Uncertainty, Investment and Cash Holding: Theory and Firm-level Evidence

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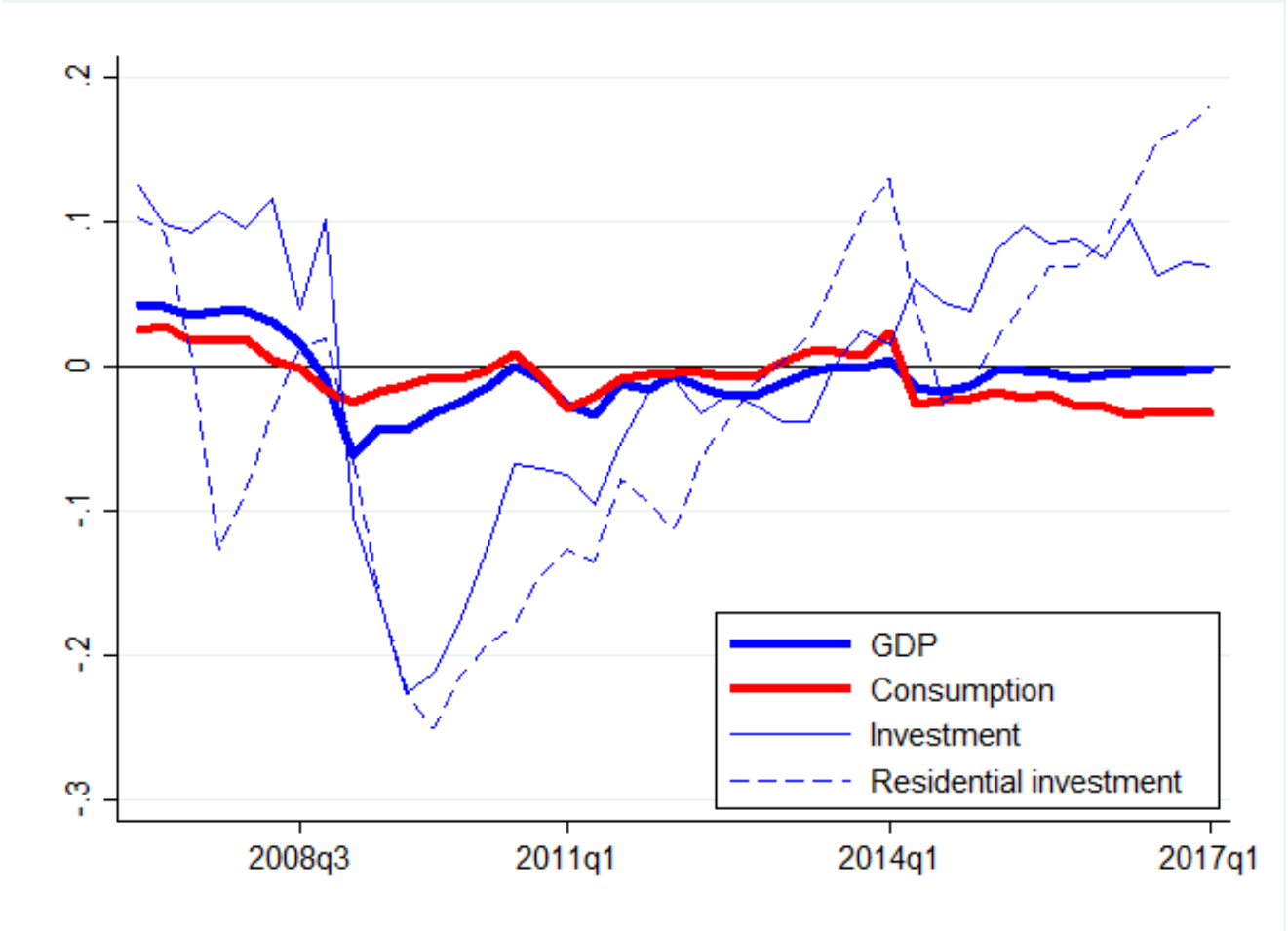
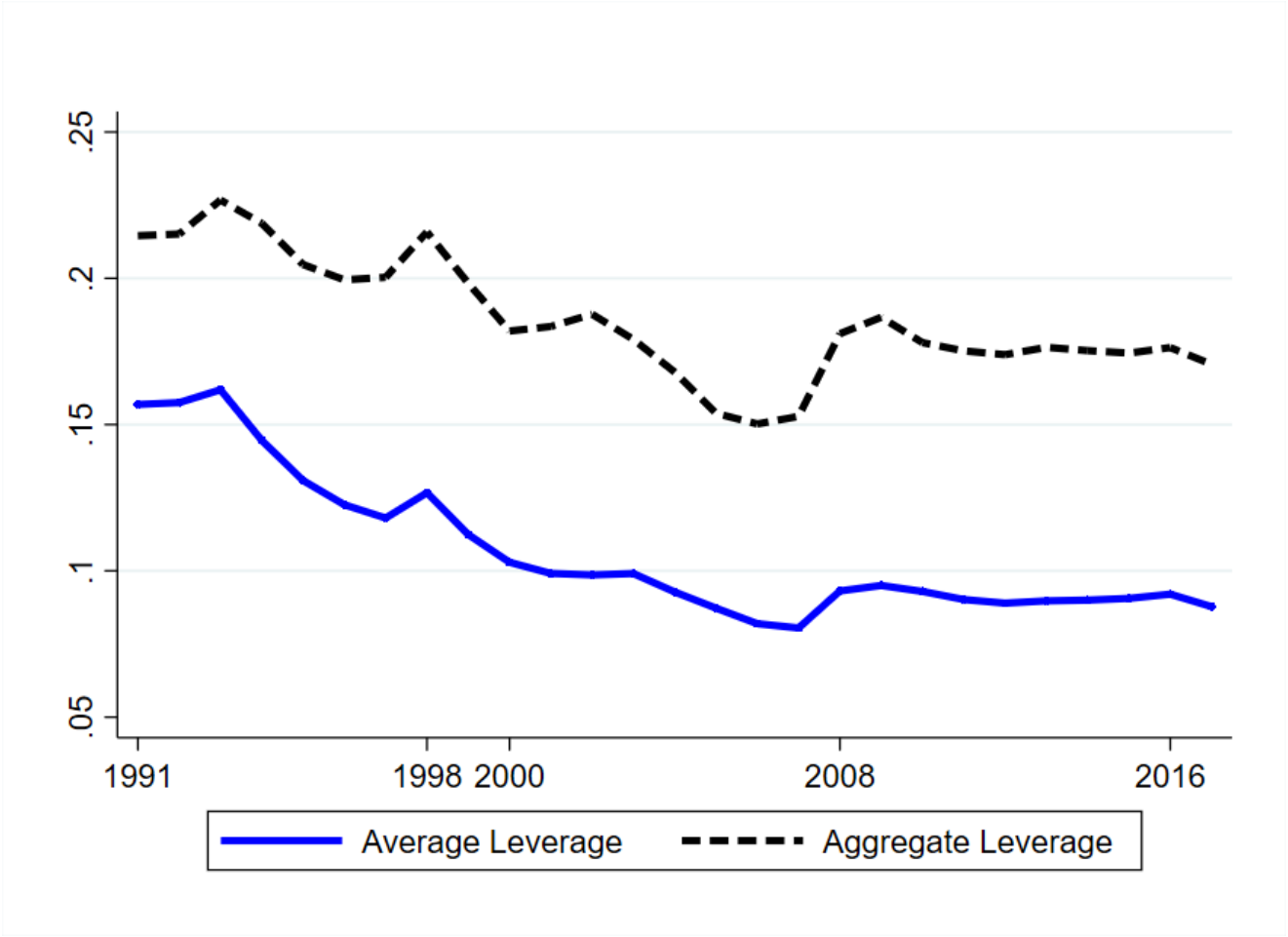
Recent business cycles in Japan



