.2	216.3
Cash ratio	20,424	0.1	0.1	0.0	0.0	0.9
Market-to-book ratio	18,048	1.7	1.0	0.5	1.4	12.7
Book leverage (broad)	20,424	0.6	0.2	0.1	0.6	1.3
Book leverage (narrow)	20,424	0.4	0.2	0.0	0.3	0.9

FIRM-LEVEL DATA AND IMPLEMENTATION

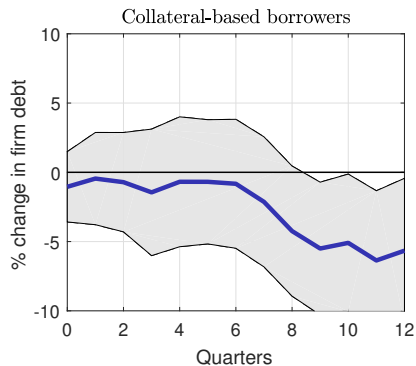
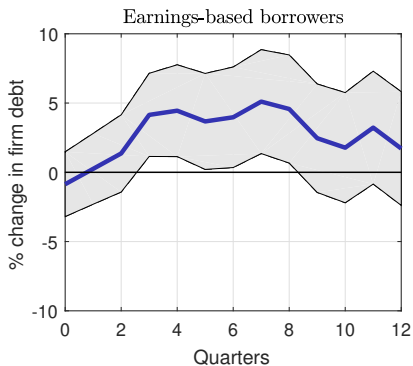
- ▶ Endogenous selection into being particular borrower type
 1. Control for firm size, firms sales growth, 3-digit industry FE
 2. Control for firm FE and sales growth
- ▶ In all specifications add one lag of $\log(\text{debt})$, two lags of the shock, time trend
- ▶ Add macro control based on orthogonalized debt innovations
- ▶ Two alternative ways to construct $\mathbb{1}_{i,t,coll}$
- ▶ Loan info “sparse”, sample reduced with $\mathbb{1}_{i,t,earn}$ and $\mathbb{1}_{i,t,coll}$
- ▶ Compute 90% bands, S.E. clustered at 3-digit industry level

FORMAL TEST

	Classification based on specific assets	Classification based on secured revolvers
$\beta_0^{earn} - \beta_0^{coll}$	0.0328 (0.0213)	-0.0029 (0.0248)
$\beta_1^{earn} - \beta_1^{coll}$	0.0308 (0.0318)	0.0004 (0.0285)
$\beta_2^{earn} - \beta_2^{coll}$	0.0340 (0.0282)	0.0162 (0.0307)
$\beta_3^{earn} - \beta_3^{coll}$	0.0511 (0.0334)	0.0511 (0.0365)
$\beta_4^{earn} - \beta_4^{coll}$	0.0600* (0.0345)	0.0464 (0.0404)
$\beta_5^{earn} - \beta_5^{coll}$	0.0491 (0.0331)	0.0384 (0.0370)
$\beta_6^{earn} - \beta_6^{coll}$	0.0581* (0.0351)	0.0400 (0.0395)
$\beta_7^{earn} - \beta_7^{coll}$	0.0688* (0.0353)	0.0642* (0.0356)
$\beta_8^{earn} - \beta_8^{coll}$	0.0865** (0.0355)	0.0813** (0.0358)
$\beta_9^{earn} - \beta_9^{coll}$	0.0810** (0.0389)	0.0725* (0.0386)
$\beta_{10}^{earn} - \beta_{10}^{coll}$	0.0773* (0.0406)	0.0624 (0.0403)
$\beta_{11}^{earn} - \beta_{11}^{coll}$	0.0927** (0.0420)	0.0893** (0.0432)
$\beta_{12}^{earn} - \beta_{12}^{coll}$	0.0690 (0.0433)	0.0658 (0.0442)

HETEROGENEOUS IRFS ACROSS BORROWER TYPES

ALTERNATIVE BORROWER CLASSIFICATION



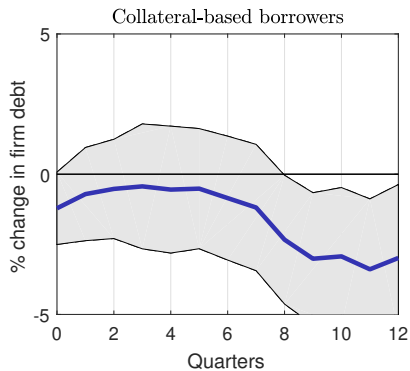
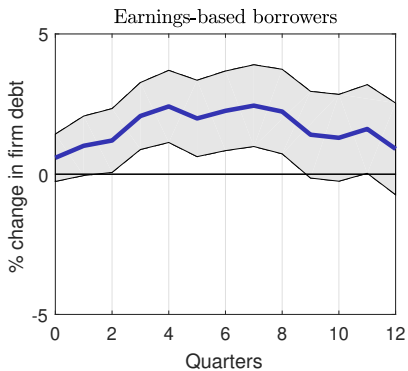
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IV SPECIFICATION (1/3)

$$\begin{aligned} \log(b_{i,t+h}) = & \alpha_h + \beta_h p_{k,t} + \gamma X_{i,t-1} \\ & + \beta_h^{earn} \mathbb{1}_{i,t,earn} \times p_{k,t} + \alpha_h^{earn} \mathbb{1}_{i,t,earn} \\ & + \beta_h^{coll} \mathbb{1}_{i,t,coll} \times p_{k,t} + \alpha_h^{coll} \mathbb{1}_{i,t,coll} + \gamma t + \eta_{i,t+h} \end{aligned}$$

