The Macroeconomics of BigTech

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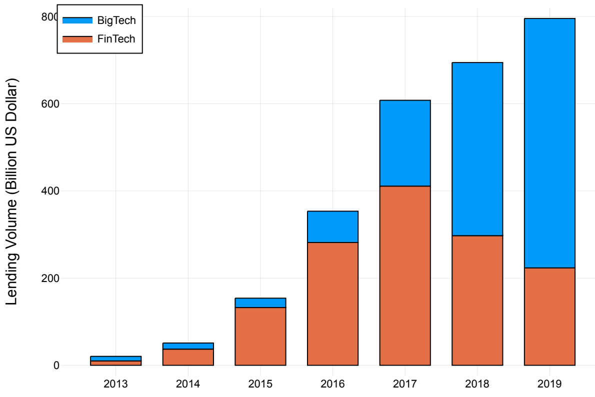
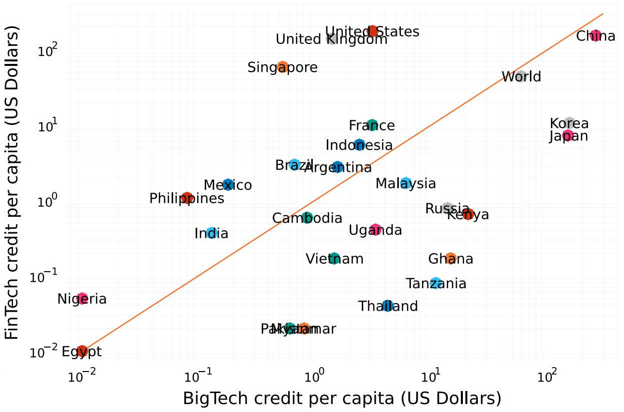
CKGSB

2024 ASSA Annual Meeting
Investment and Technological Change Session

NEW FINANCIAL INTERMEDIARIES





- **FinTech**: digital lending facilitated by online platforms (e.g., P2P, ...)
- **BigTech/TechFin**: large tech companies lend in the credit markets (e.g., Ant Group, WeBank, ...)

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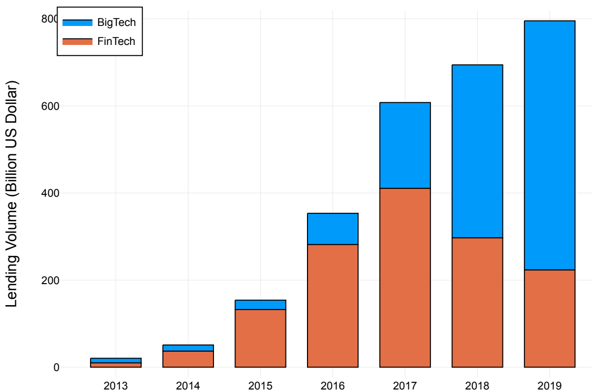

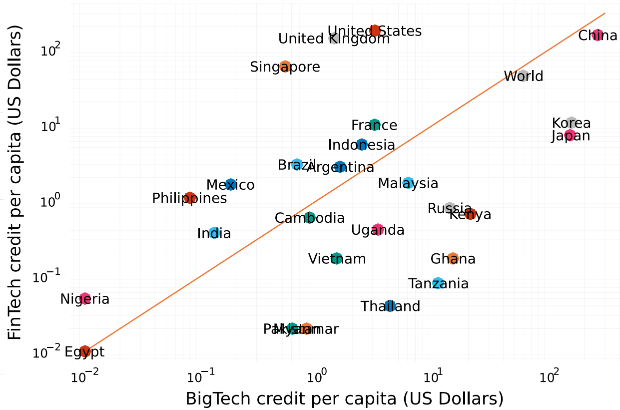

- **FinTech**: digital lending facilitated by online platforms (e.g., P2P, ...)
- **BigTech/TechFin**: large tech companies lend in the credit markets (e.g., Ant Group, WeBank, ...)
- **a growing empirical literature, but theoretical implications?**

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why BigTech instead of FinTech: BigTech is more bank-like (Stulz, 2019; King, 2019)

Bank v.s. BigTech: Macro Perspective

- **Banking sector**: **collateral**-based borrowing constraint
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Bank v.s. BigTech: Macro Perspective

- **Banking sector**: **collateral**-based borrowing constraint
- **BigTech sector**: **(expected-)earnings**-based borrowing constraint
- **Microfoundation** of incomplete-collateralization contract:
  1. *technology story*: tech/data advantages $\rightarrow$ reduced cost of state verification
  2. *intangible capital story*: intangible capital $\rightarrow$ low liquidation value

Bank v.s. BigTech: Macro Perspective

- **Banking sector**: **collateral**-based borrowing constraint
- **BigTech sector**: **(expected-)earnings**-based borrowing constraint
- **Empirical evidence**:
  1. Gambacorta et al. (2023): ✗ local business conditions and house prices; ✓ firm-specific characteristics
  2. Beck et al. (2022): liquidation cost decreasing in asset tangibility

Bank v.s. BigTech: Macro Perspective

- **Banking sector**: **collateral**-based borrowing constraint
- **BigTech sector**: **(expected-)earnings**-based borrowing constraint
- **Other possible difference**: fast data processing ability (Fuster et al., 2019); new credit-sorting models (Gambacorta et al., 2019); different maturities (Liu, Lu and Xiong, 2022)...