- 2008 Q3: Lehman Brothers filed for bankruptcy (15 September, 2008)
- 2011 Q1: The Tohoku earthquake (11 March, 2011)
- 2014 Q1: Consumption Tax increased to 8% from 5%

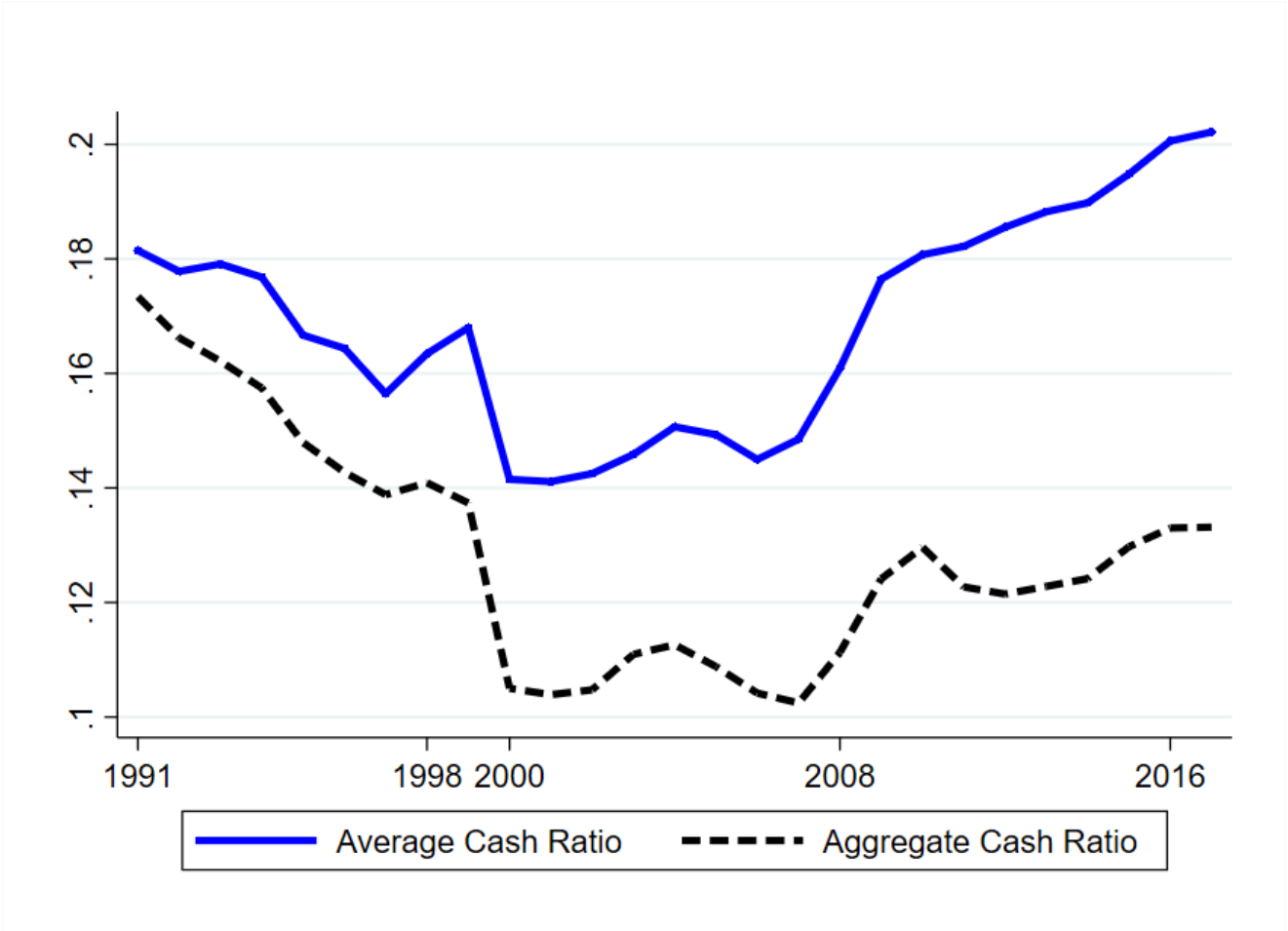
Deleveraging

- Long-Term Debt / Total Assets



Increasing cash

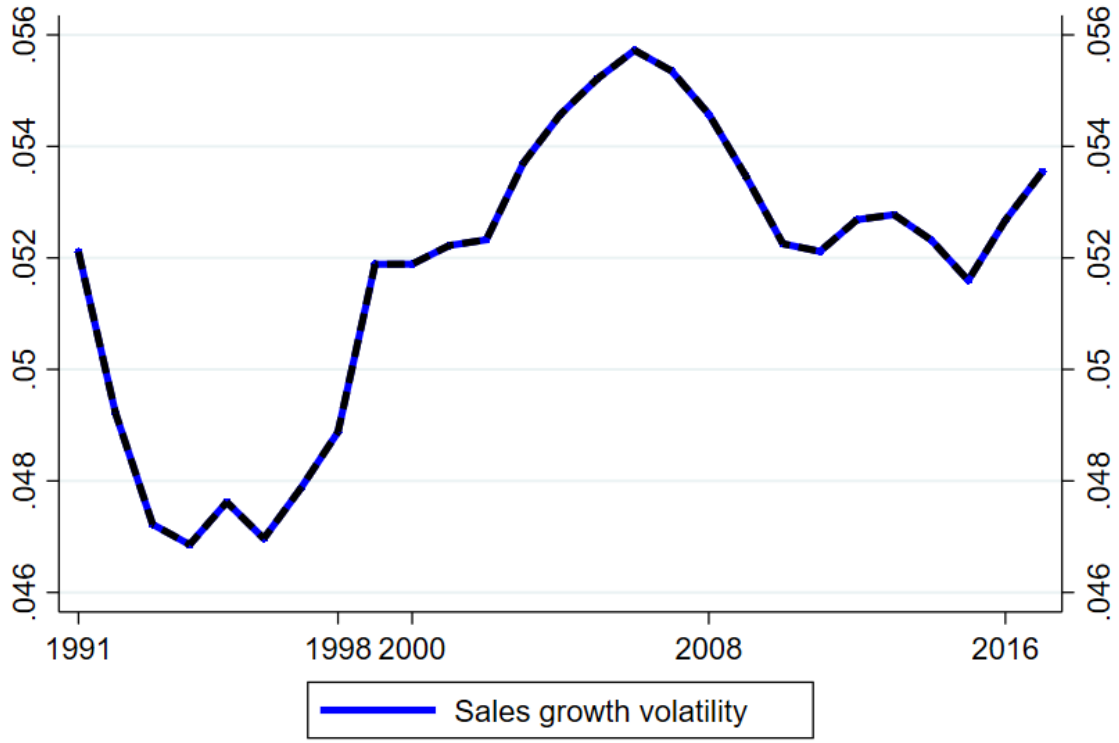
- (Cash + Short-term Investment) / Total Assets



High Sales Growth Volatility

$$\sigma_{i,t} = \frac{1}{10}\Big[\sum_{\tau=-4}^{\tau=+5}(g_{i,t+\tau} - \bar{g}_{i,t})^2\Big]^{\frac{1}{2}}$$

