Uncertainty Shocks in An Intangible Economy

Shuonan Zhang

Shuonan.Zhang@soton.ac.uk

University of Southampton

EEA2024 Rotterdam

Introduction

⊙ Intangibles: knowledge derived from research and development (R&D), intellectual property, organization, brands, and business strategy, etc.

- Lacks a physical presence
- Intangible investment increased rapidly over time

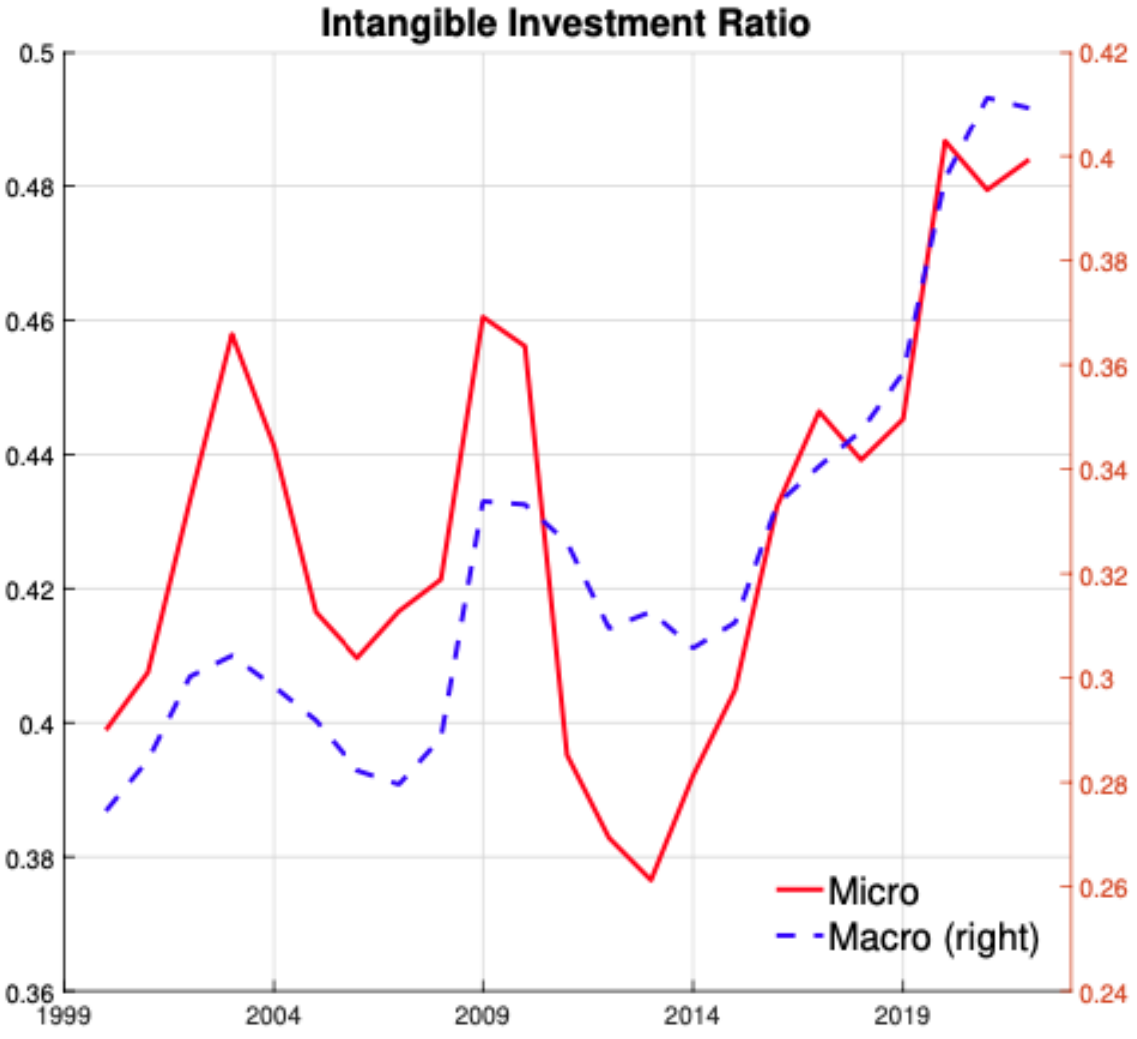
⊙ Research question: what are the macroeconomic implications of the rising importance of intangibles?

- Focusing level (or first-moment) shocks, e.g., financial shocks
  - Amplifier for financial shocks
- Uncertainty shocks?

⊙ Importance

- Uncertainty is a key driver of business cycles
- How intangibles affects uncertainty-driven business cycles?

Introduction



The Micro data is compiled by the author based on firm-level data from Compustat

Literature and Contributions

⊙ Macroeconomic consequences of uncertainty (Bloom et al. 2007; Fernádez-Villaverde et al. 2015; Segal et al. 2015; Leduc & Liu 2016; Basu & Bundick 2017; Alfaro, Bloom, & Lin 2024)
⊙ Intangible investment (Lopez & Olivella 2018; Mitra 2019; Döttling & Ratnovski 2023) and/or technology innovation (Anzoategui et al. 2019; Ikeda & Kurozumi 2019)
This paper: a crossroad between the two strands of literature

- transmission of uncertainty shocks in the presence of intangibles
- roles of intangibles in the uncertainty-driven business cycle

⊙ Corporate investment (Brown et al. 2009; Peters & Taylor 2017; Bianchi et al. 2019, Caggese & Pérez-Orive 2022; Döttling & Ratnovski 2023)

- changes of investment composition in business cycles

Empirical Analysis

- Step 1
  - A six-variable VAR: uncertainty measured by VIX index, real GDP, real private investment, CPI inflation, federal fund rate, and excess bond premium.
  - Aim: obtain an adjusted VIX index that removes contributions from non-uncertainty shocks (Bhattarai et al., 2020 JME)
- Step 2
  - Firm-level variables from Compustat from 2000Q1 to 2023Q2
  - Intangible investment: R&D expense + 30% of selling, general and administrative (SG&A) expense (Peters & Taylor 2017; Döttling & Ratnovski 2023)
  - Intangible capital: on-balance components (Intan) + off-balance sheet components
    - Perpetual inventory method applied to intangible inv.