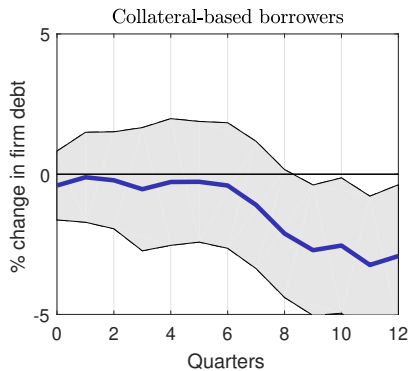
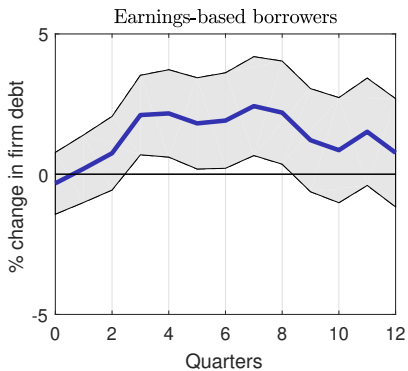
where $p_{k,t}$ is defined as in in the SVAR model. This equation is then estimated by using $\hat{u}_{IST,t}$ as an IV for $p_{k,t}$

IV SPECIFICATION (2/3)



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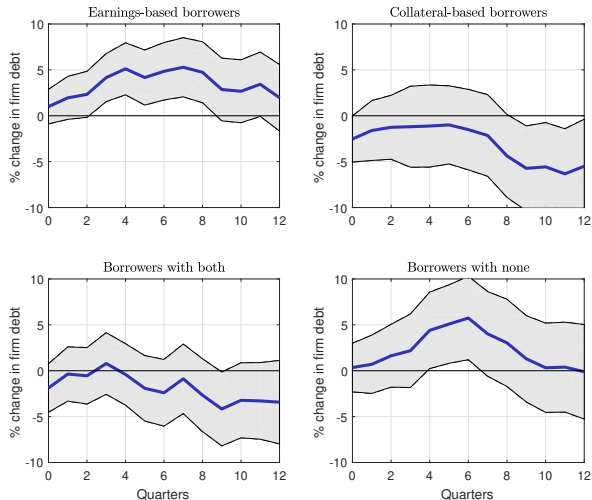
IV SPECIFICATION (3/3)



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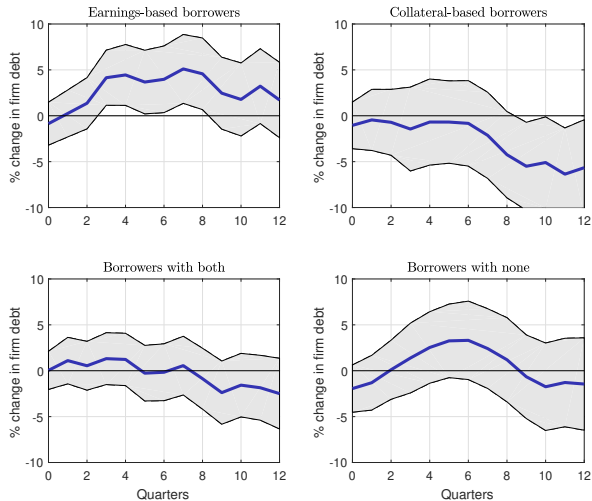
HETEROGENEOUS IRFS ACROSS BORROWER TYPES

SPECIFICATION WITH: 3-DIGIT INDUSTRY FE, FIRM SIZE, AND SALES GROWTH



HETEROGENEOUS IRFS ACROSS BORROWER TYPES

ALTERNATIVE BORROWER CLASSIFICATION



QUANTITATIVE MODEL: DETAILS

- ▶ Closely related model: Jermann and Quadrini (2012) variation of Smets and Wouters (2007)
- ▶ Continuum of households supply differentiated labor in monopolistic competition s.t. Calvo-style wage setting
- ▶ Continuum of firms supply differentiated consumption good in monopolistic competition s.t. Rotemberg price setting
- ▶ Firms own and accumulate the capital stock, borrow from household's subject to tax advantage and constraint
- ▶ Monetary authority which follows a Taylor rule, government with exogenous spending shocks
- ▶ Use 8 observables (including business sector credit) and 8 shocks

QUANTITATIVE MODEL: DETAILS

Differences to Smets and Wouters (2007):

- ▶ Firms rather than households own and accumulate capital
- ▶ Rotemberg price adjustment costs rather than Calvo pricing
- ▶ The monetary policy maker targets output deviations from steady state rather than from the natural level
- ▶ Firms have access to debt and receive a tax advantage on debt