- $g_{i,t} = log(sales_{i,t}) - log(sales_{i,t-1})$, for firm i and year t.
- Cross-sectional average: $\sigma_t^{mean} = \text{mean}\{\sigma_{i,t}\}_{\text{over } i}$



This paper

What is the role of uncertainty/volatility in driving Japanese firms' investment and financial behaviors?

- Build a general equilibrium model with heterogeneous firms with default risk
- Test the prediction of the model using Japanese micro-level data

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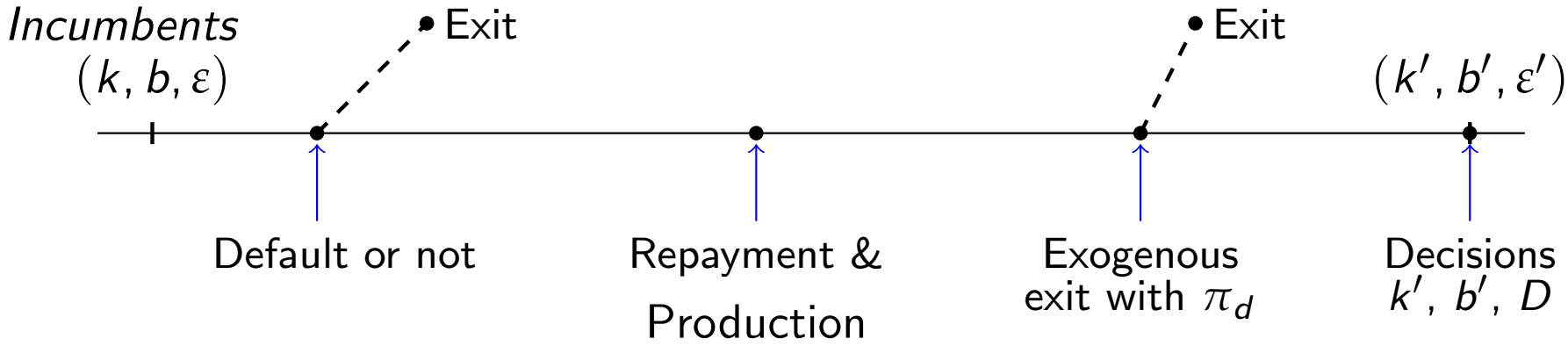
Key model ingredients:

- $y = \varepsilon k^{\alpha} n^{\nu}$
  - heterogeneity of ε (firm-level productivity)
  - a conditional volatility of ε (uncertainty)
  - an optimal scale of capital $k^{*}(\varepsilon)$
- firms can borrow $b > 0$, alternatively have financial savings $b < 0$

(Timing within a Period)



(Key model ingredients)

$$
\begin{aligned}
n^*(k,\varepsilon) &= \max_n \left[\varepsilon k^\alpha n^\nu - \omega n\right] \\
\pi(k,\varepsilon) &= \varepsilon k^\alpha n^*(k,\varepsilon)^\nu - \omega n^*(k,\varepsilon) \\
x &= \pi(k,\varepsilon) + (1-\delta)k - b - \xi
\end{aligned}
$$

Values of firms

x (wealth) and ε_i (firm-level productivity) identify a firm.

$$
\begin{aligned}
V^0(x,\varepsilon_i) &= \max\{V^1(x,\varepsilon_i),0\} \\
V^1(x,\varepsilon_i) &= \pi_d x + (1-\pi_d)V^2(x,\varepsilon_i) \\
V^2(x,\varepsilon_i) &= \max_{k',b'\in\Phi(x,\varepsilon_i)}\left[D+\beta\sum_{j=1}^{N_\varepsilon}\pi_{ij}^{\varepsilon}V^0\left(x_j',\varepsilon_j\right)\right], \\
\text{subject to} &: \\
D &= x-k'+q\left(k',b',\varepsilon_i\right)b' \\
\Phi(x,\varepsilon_i) &= \left\{\left(k',b'\right)\in R_+\times R \mid D\left(x,\varepsilon,k',b'\right)\geq 0\right\} \\
x_j' &= \pi\left(k',\varepsilon_j\right)+(1-\delta)k'-b'-\xi
\end{aligned}
$$

Default risk and loan rates

$q\left(k', b', \varepsilon_i\right)$: loan rates, which depend on the probability of default

$$
\begin{aligned}
q\left(k', b', \varepsilon_i\right) b' &= \beta \sum_{j=1}^{N_\varepsilon} \pi_{ij}^{\varepsilon} \Big[\underbrace{\chi\left(x_j', \varepsilon_j\right) b'}_{repayment} \\
&+ \underbrace{\left[1-\chi\left(x_j', \varepsilon_j\right)\right] \min\left\{b', \rho\left(1-\delta\right) k'\right\}}_{default} \Big].
\end{aligned}
$$

- $\chi\left(x_j', \varepsilon_j\right)$: default probability

Minimum savings policy

$B^w(\varepsilon)$ is the minimum savings policy ensuring unconstrained firm of type ε adopting $k^*(\varepsilon)$ will remain unconstrained and never default.

$$B^w(\varepsilon) = \min_{\{\varepsilon_j | \pi_{ij}^{\varepsilon} > 0\}} \widetilde{B}\left(k^*(\varepsilon), \varepsilon_j\right)$$

$$\begin{aligned} \widetilde{B}(k,\varepsilon) &\equiv \pi(k,\varepsilon) - \xi + (1-\delta)k \\ &+ \min\left\{-k^*(\varepsilon) + q_0 B^w(\varepsilon), 0\right\} \end{aligned}$$

$\widetilde{B}(k,\varepsilon)$ is the largest b a type (k,ε_i) firm can owe this period and implement $k^*(\varepsilon_i)$ and $b' = B^w(\varepsilon_i)$ while satisfying $D \geq 0$.