MacroFin ⇒ MacroBigTech

FRAMEWORK

- **A macro model with three key elements**:

  1. heterogeneous agent model with incomplete markets
  2. two types of borrowing constraints
  3. defaultable debt

MacroFin ⇒ MacroBigTech

Mechanism

- **Key feature**: **convex** relationship between (expected) productivity and wealth growth rate
  - advantage: rely less on collateral, which is unrelated to *individual* productivity
  - disadvantage: depend on the accuracy of predicting *individual* earnings
- expected-earnings-based borrowing constraint

MacroFin ⇒ MacroBigTech

IMPLICATION

- **Main conclusions** on the rise of BigTech

  1. efficiency-instability trade-off: smaller aggregate productivity losses but more financial instability in the steady state
  2. different financial accelerator: amplification and propagation of second-moment uncertainty shocks
  3. extensions: algorithm bias; optimal BigTech development; pricing effect; non-M.I.T. shocks

Related Literature

- **FinTech/BigTech**: Gambacorta et al. (2023); Tang (2019); Hau et al. (2018); Cornelli et al. (2023); Huang (2022); Manea, Fiore and Gambarcorta (2023); Liu, Lu and Xiong (2022)...
- **Financial frictions and macroeconomy**: Kiyotaki and Moore (1997); Bernanke and Gertler (1989); Brunnermeier and Sannikov (2014); Di Tella (2017); He and Krishnamurthy (2013); Fernandez-Villaverde, Hurtado and Nuno (2019); ...
- **Distributional macro**: Moll (2014); Fernandez-Villaverde, Hurtado and Nuno (2019); Achdou et al. (2022); ...
- **Earnings-based borrowing constraint**: Lian and Ma (2021); Greenwald (2019); Drechsel (2023); Drechsel and Kim (2022); ...

MODEL

- **Infinite-horizon, continuous-time economy**
- **Two types of entrepreneurs** + Homogeneous hand-to-mouth workers ($\mathcal{S} = 1$ in baseline)
  - i 1 continuum of entrepreneurs borrowing from the banking sector **B**
  - ii $\mathcal{S}$ continuum of entrepreneurs borrowing from the BigTech sector **F**
- **Preference**: $\mathbb{E}_0 \int_0^\infty e^{-\rho t} \log c(t)\, dt$
- **Production function**: $y = zk^\alpha l^{1-\alpha}$
- **Stochastic productivity process**: $dz = \frac{1}{\theta}(\bar{\mu} - z)\, dt + \sigma \sqrt{\frac{1}{\theta}} d\mathcal{W}$

Timing and Expectation

- **Expected productivity** ($\gamma = 0$ in baseline):

$$\tilde{\mathbb{E}}[z] = \tilde{\mathbb{E}}[\tilde{z} + dz] = \underbrace{\frac{1}{\theta}[\bar{\mu} + (\theta - 1)\tilde{z}]}_{\text{rational expectation}} + \underbrace{\gamma(\tilde{z} - \bar{\mu})}_{\text{algorithm bias}}$$

  - γ: degree of bias
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$$\pi(a, z, \tilde{z}) = \pi\left(a, z, \tilde{\mathbb{E}}[z]\right) \equiv zk\left(a, \tilde{\mathbb{E}}[z]\right)^{\alpha} l\left(a, \tilde{\mathbb{E}}[z]\right)^{1-\alpha} - (r + \delta) k\left(a, \tilde{\mathbb{E}}[z]\right) - wl\left(a, \tilde{\mathbb{E}}[z]\right)$$

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- **"Costless" default** (in the baseline): focus on exogenous borrowing constraints

- **State of the economy**:

$$\{\omega_F(t, a, z, \tilde{z}), \omega_B(t, a, z, \tilde{z})\}$$

Two Types of Borrowing Constraints

- **Banking sector**: collateral-based borrowing constraint

$$k - a \leq \lambda_B k \Rightarrow \underline{k \leq \frac{1}{1-\lambda_B} a}$$