Empirical Analysis

- Other sampling procedures in Step 2
  - Exclude firms in utility (SIC 4900-4999), finance (SIC 6000-6999), and public service (SIC 9000 and above).
  - Remove observations with missing or negative assets, sales, CAPX, R&D, or SD&A expenditure
  - Drop very small firm with physical capital under \$5 million
- Step 3
  - Merge firm-level variables with the adj. VIX index
  - Period correction
    - Fiscal quarters are mapped to calendar quarters using information on firms' fiscal-year end
  - Manually check and drop duplicated observations
  - Hampel Identifier (Wilcox 2011) to detect and drop outliers

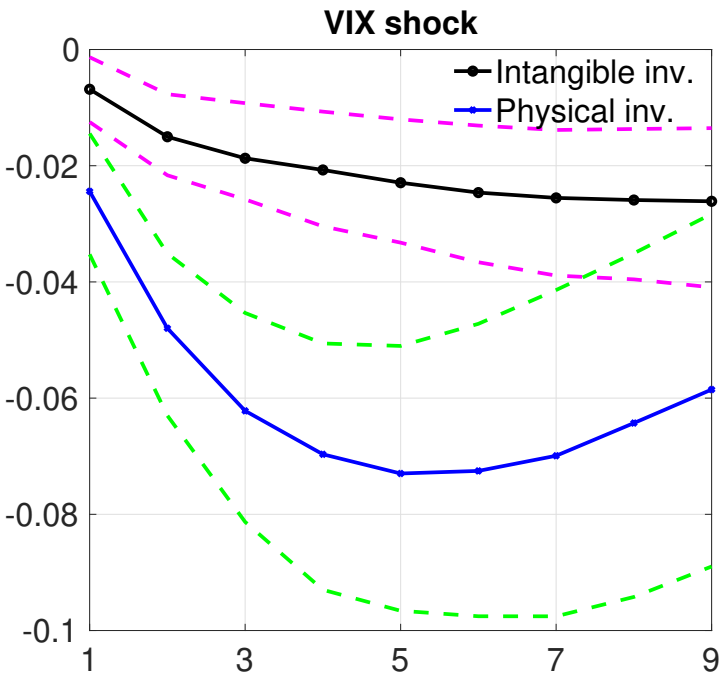
Empirical Analysis

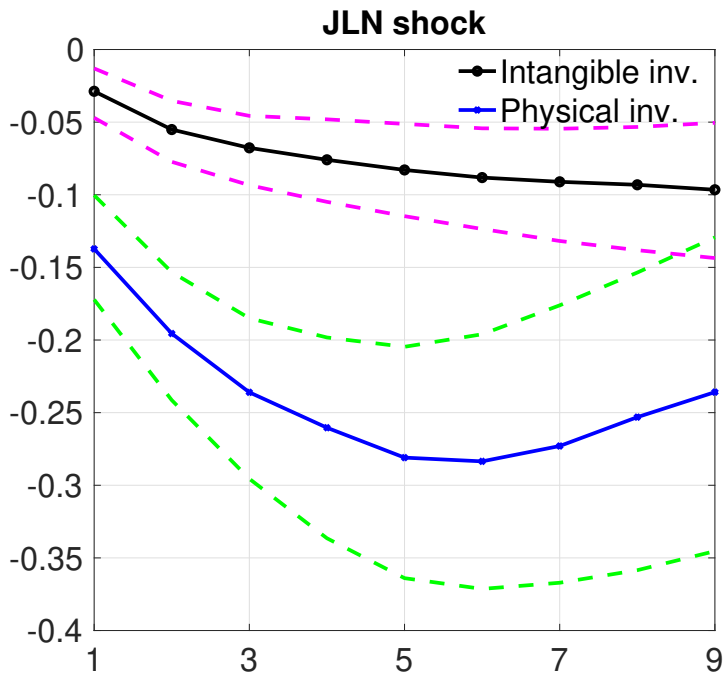
- Intangible firms are less affected by uncertainty
- Intangible investment is less sensitive to uncertainty than tangible investment

	Total Inv. Rate			Intan. Inv. Rate	Tan. Inv. Rate
	[1]	[2]	[3]	[4]	[5]
u	-0.0542***	-0.2431***		-0.0322***	-0.0869***
	(0.007)	(0.032)		(0.005)	(0.012)
u $\times$ k^{int}		0.2361***	0.2350***		
		(0.039)	(0.039)		
Observations	112167	103822	103747	111572	111520
Adj. R^2	0.37	0.39	0.414	0.214	0.544
Controls	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes
Quarter FE	Yes	Yes	Yes	Yes	Yes
Time FE	No	No	Yes	No	No

Empirical Analysis

- Confirming the lower sensitivity of intangible investment based on macro measure