Parameterization

TABLE 1. Parameter Values

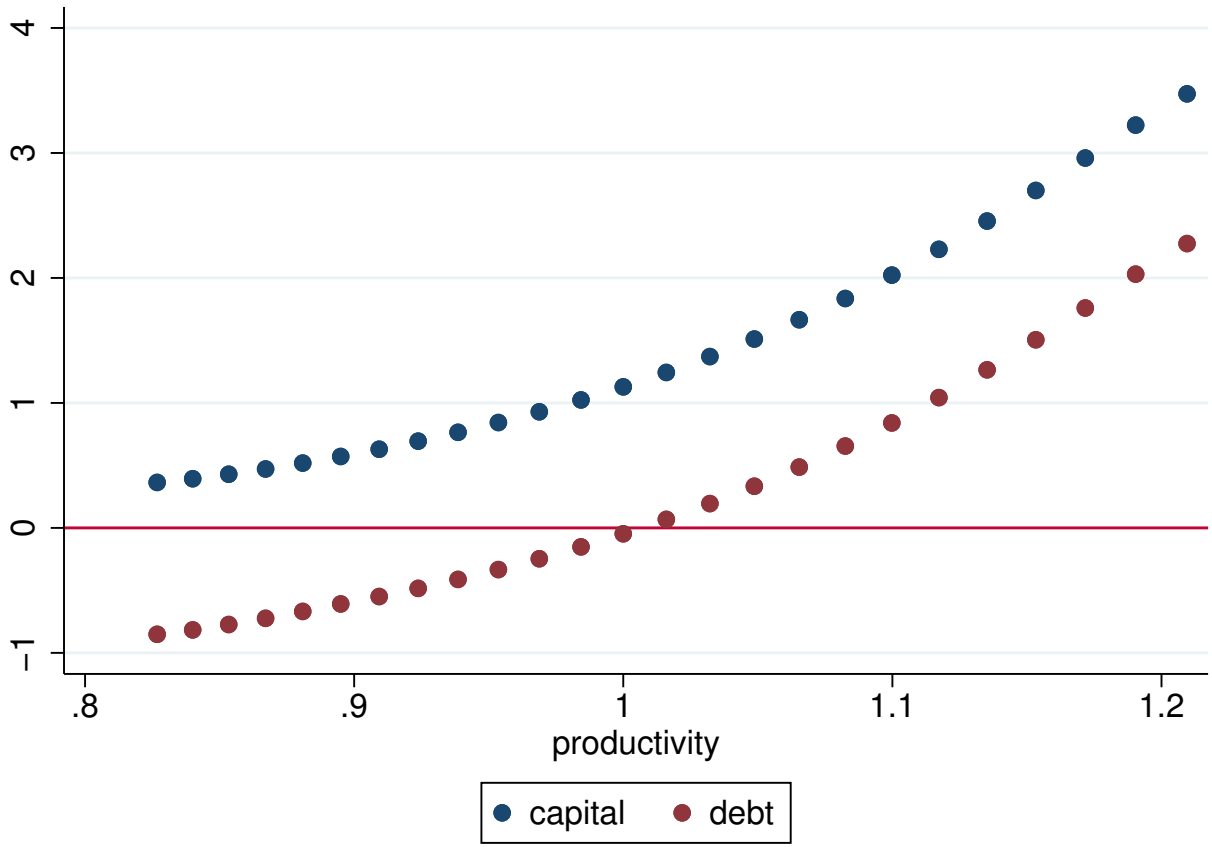
β	ν	δ	α	η	ρ	σ^2	ξ
0.96	0.60	0.07	0.2533	2.416	0.90	0.0331	0.0468

TABLE 2. Moments

Description	Data	Model
Real interest rate	0.96	0.96
Labor share	0.60	0.60
Investment to capital ratio	0.07	0.07
Capital to output ratio	2.300	2.269
Average hours worked	0.33	0.33
Persistence of productivity	-	0.90
Debt to capital ratio	0.180	0.180
Cash to capital ratio	0.130	0.129