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- **BigTech sector**: earnings-based borrowing constraint

$$k - a \leq \lambda_F \tilde{\mathbb{E}}\left[\pi\right] \Rightarrow \underline{k \leq \frac{1}{1+\lambda_F\left[\frac{r+\delta}{\alpha} - \zeta \tilde{\mathbb{E}}\left[z\right]\right]} a}$$

where $\zeta \equiv \left(\frac{(1-\alpha)(r+\delta)}{\alpha w}\right)^{1-\alpha}$

Similarity and Difference I

- **Similarity**: corporate debt capacity depends on **(expected) net worth**

$$\textbf{debt capacity} = \phi \times \textbf{net worth}$$

  - ? "With cash flow-based lending and EBCs, we find that asset price feedback through firms' balance sheets could diminish significantly."(Lian and Ma, 2021)
  - ? "This evidence implies that a greater use of big tech credit could reduce the importance of collateral in credit markets and potentially weaken the financial accelerator mechanism." (Gambacorta et al., 2023)

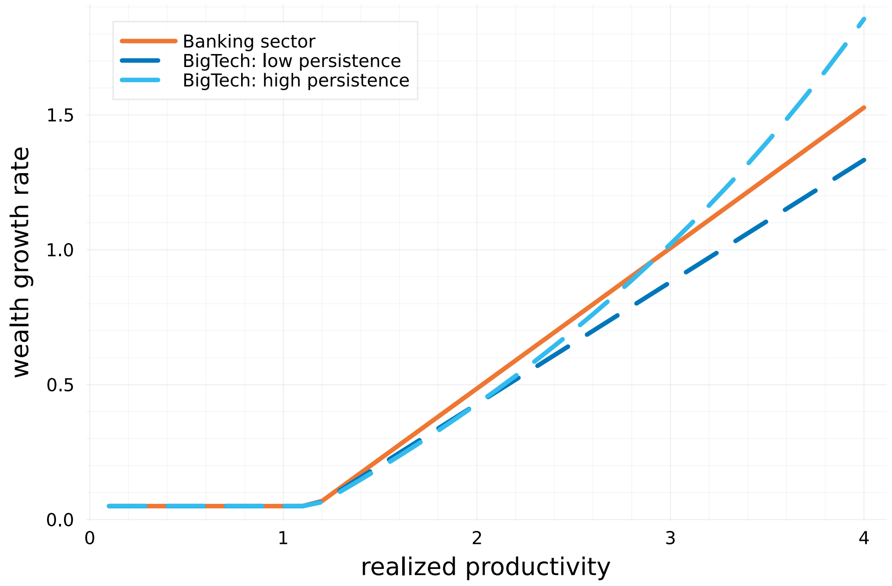
Similarity and Difference II

- **Difference**: (expected) productive firms get to use more leverage in BigTech

$$k \leq \frac{1}{1-\lambda_B} a$$
$$k \leq \frac{1}{1+\lambda_F \left[\frac{r+\delta}{\alpha} - \zeta \tilde{\mathbb{E}}\left[z\right]\right]} a$$

- asymmetric **wealth** growth rate for firms with different (expected) productivity

Key Mechanism: Convexity + Uncertainty



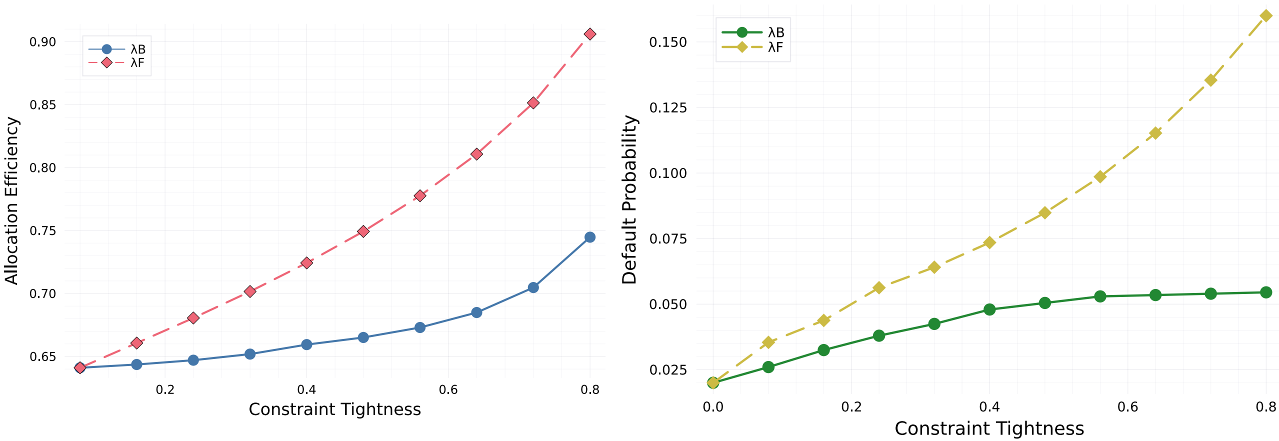
▸ Policy Function ▸ Wealth Dynamics ▸ Distribution Dynamics