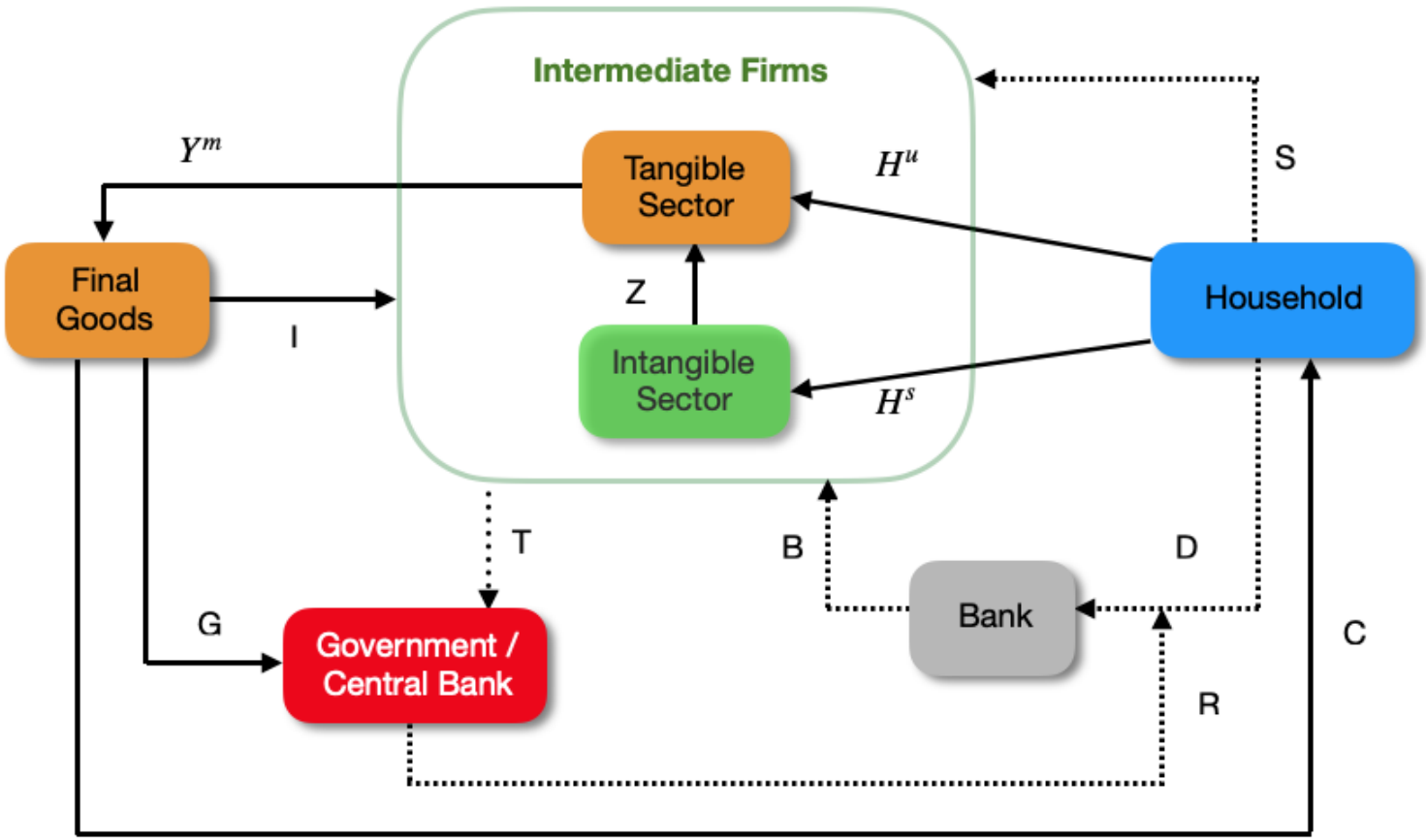


robustness check

The Model–Overview

Two-sector DSGE model: augment Basu & Bundick (2017 ECMA)

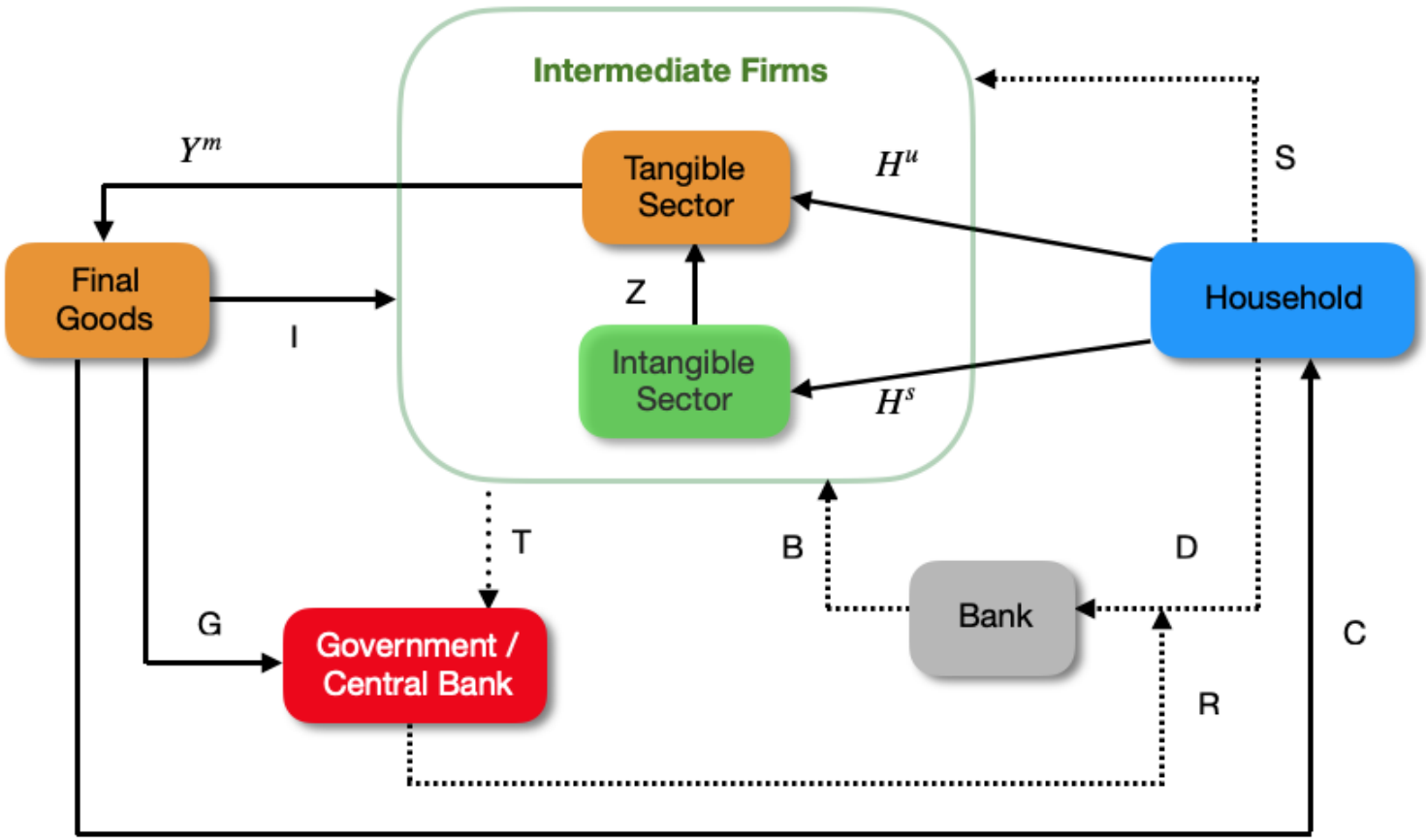
- Intangible production sector
- Distinguish skill and unskilled labor hours



The Model–Overview

Uncertainty shocks

- Preference uncertainty shock (main analysis) household
- Intangible-specific uncertainty shock



The Model–Production

- Production of tangible Y_{jt}^m and intangible goods X_{jt}

$$Y_{jt}^m = A_t Z_{jt}^{\zeta} (u_{jt} K_{jt}^y)^{\alpha} (H_{jt}^u)^{1-\alpha-\zeta} \tag{1}$$

$$X_{jt} = \chi Z_{jt}^{\zeta} (u_{jt} K_{jt}^z)^{\alpha} (H_{jt}^s)^{1-\alpha-\zeta} \tag{2}$$

- Accumulation of tangible $K_{j,t}$ and intangible capital $Z_{j,t}$

$$K_{j,t+1} = [1 - \delta(u_{jt})] K_{jt} + \Omega_{j,t}^k I_{jt} \tag{3}$$

$$Z_{j,t+1} = (1 - \delta_z) Z_{jt} + X_{jt} \tag{4}$$

Comparing tangibles and intangibles

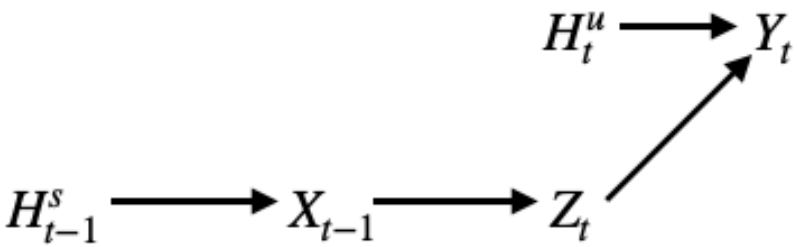
⊙ Difference 1: intangible capital is non-rival