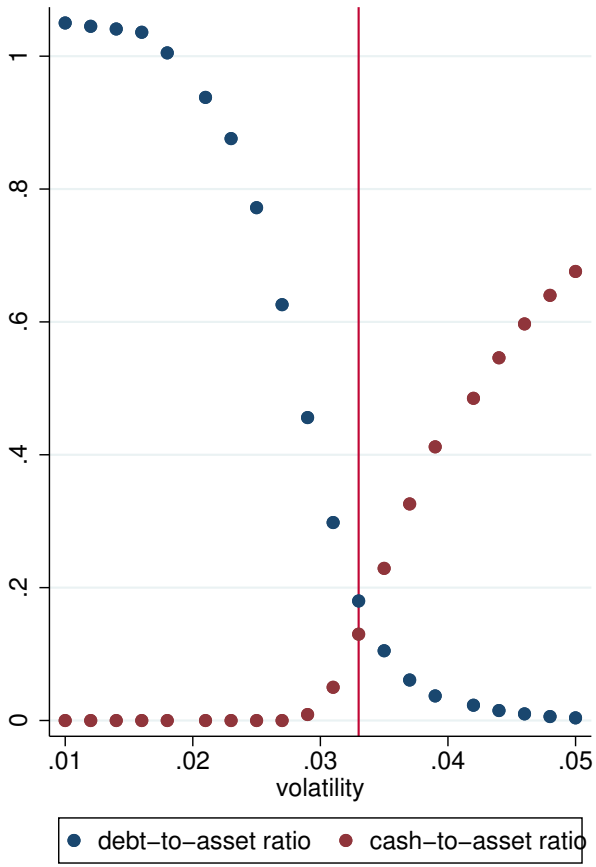
Estimated parameters are in red.

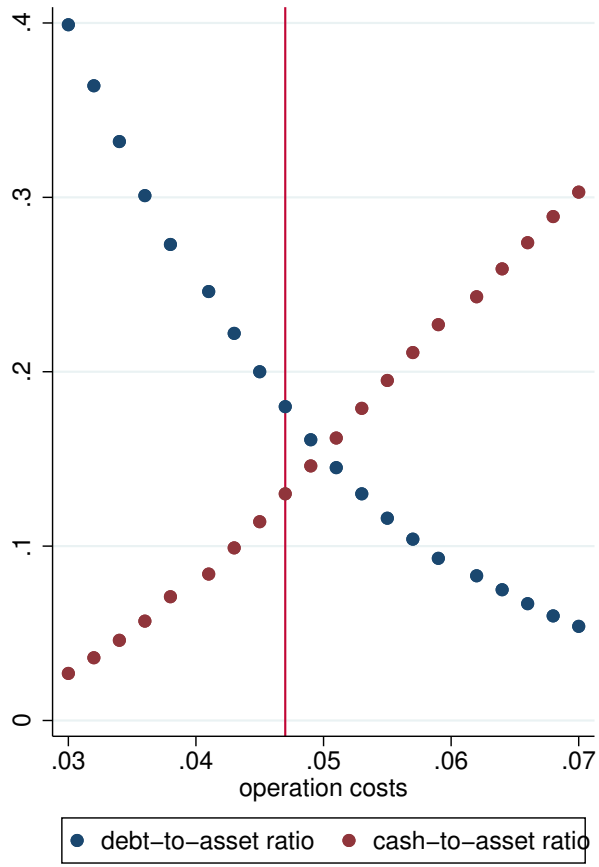
Decision rules



Aggregate moments

σ and ξ are varied to show that debt falls and cash rises with uncertainty and default risk.





Panel Regression

Uncertainty is positively related to cash holdings at the firm level

	Cash-to-asset ratio							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Sales volatility	0.094***		0.061***		0.028***		0.026***	
	(0.0115)		(0.0109)		(0.00914)		(0.00940)	
Profit volatility		0.159***		0.121***		0.030***		0.032***
		(0.0353)		(0.0335)		(0.0294)		(0.0304)
Year FE	N	N	Y	Y	Y	Y	Y	Y
Industry FE	N	N	Y	Y	N	N	N	N
Firm FE	N	N	N	N	Y	Y	Y	Y
Observations	25017	25473	25017	25473	25017	25473	22430	22676
R^2	0.156	0.169	0.418	0.422	0.802	0.799	0.823	0.822

Summary

- We propose a general equilibrium model of corporate cash-holdings, arising from uncertainty about productivity and default risk.
- The model predicts that cash rises with uncertainty faced by firms.
- We use Japanese micro-level data to validate our model's prediction empirically.

Policy implications

1. It is easy to say *policy should be transparent, consistent, evidence-based*. But we know it is not:
   - Trump administration, upending U.S. trade policy and making it complex.
2. Improve measurement of uncertainty faced by Japanese businesses.
   - Business surveys are useful but we should keep improving to reflect on what we should measure.
3. Evidence can be collected from academics to shape policy packages.
   - The UK Chancellor's policy announcement draws from the Business Productivity Reviews call for evidence.