Parametrization

Parameter	Description	Value	Source/Reference
ρ	rate of time preference	0.05	
α	capital share	0.33	Moll (2014)
$\mathcal{L}$	labor market size	1.0	
δ	capital depreciation rate	0.06	BEA-FAT
γ	algorithm bias	0.4	match the default probability
$\mathcal{S}$	size of BigTech	1.0	
$\overline{\mu}$	log idiosyncratic productivity mean	0.0	
θ	autocorrelation $e^{-\theta}$	0.16 (corr = 0.85)	Asker, Collard-Wexler and Loecker (2014)
σ	log idiosyncratic productivity s.d.	0.56	

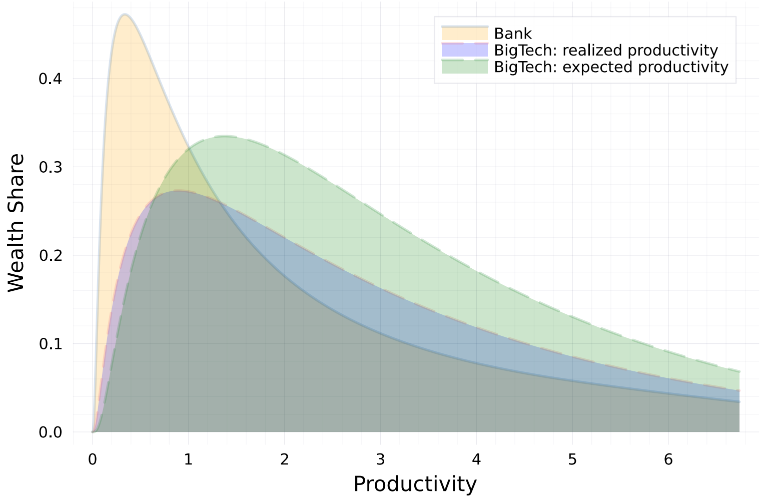
1. steady state analysis
2. business cycles with M.I.T shocks
3. extensions

EFFICIENCY-INSTABILITY TRADE-OFF



- **BigTech cannot fully replace the role of traditional banks**

Efficiency-Instability Trade-off



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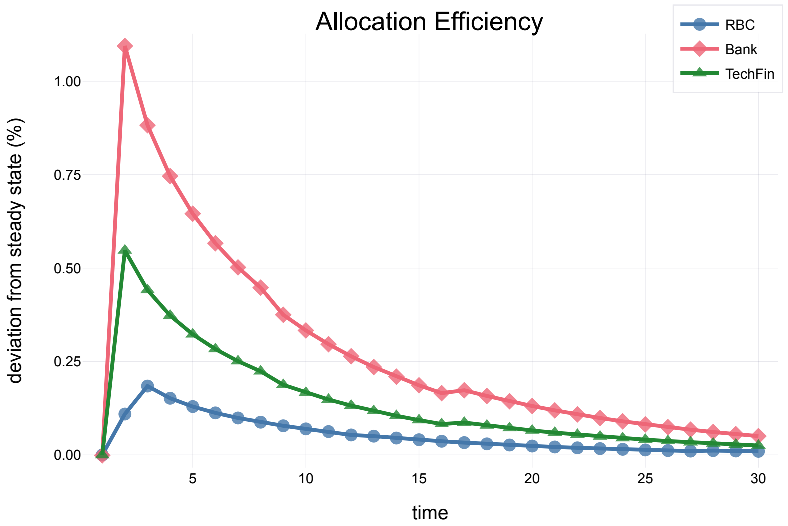
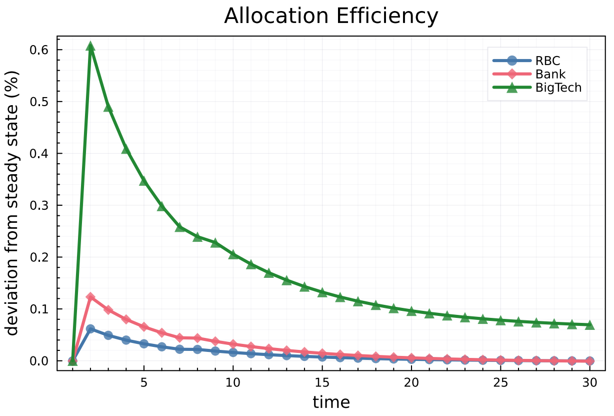
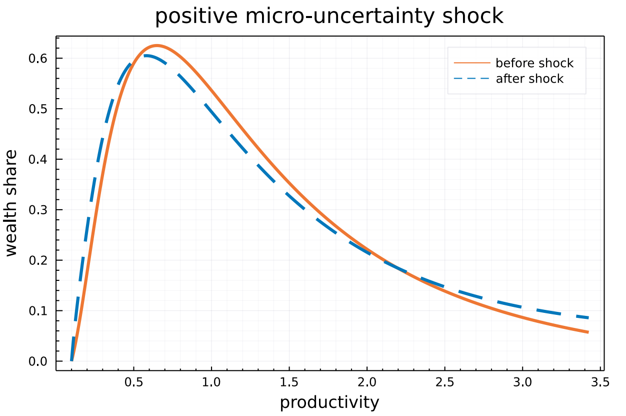
Business Cycles: First-Moment Shocks