⊙ Difference 2: skilled labor has a long-term nature

The Model–Production

⊙ Difference 2: skilled labor has a long-term nature

Figure: Contributions of the Two Types of Labors on Y_t



- Borrowing constraint

$$B_{jt} \leqslant \xi_t(P_t K_{jt} + \nu P_t Z_{jt}),\ 0 < \nu < 1 \tag{5}$$

⊙ Difference 3: intangible capital $Z_{j,t}$ is partially pleadgeable

household measurement

Calibration

Parameters	Description	Value	Targets/Sources
α	physical capital share	0.3	standard
ζ	intangible capital share	0.15	data & literature
β	discount factor	0.995	data
b	degree of habit formation	0.75	Bianchi et al. (2023)
η	inverse labour elasticity	2	Smets & Wouters (2007)
δ_k	physical capital depreciation	0.025	standard
δ_z	intangible capital depreciation	0.0375	Jinnai (2015)
δ_2/δ_1	capital utilization cost	0.1	Born & Pfeifer (2014)
κ	equity adjustment cost	0.15	Jermann & Quadrini (2012)
ϕ_k	investment adjustment cost	1.6	Born & Pfeifer (2014)
ϕ_p	price adjustment cost	100	Basu & Bundick (2017)
ψ	intertemporal elast. of substit.	0.95	Basu & Bundick (2017)
σ	risk aversion	80	Basu & Bundick (2017)

Calibration

Parameters	Description	Value	Targets/Sources
τ	tax rate	0.35	Jermann & Quadrini (2012)
θ_m	IG elast. of subst.	10	standard
θ_f	FG elast. of subst.	10	standard
ρ	taylor smoothing	0.7	commonly-used
ρ_π	taylor parameter	1.85	commonly-used
ρ_y	taylor parameter	0.25	commonly-used
ν	intangible pledgeability	0.2	Mann (2018), OECD (2021)
$1+g_y$	ss per capita GDP growth	1.005	data
G/Y	ss exo. demand share	0.15	data
H^u	ss unskilled hours worked	1/3	normalization
H^s	ss skilled hours worked	0.015	model-implied
ξ	ss financial constraint	0.4	data

Calibration

Parameters	Description	Value
ρ_a	per. of tangible productivity	0.95
ρ_d	per. of preference	0.80
ρ_g	per. of government spending	0.98
ρ_f	per. of financial const.	0.98
ρ_u	per. of uncertainty	0.75
σ_a	std. of tangible productivity	0.007
σ_d	std. of preference	0.020
σ_g	std. of government spending	0.002
σ_f	std. of financial const.	0.009
σ_u	std. of uncertainty	0.009

Sources: Jermann & Quadrini (2012), Christiano et al. (2014), Fernádez-Villaverde et al. (2015), Leduc & Liu (2016), Basu & Bundick (2017), Bianchi et al. (2019)

Moments

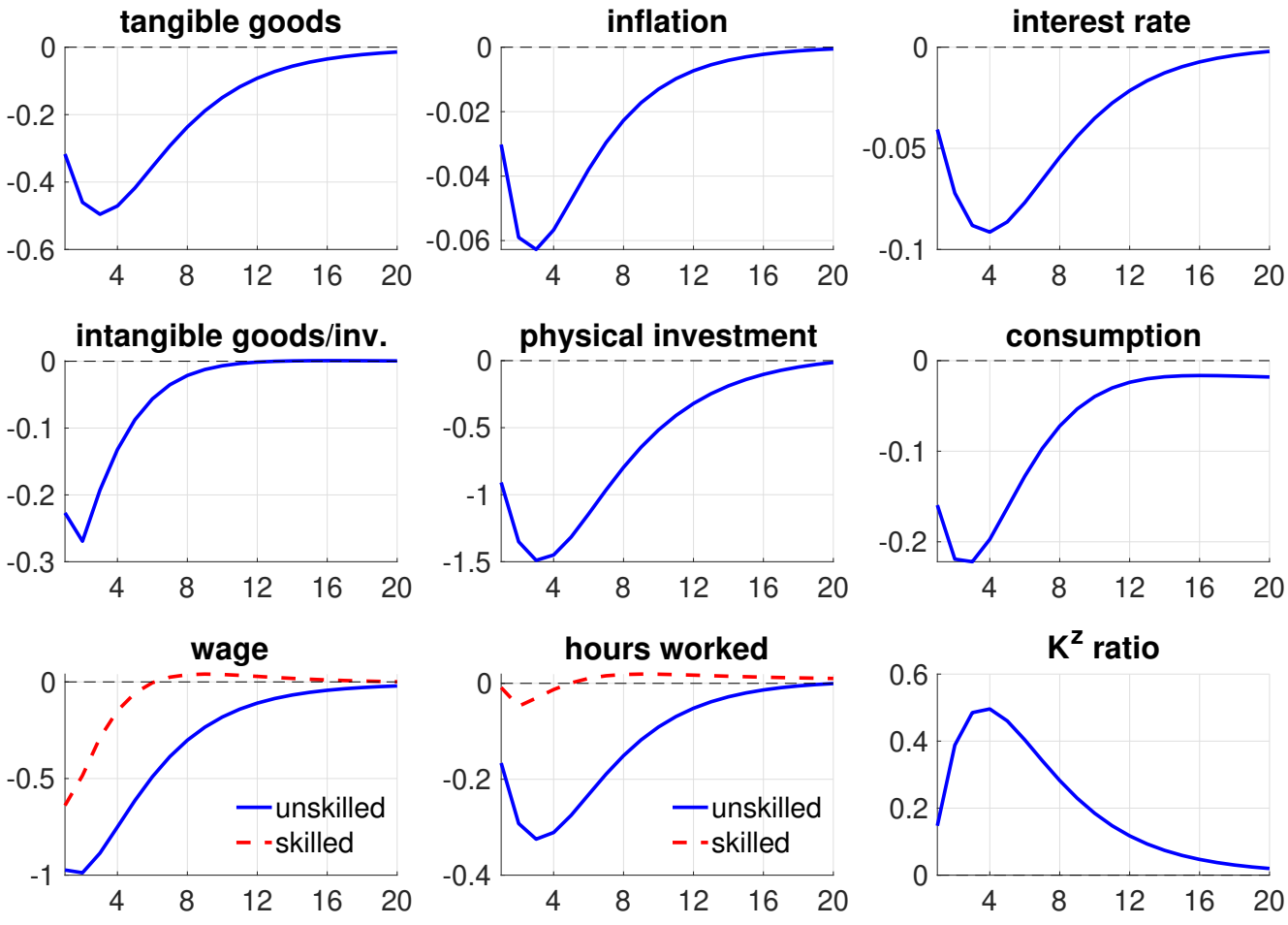
Table: Empirical and Model-implied Moments

Moment	Data	Model Baseline	Model w/o Un. shock
$\sigma(\Delta y)$	0.63	0.70	0.59
$\sigma(\Delta c)$	0.55	0.58	0.47
$\sigma(\Delta i)$	2.27	2.23	1.87
$\sigma(h)$	1.23	1.38	1.17

Note: the empirical sample period is 1986-2019 at quarterly frequency. The empirical counterpart of tangible output y is defined as GDP excluding intellectual property products (IPP). The empirical counterpart of tangible investment i is defined as fixed private investment excluding IPP.