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FULL DECOMPOSITIONS WITH EARNINGS-BASED CONSTRAINT

Variable	Horizon	TFP	Inv	Pref	Price	Wage	Gov	Mon	Fin
Output growth	1 quarter	19.79	0.28	0.03	56.12	0.04	6.60	1.06	16.08
	1 year	18.90	0.54	0.04	52.91	0.04	10.07	2.38	15.11
	2 years	18.84	0.56	0.04	52.67	0.04	9.99	2.74	15.12
Consumption growth	1 quarter	27.03	0.52	34.50	10.86	0.04	3.40	21.77	1.88
	1 year	42.75	0.54	22.45	11.15	0.06	2.08	18.68	2.28
	2 years	47.65	0.89	20.29	10.26	0.07	1.88	16.87	2.09
Investment growth	1 quarter	16.73	23.26	0.18	11.91	0.03	0.84	45.70	1.35
	1 year	20.44	19.10	0.22	14.41	0.05	0.66	43.21	1.91
	2 years	20.33	19.12	0.22	14.46	0.05	0.67	43.25	1.91
Inflation	1 quarter	33.71	0.82	0.08	48.11	0.07	8.41	0.04	8.77
	1 year	28.93	0.80	0.07	45.43	0.06	13.23	2.51	8.97
	2 years	28.86	0.81	0.07	45.33	0.06	13.15	2.67	9.05
Interest rate	1 quarter	0.02	0.20	0.01	28.48	0.00	0.65	51.86	18.79
	1 year	5.31	1.68	0.04	15.69	0.02	0.29	64.73	12.23
	2 years	10.57	2.63	0.06	14.06	0.04	0.27	61.40	10.97
Employment growth	1 quarter	48.37	2.46	0.03	24.79	0.03	7.02	11.68	5.62
	1 year	44.24	2.40	0.03	22.52	0.03	14.19	11.40	5.19
	2 years	44.09	2.52	0.03	22.49	0.03	14.14	11.47	5.22
Wage growth	1 quarter	32.96	0.74	0.04	48.54	0.02	8.55	0.00	9.15
	1 year	28.87	0.80	0.05	45.95	0.02	13.41	1.80	9.11
	2 years	28.72	0.83	0.05	45.76	0.02	13.31	2.19	9.13
Credit growth	1 quarter	37.02	0.54	0.07	42.50	0.07	13.16	1.97	4.66
	1 year	30.25	0.86	0.07	41.37	0.06	17.73	3.78	5.88
	2 years	30.08	0.89	0.07	41.17	0.06	17.56	4.29	5.88

FULL DECOMPOSITIONS WITH COLLATERAL CONSTRAINT

Variable	Horizon	TFP	Inv	Pref	Price	Wage	Gov	Mon	Fin
Output growth	1 quarter	16.03	15.26	7.01	8.03	0.21	30.33	22.78	0.34
	1 year	29.21	13.43	5.7	9.22	0.89	22.42	18.89	0.25
	2 years	31.12	13.25	5.51	9.19	1.13	21.07	18.5	0.24
Consumption growth	1 quarter	20.71	0.01	43.72	4.85	0.89	0.25	29.55	0.00
	1 year	36.76	0.09	33.21	6.26	1.72	0.38	21.58	0.01
	2 years	40.76	0.21	30.61	6.45	2.02	0.41	19.54	0.01
Investment growth	1 quarter	10.78	57.46	0.01	4.18	0.44	0.04	25.65	1.44
	1 year	18.71	51.69	0.01	5.81	0.94	0.11	21.72	1.01
	2 years	21.1	49.51	0.04	6.15	1.23	0.15	20.88	0.95
Inflation	1 quarter	47.32	1.62	2.54	43.42	0.76	1.27	3.02	0.05
	1 year	49.39	3.73	4.85	31.73	0.96	3.22	6.00	0.13
	2 years	46.57	4.68	5.57	29.86	0.89	5.13	7.08	0.22
Interest rate	1 quarter	3.41	0.28	0.33	3.28	0.06	0.31	92.32	0.01
	1 year	5.93	0.77	0.87	3.40	0.12	0.64	88.25	0.02
	2 years	6.06	0.94	1.06	3.49	0.12	0.98	87.31	0.04
Employment growth	1 quarter	71.29	5.82	2.12	0.28	0.36	12.01	7.98	0.14
	1 year	70.18	6.33	2.22	0.89	0.60	11.23	8.42	0.13
	2 years	69.75	6.59	2.22	1.01	0.70	10.97	8.62	0.12
Wage growth	1 quarter	53.94	0.05	1.13	41.4	2.66	0.00	0.81	0.00
	1 year	63.64	0.09	0.84	32.87	1.97	0.00	0.58	0.00
	2 years	64.13	0.10	0.87	32.38	1.95	0.00	0.57	0.00
Credit growth	1 quarter	4.26	0.00	0.90	7.97	0.12	0.56	9.67	76.52
	1 year	4.42	2.11	0.90	7.33	0.11	0.51	14.89	69.72
	2 years	4.70	2.87	0.91	7.32	0.14	0.52	14.88	68.66

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