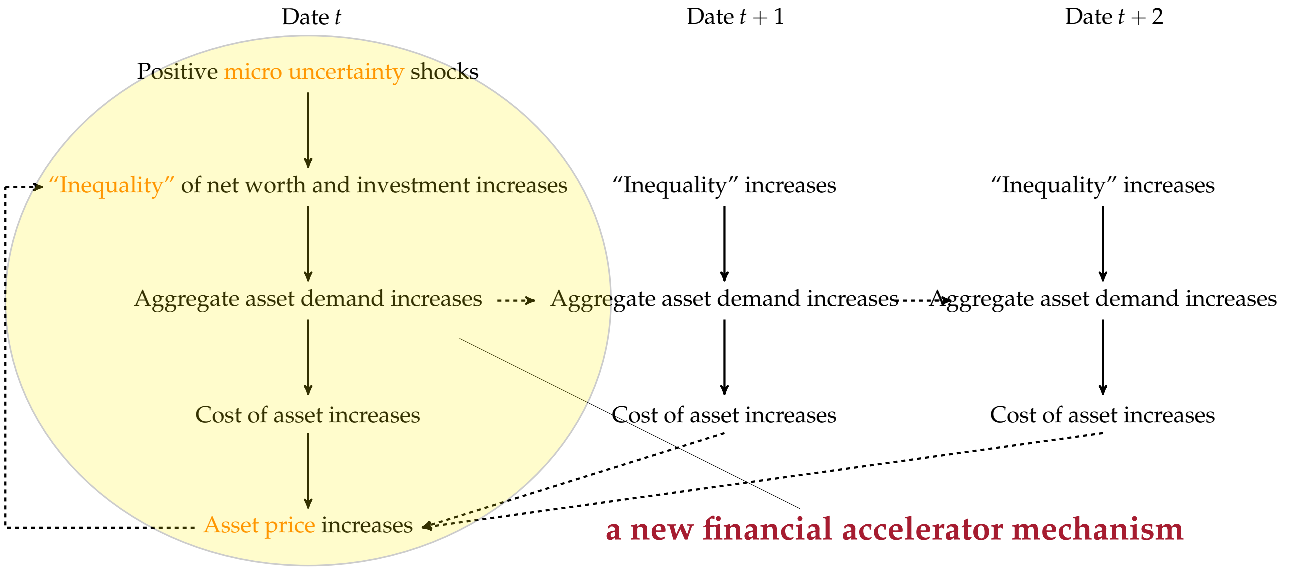
BUSINESS CYCLES: SECOND-MOMENT SHOCKS





- **BigTech lending is sensitive to uncertainty shocks**

AMPLIFICATION AND PERSISTENCE



Amplification and Persistence

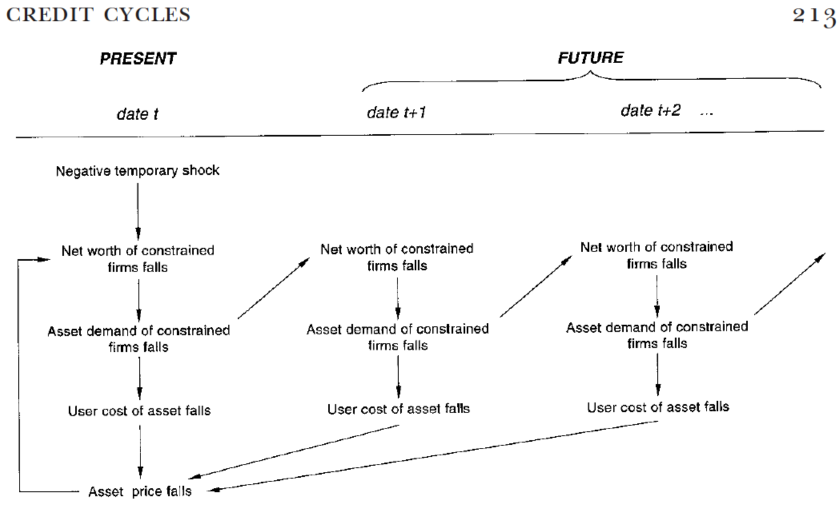


Figure. Kiyotaki and Moore (1997)