The (Preference) Uncertainty Shock

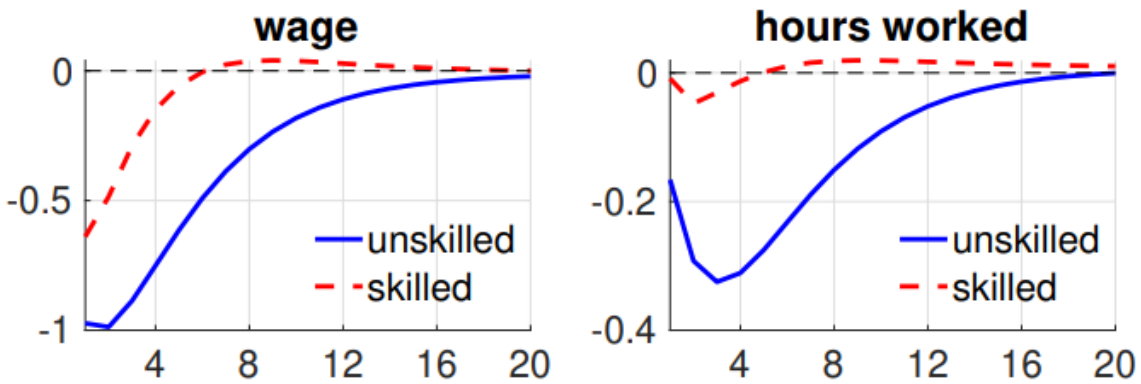
- Adverse effects; comovement between macro aggregates
- Less responsive intangible goods/inv. than tangible inv.



The Uncertainty Shock: mechanisms

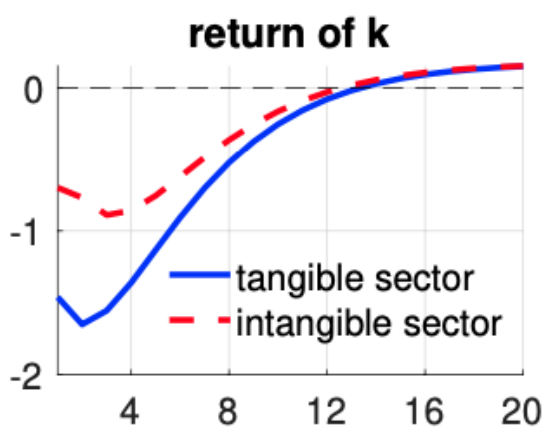
⊙ Precautionary labor motive

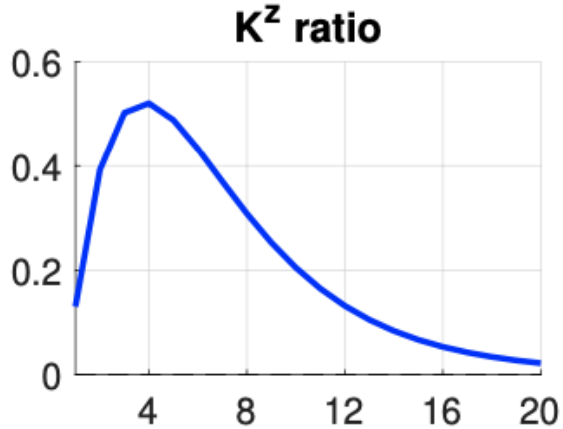
- Households tend to work more to combat the adverse effects from uncertainty (Basu & Bundick 2017)
  - Smaller ↓ in the skilled wage
  - Larger ↓ ↓ in the unskilled wage
- ⇒ Keep skilled working H_t^s
- Precautionary labor motive stronger for H_t^s
- Maintain intangible production



The Uncertainty Shock: mechanisms

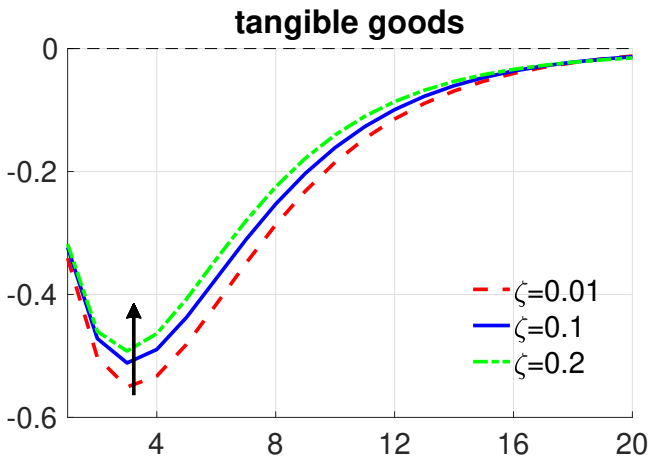
- ⊙ Capital reallocation effect
  - Uncertainty ↑ ⇒ return of physical capital ↓
    - Smaller ↓ in the intangible sector
    - Larger ↓ ↓ in the tangible sector
  - Reallocate physical capital toward the intangible sector
  - Maintain intangible production