On Financial Accelerator Mechanism

- Different from the classical one (e.g., Kiyotaki and Moore, 1997; Bernanke and Gertler, 1989) in three aspects
  - **primitive shock**: micro uncertainty instead of aggregate productivity
  - **financial friction**: earnings-based borrowing constraint instead of collateral-based borrowing constraint
  - **feedback loops**: between net worth inequality, instead of net worth level, and asset prices

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  - **feedback loops**: between net worth inequality, instead of net worth level, and asset prices
- **Macroeconomics of BigTech**: a different financial accelerator mechanism

EXTENSIONS

- **Algorithm Bias**: $\gamma \neq 0$
- **Optimal BigTech Development**: $\mathcal{S} \neq 1$

$$\mathcal{U}(\mathcal{S}) = \mathcal{Z}^{\iota}(\mathcal{S}) - \eta \mathcal{P}(\mathcal{S})$$

- **Risky Bond**:

$$qb' = \frac{\mathbb{E}\left\{\mathbf{1}_{V' \geq 0} b' + \mathbf{1}_{V' < 0}\left(\chi_k k + \chi_\pi \pi\right)\right\}}{1 + r}$$

- **Non-M.I.T. Shocks**:

$$\begin{aligned} dz &= \frac{1}{\theta}(\bar{\mu} - z)\, dt + \sigma \sqrt{\frac{1}{\theta}} d\mathcal{W} \\ \bar{\mu} &\in \{\bar{\mu}_L, \bar{\mu}_H\}, \text{ where } Pr\left(\bar{\mu}' = \bar{\mu}_l | \bar{\mu} = \bar{\mu}_k\right) = \zeta_{kl} \\ \sigma &\in \{\sigma_L, \sigma_H\}, \text{ where } Pr\left(\sigma' = \sigma_l | \sigma = \sigma_k\right) = \chi_{kl} \end{aligned}$$

▸ Algorithm Bias ▸ Optimality ▸ Risky Debt ▸ Non-MIT Shock

Conclusion

- **Research question**: introduce BigTech into the existing macro-finance literature
- **Key take-aways**: BigTech v.s. Bank as two types of borrowing constraints
  - efficiency-instability trade-off
  - a different financial accelerator
- **Extensions**:
  - algorithm bias
  - optimal BigTech development

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Optimal Policy Functions ◂ Back

- **Banking sector**

$$k^{B}\left(a,z,\tilde{z}\right)=\begin{cases}\frac{a}{1-\lambda_B} & \tilde{\mathbb{E}}\left[z\right]\geq\underline{\tilde{z}}\\ 0 & \tilde{\mathbb{E}}\left[z\right]<\underline{\tilde{z}}\end{cases}$$

- **BigTech sector**

$$k^{F}\left(a,z,\tilde{z}\right)=\begin{cases}\frac{1}{1+\lambda_F\left(\frac{r+\delta}{\alpha}-\zeta\tilde{\mathbb{E}}[z]\right)}a & \tilde{\mathbb{E}}\left[z\right]\geq\underline{\tilde{z}}\\ 0 & \tilde{\mathbb{E}}\left[z\right]<\underline{\tilde{z}}\end{cases}$$

where $\underline{\tilde{z}}=\left(\frac{r+\delta}{\alpha}\right)^{\alpha}\left(\frac{w}{1-\alpha}\right)^{1-\alpha}$

WEALTH DYNAMICS ◂ BACK

$$da_B = \left\{ 1_{\tilde{\mathbb{E}}[z] \geq \tilde{\underline{z}}} \times \left[\frac{\zeta z - \frac{r+\delta}{\alpha}}{1 - \lambda_B} + r - \rho \right] + 1_{\tilde{\mathbb{E}}[z] < \tilde{\underline{z}}} \times (r - \rho) \right\} a_B dt$$

$$da_F = \left\{ 1_{\tilde{\mathbb{E}}[z] \geq \tilde{\underline{z}}} \times \left[\frac{\zeta z - \frac{r+\delta}{\alpha}}{1 + \lambda_F \left[\frac{r+\delta}{\alpha} - \zeta \left(\frac{1}{\theta} - \gamma \right) \bar{\mu} - \frac{\zeta(\theta - 1 + \theta\gamma)}{\theta} \tilde{z} \right]} + r - \rho \right] + 1_{\tilde{\mathbb{E}}[z] < \tilde{\underline{z}}} \times (r - \rho) \right\} a_F dt$$