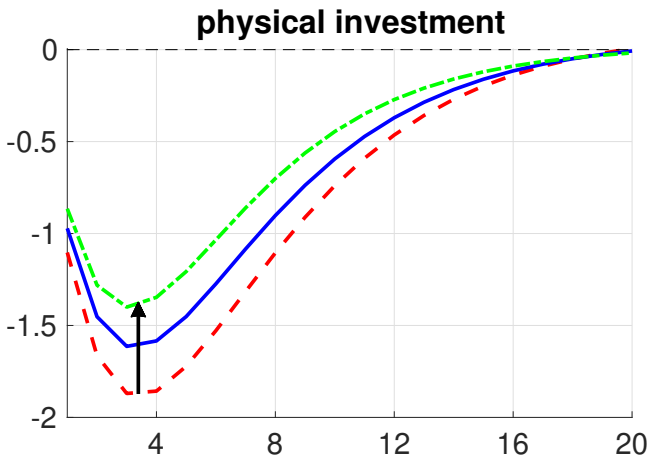


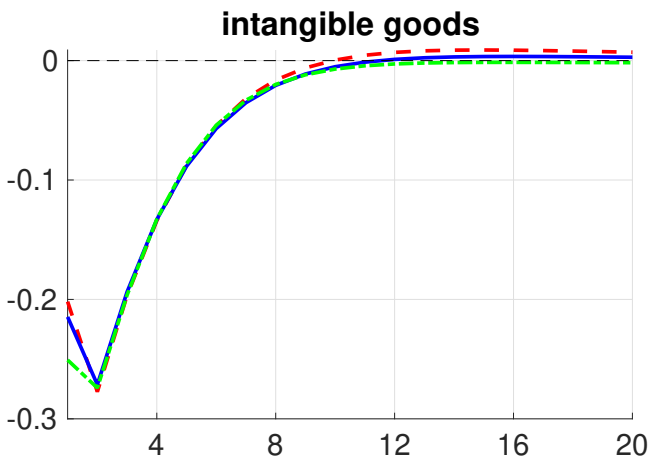


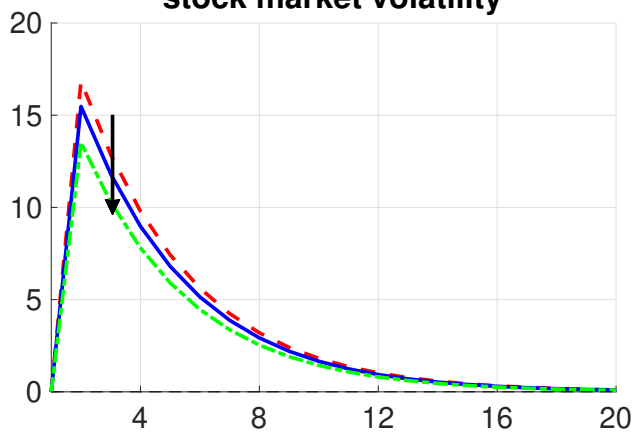
The Uncertainty Shock with Increasing Intangible Shares

- Dampening effects on both real and financial sides



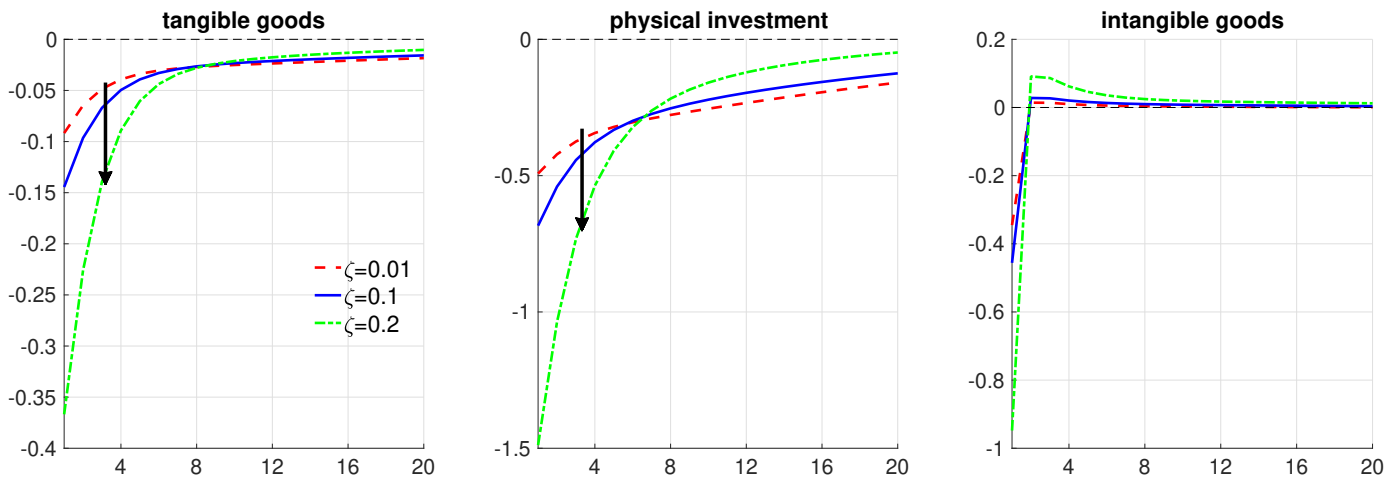






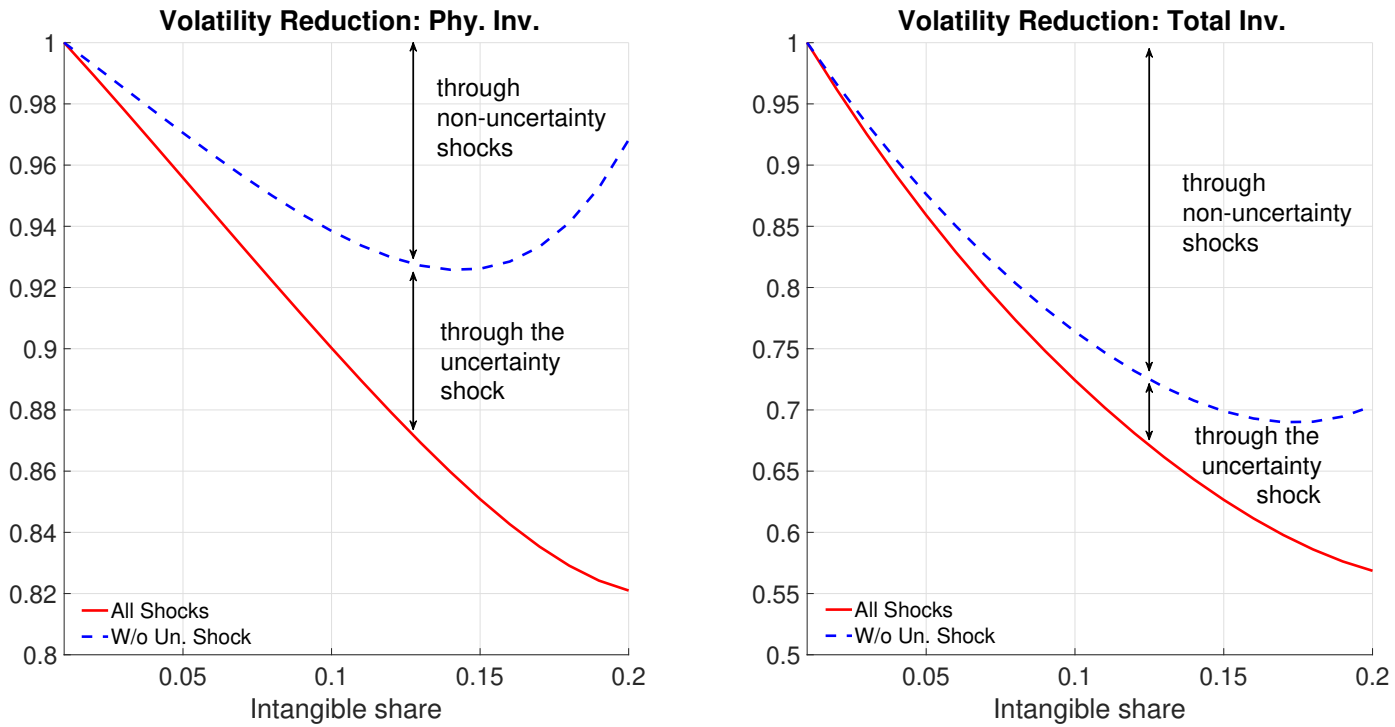
Implications for the Financial Shock

- More substantial decline in intangible investment
  - Intangible capital is disfavored due to limited pledgeability
  - Cut down relatively more intangible investment
- Amplification effects
  - Consistent with the literature (Lopez & Olivella 2018; Anzoategui et al. 2019; Ikeda & Kurozumi 2019)



Results-Implications of Rising Intangible Shares

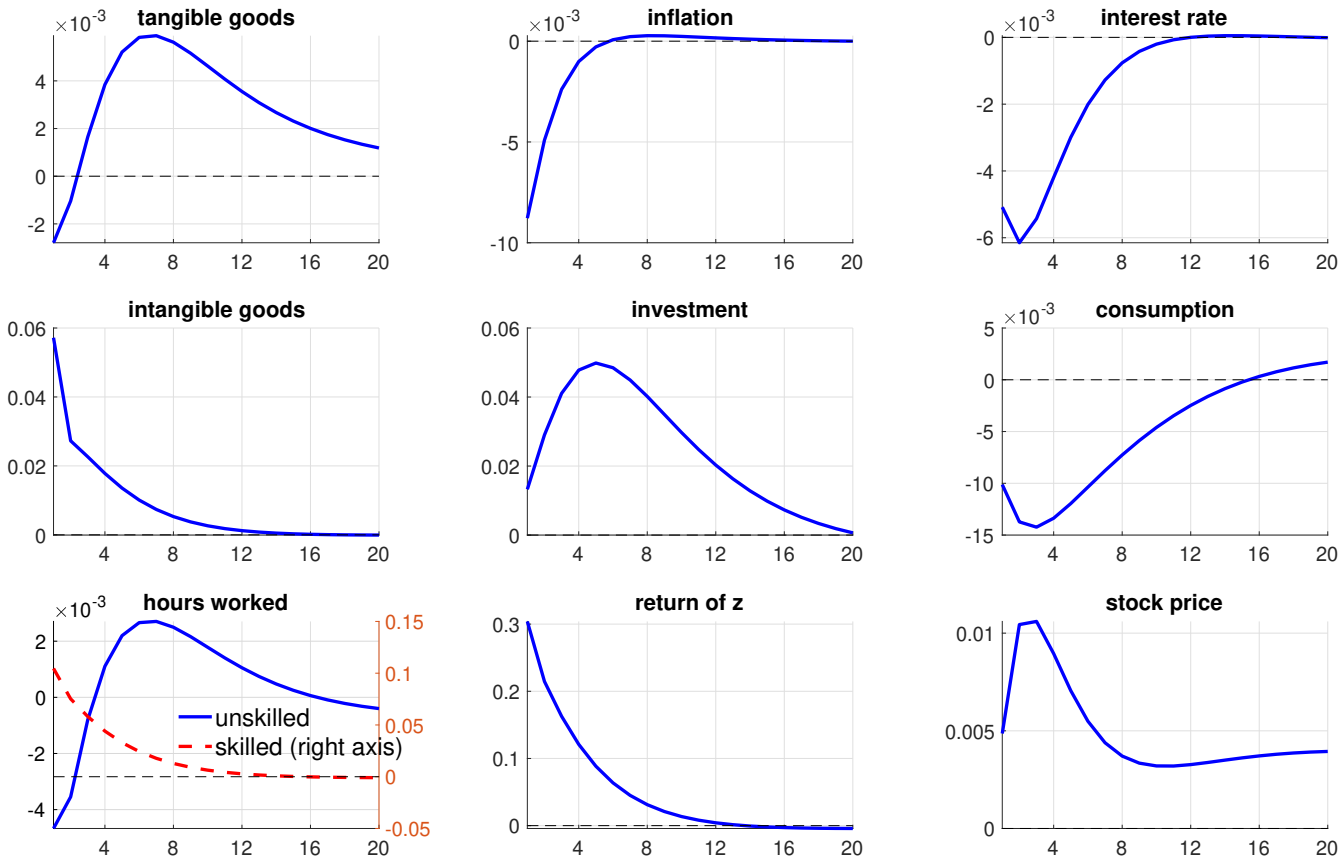
Figure: Volatility Reduction Effects of Intangibles on Investment



Note: this figure shows relative volatility of physical investment (left panel) and total investment $i+x$ (right panel) conditional on different intangible shares.

Intangible-specific Uncertainty Shock

- Motivation: high-tech boom in the 1990s
- Good uncertainty–expansionary effects in the mid-to-long run
- But the effects are quantitatively small



Conclusion

⊙ What are implications of intangibles for uncertainty-driven business cycles?

- Firm-level empirical analysis
- Theoretical analysis based on the two-sector DSGE model

⊙ Major findings

- Intangibles dampen the transmission of the (preference) uncertainty shock
  - Capital reallocation effect
  - Precautionary skilled labor motive
- Contrast to the amplification role in transmission of the financial shock
- Intangible-specific uncertainty shock
  - Triggers growth-option effects
  - Expansionary effects in the medium-to-long run

⊙ The economy becomes more knowledge-intensive in the wake of heightened uncertainty

Thank you for listening!

Empirical Analysis

back

- Robustness check
  - Another measure: macroeconomic uncertainty–JLN index (Jurado et al. 2015)
  - Alternative order of the uncertainty measures
    - Uncertainty is the leading variable in the main analysis, consistent with theoretical implications (Basu & Bundick, 2017)
  - Original but lagged uncertainty indices (and lagged other independent variables)
    - Is the effect of uncertainty delayed?
  - Stock price-uncertainty relationship
    - Similar findings
  - No Hampel Identifier
    - A range of estimated coefficients

The Model–Households

- Epstein–Zin preference
- Time-varying volatility in the preference shock ε_t^d

$$V_t = [\varepsilon_t^d U_t^{(1-\sigma)/\theta_v} + \beta(E_t V_{t+1}^{1-\sigma})^{1/\theta_v}]^{\theta_v/(1-\sigma)} \tag{6}$$

- Households supply skilled H_t^s and unskilled labor H_t^u

$$U_t = log(C_t - h\bar{C}_{t-1})e^{-\frac{\psi^u (H_t^u)^{1+\eta} + \psi^s (H_t^s)^{1+\eta}}{1+\eta}} \tag{7}$$