- **Low productivity firms**
  - constant net worth growth rate
  - low-productivity entrepreneurs do not operate and lend all their net worth to good firms
- **High productivity firms**
  - net worth growth rate is higher than its actual productivity: leverage effect
  - BigTech: most-productive firm's net worth grows even faster

Joint Distribution Dynamics ◂ Back

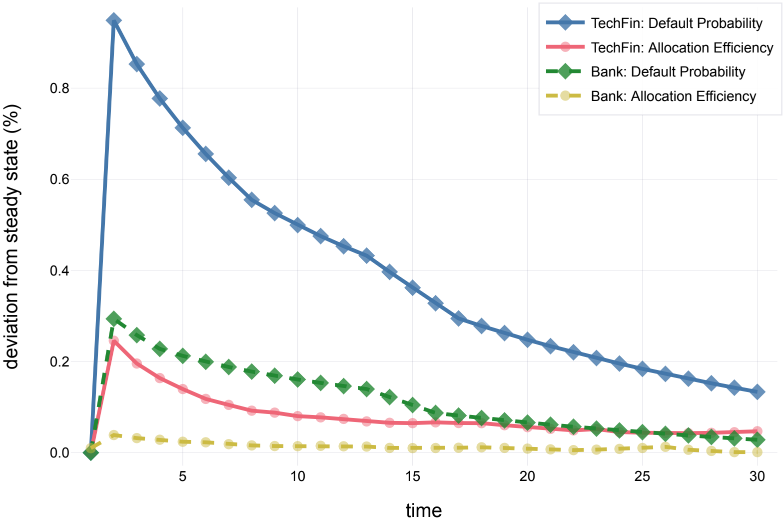
$$
\begin{aligned}
\frac{\partial \omega^j(t,a,z,\tilde{z})}{\partial t} &= -\frac{\partial\left[\Gamma^j(t,z,\tilde{z})\,a\omega^j(t,a,z,\tilde{z})\right]}{\partial a} - \frac{\partial\left[\frac{1}{\theta}(\overline{\mu}-z)\,\omega^j(t,a,z,\tilde{z})\right]}{\partial z} - \frac{\partial\left[\frac{1}{\theta}(\overline{\mu}-\tilde{z})\,\omega^j(t,a,z,\tilde{z})\right]}{\partial \tilde{z}} \\
&+ \frac{\sigma^2}{2\theta}\frac{\partial^2\left[\omega^j(t,a,z,\tilde{z})\right]}{\partial \tilde{z}^2} + \frac{\sigma^2}{2\theta}\frac{\partial^2\left[\omega^j(t,a,z,\tilde{z})\right]}{\partial z^2} \text{ where } j \in \{\mathcal{B},\mathcal{F}\}
\end{aligned}
$$

- ✗ **wealth share approach**: Caselli and Gennaioli (2013); Moll (2014); ...
- ✗ **(adaptive) sparse grid approach**: Brumm and Scheidegger (2017); ...
- ✓ **deep learning approach**: Han and E (2016); Raissi, Perdikaris and Karniadakis (2019); Fernandez-Villaverde et al. (2020); Chen, Didisheim and Scheidegger (2021); ...