- Households saving in the form of deposit D_t and equity S_t

$$\begin{aligned} &P_t C_t + D_t + P_t^E S_t \\ &= R_{t-1} D_{t-1} + (D_{t-1}^E + P_{t-1}^E) S_{t-1} + W_t^u H_t^u + W_t^s H_t^s + \Pi_t^f \end{aligned} \tag{8}$$

overview

The Model–Measurement

- GDP
  - Traditional measure: treat intangibles as intermediate costs
  - Actual measure: treat intangibles as final output

$$GDP_t = C_t + I_t + G_t \tag{9}$$

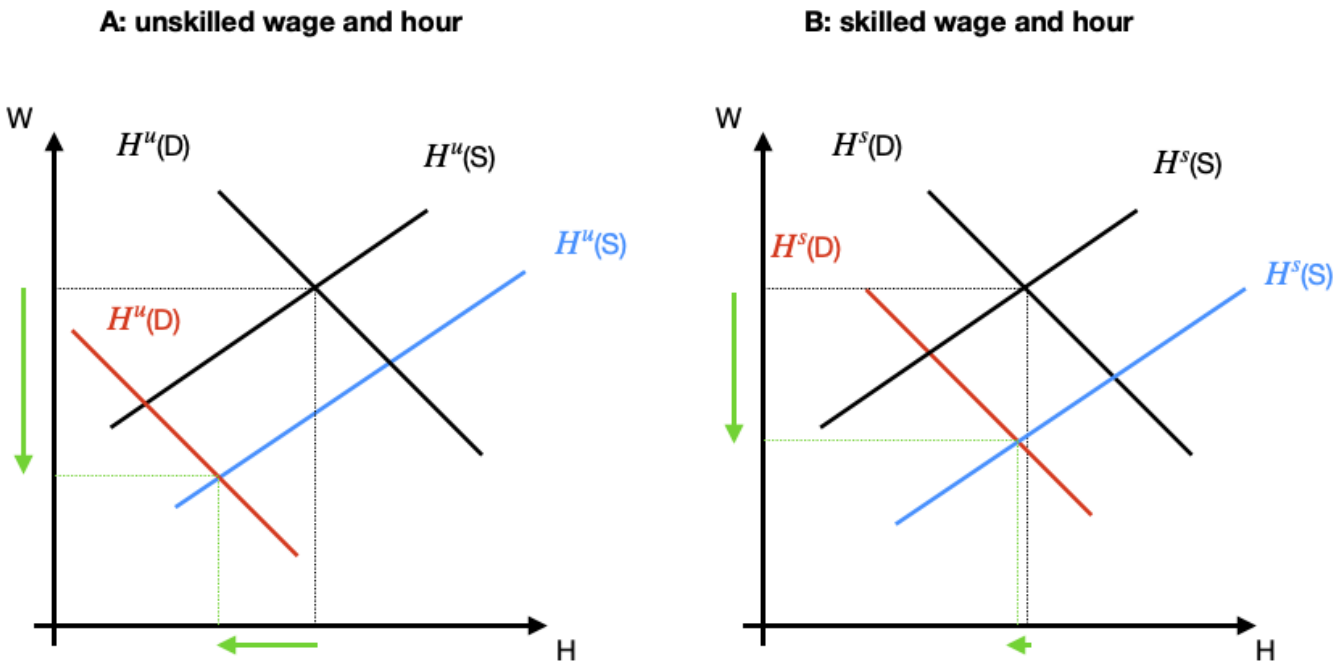
$$GDP_t^a = C_t + I_t + X_t + G_t \tag{10}$$

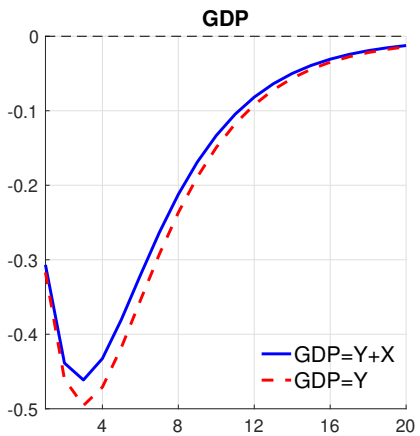
- Intangible investment
  - Output measure X_t is hard to observe
  - Input measure I_t^z

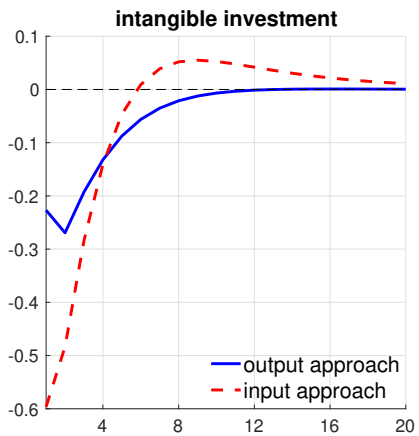
$$I_t^z = R_t^{k,z} K_t^z + W_t^s H_t^s \tag{11}$$

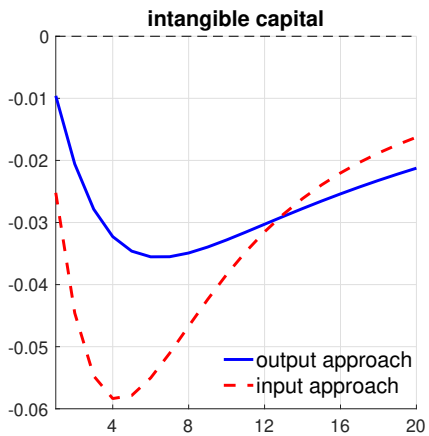
model

Results–Uncertainty Shock









Results-Implications of Rising Intangible Shares

Table: Effects of Intangibles on Aggregate Volatility

Variable	Fin. Shock Only	All Level Shocks	All Shocks
y	2.42	1.06	0.98
c	1.35	1.01	0.99
i	1.78	0.93	0.85
x	1.73	1.06	0.96
h	1.93	1.13	0.96

Note: this table contains relative volatility of key macroeconomic aggregates between an intangible economy ($\zeta = 0.15$) and a tangible economy ($\zeta = 0.01$). Volatility is measured with model-implied standard deviation. An entry below (above) 1 implies that intangibles dampens (amplifies) volatility of a variable.

Results-Implications of Rising Intangible Shares

Table: Effects of Intangibles on Deterministic and Stochastic Steady State

	DSS			SSS		
	Tangible Economy	Intangible Economy	Intangible/ Tangible	Tangible Economy	Intangible Economy	Intangible/ Tangible
y	0.765	1.312	1.715	0.762	1.308	1.717
gdp^a	0.771	1.477	1.916	0.768	1.475	1.921
i	0.166	0.326	1.964	0.160	0.317	1.981
x	0.006	0.165	27.500	0.006	0.167	27.833
c	0.484	0.789	1.630	0.487	0.794	1.630

Note: this table compares steady-state value of key macroeconomic aggregates between the intangible economy ($\zeta = 0.15$) and the tangible economy ($\zeta = 0.01$). Columns Intangible/Tangible show relative value of a variable between the two cases in either deterministic steady state or stochastic steady state.