EXTENSION: ALGORITHM BIAS

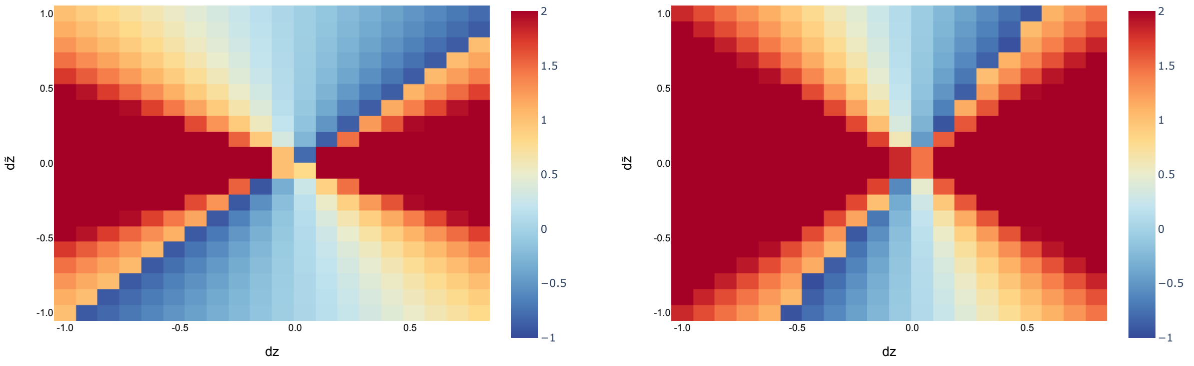
◂ BACK

- **fragile booms**



 ◂ BACK

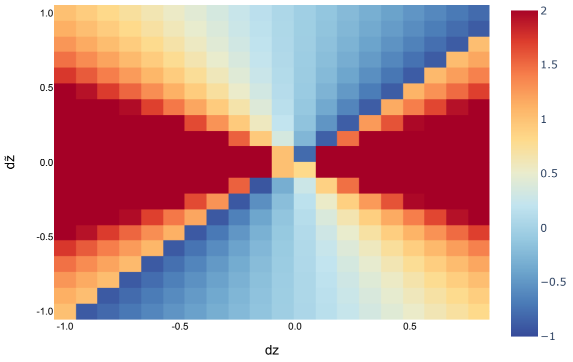
- **overlending issues**

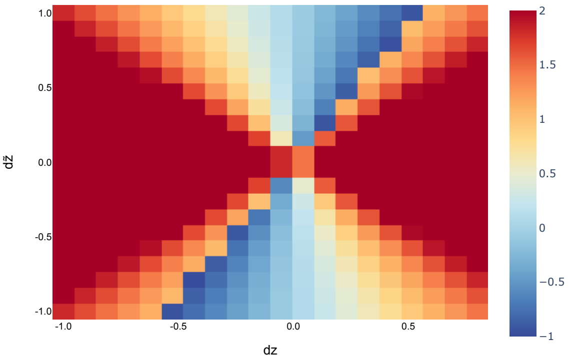


BigTech: Overborrowing and Financial Instability

◂ Back

- **overlending issues**



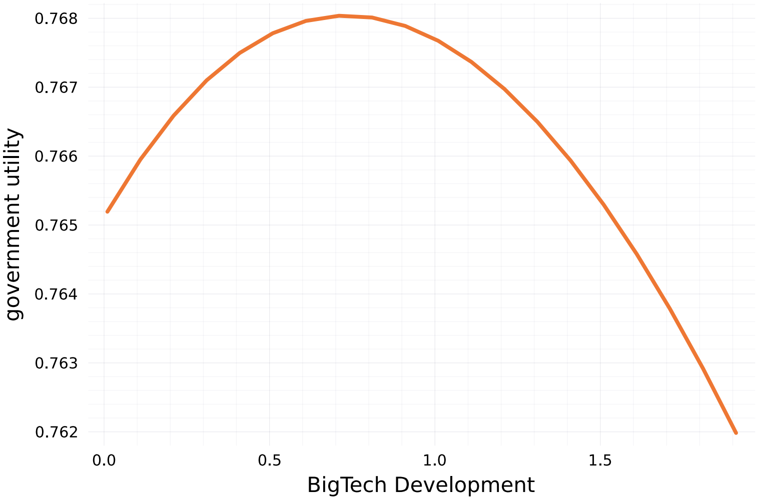


- Financial markets are *less* efficient in booms than in recessions:
  - **Minsky's financial instability hypothesis**: economic prosperity encourages borrowers and lender to be reckless
  - **Greenspan/Shiller's irrational exuberance**: overheated economy generates bubbles

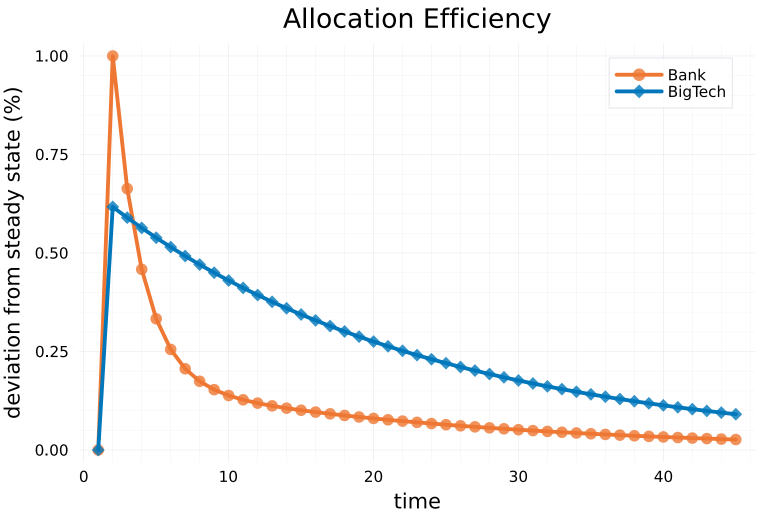
Extension: Optimal BigTech Development ◂ Back

- assume that the government cares about both efficiency and financial stability

$$\mathcal{U}(\mathcal{S}) = \mathcal{Z}^{\iota}(\mathcal{S}) - \eta\mathcal{P}(\mathcal{S})$$



Extension: Risky Bond ◂ Back



Extension: Non-MIT Shocks

◂ Back