Volatility and Growth: Credit Constraints and the Composition of Investment

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Links: Kalina Manova's webpage and research portfolio, this paper, and these slides

Motivation

- Business-cycle models give a central position to productivity shocks and the role of financial markets in the propagation of these shocks
  - But they typically take the entire productivity process as exogenous
- Growth models give a central position to endogenous productivity growth and the role of financial markets in the growth process
  - But they focus on trends, largely ignoring shocks and cycles
- Broad goal: theory of the joint determination of growth and volatility

Motivation

- Ramey and Ramey (1995)
  - Negative correlation between volatility and mean rate of GDP per capita growth
- Possible causal interpretations
  - Risk discourages demand for investment more than it encourages precautionary supply of savings
  - Higher volatility increases the likelihood of binding credit constraints and thereby reduces investment
- These interpretations cannot explain the observed negative correlation between volatility and growth

Growth and Investment Volatility

Dependent variable	Average growth, 1960–2000				Growth volatility, 1960–2000		Investment volatility, 1960–2000	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
initial income	0.002	−0.010	−0.006	−0.010	−0.012	−0.005	−0.940	−1.526
	(0.88)	(−3.31)***	(−3.59)***	(−4.07)***	(−3.23)***	(−1.22)	(−2.18)**	(−2.63)**
growth volatility	−0.127	−0.116	−0.113	−0.101				
	(−2.10)**	(−1.27)	(−2.64)***	(−1.35)				
investment/GDP			0.002	0.001				
			(10.11)***	(5.64)***				
private credit					−0.024	−0.006	0.577	2.362
					(−2.09)**	(−0.52)	(0.43)	(1.41)
Controls								
pop growth, sec enroll	No	Yes	No	Yes	No	Yes	No	Yes
Levine et al. policy set	No	Yes	No	Yes	No	Yes	No	Yes
R-squared	0.078	0.423	0.540	0.617	0.241	0.498	0.052	0.369
N	106	73	106	73	106	73	106	73

Motivation

- The point estimate of the volatility coefficient falls only by one tenth when the investment rate is included as an additional control
  - Observed negative relation between volatility and growth is not channeled through the overall rate of saving and investment
- The correlation between private credit and the st dev of the ratio of investment to GDP is about zero
  - Volatility effects of credit constraints are not channeled through the overall rate of investment
- Need to look beyond the standard transmission channel to understand the effect of uncertainty and credit constraints on growth and volatility

This Paper

- Study how financial frictions impact both the *level* and the *composition* of investment over the business cycle and their implications for volatility and growth

- Model
  - Short-term and long-term investments
  - Fraction of capital allocated to long-term investment is countercyclical under perfect credit markets, but turns procyclical under sufficiently tight constraint

- Predictions
  - Tighter credit constraints contribute to a more procyclical share of long-term investment
  - Financial frictions contribute to both lower mean growth and higher volatility

This Paper

- Empirics
  - Panel of 21 OECD countries over the 1960–2000 period
  - Business-cycle shocks: innovations in commodity prices weighted by commodities' share in net exports
  - Share of long-term investment: ratio of structural investment to total private investment
  - Tightness of credit constraints: private credit to GDP ratio

- Results
  - Impact of shocks on the share of structural investment is greater in countries with lower financial development, but not on the overall investment rate
  - Tighter credit amplifies the effects of shocks on output growth
  - Financially underdeveloped countries exhibit less growth, more volatility, and a more negative correlation between growth and volatility

Outline

1. Introduction and motivation
2. Model
3. Empirical findings
    1. Impact of shocks on investment
    2. Impact of shocks on growth
4. Conclusion

Theoretical Framework

- Set up
  - Single type of agents
  - Each generation consists of a unit mass of agents
  - Each agent lives for three periods, endowed with unit labor in each period
  - Single consumption good, two types of capital goods

- Endowments and preferences
  - Agent born in period t has labor endowment of H_t in efficiency units
  - H_t is fixed over the productive life of the agent and exogenous to her choices
  - Linear preferences

$$U_t = C_{t.t} + \beta C_{t,t+1} + \beta^2 C_{t,t+2}$$

Production Technology

- Production of capital goods
  - At period t, agent can transform labor to either of two types of capital goods, K and Z, using CRS technology:

$$K_t = \theta H_{k,t}, \qquad Z_t = \theta H_{z,t}$$

  - Short-term investment: K becomes productive in $t+1$
  - Long-term investment: Z becomes productive in $t+2$

- Production of consumption good

$$Y_{t,t+1} = A_{t+1} K_t^{\alpha} H_t^{1-\alpha}, \qquad Y_{t,t+2} = A_{t+2} Z_t^{\alpha} H_t^{1-\alpha}$$

  - $Y_{t,s}$ is the consumption good produced in period s by an agent born in t
  - A_s is aggregate productivity in period s

Liquidity Shock

- Liquidity shock
  - At period $t+1$, agent faces an idiosyncratic shock $L_{t+1} \geq 0$ that she must incur to produce consumption goods in period $t+2$
  - Failure to cover the liquidity shock results in zero output
  - If the agent covers the shock, she recovers fully the associated expense in $t+2$
- Financial markets
  - Agents can trade only a riskless short-term bond
  - Net borrowing of an agent in the first or second period cannot exceed a multiple $\mu \geq 0$ of her contemporaneous income

Budget and Borrowing Constraints

Period 1 Constraint: $C_{t,t} + q_t(K_t + Z_t) = q_t\theta H_t + B_{t,t},\ B_{t,t} \leq \mu q_t \theta H_t$

- $C_{t,s}$: consumption at period s by agent born in t
- q_t : price of capital at t
- $B_{t,t}$: first period borrowing

Period 2 constraint: $C_{t,t+1} + L_{t+1}e_{t,t+1} = Y_{t,t+1} + B_{t,t+1} - (1 + R_t)B_{t,t},\ B_{t,t+1} \leq \mu Y_{t,t+1}$

- L_{t+1} : liquidity shock
- $e_{t,t+1}$: 1 if the agent covers the shock
- $Y_{t,t+1}$: income from short-term investment
- R_t : risk-free rate between t and $t + 1$

Period 3 constraint: $C_{t,t+2} = \left(Y_{t,t+2} + \beta^{-1}L_{t+1}\right)e_{t,t+1} - (1 + R_{t+1})B_{t,t+1}$

- $Y_{t,t+2}$: income from long-term investment
- $\beta^{-1}\, L_{t+1}$: recovery of liquidity expense

Dynamics

- Stock of human capital

$$H_{t+1} = \Gamma(H_t, \tilde{Z}_t, K_t)$$

  - $\tilde{Z}_t$: long-term investment that survives liquidity shocks
  - Γ : homogeneous of degree 1, increasing in Z/K (long-term investment more conducive to productivity growth)

- Productivity shock

$$\log A_t = \rho \log A_{t-1} + \log \nu_t$$

  - ν_t : innovation in productivity shock, mean normalized to 1
  - ρ : persistence of productivity shock

- Liquidity shock

  - Distribution of $l_{t+1} \equiv L_{t+1}/H_t$ invariant over time, has support $[0, l_{max}]$, cdf Φ
  - Assume $\Phi(l) = (l/l_{max})^{\phi}$

Perfect Credit Markets

Proposition 1 Suppose that credit markets are perfect.

i. The equilibrium exists and is unique.

ii. There exists a continuous function $z^*: \mathbb{R}_+ \to (0, \theta)$ such that the equilibrium levels of short-term and long-term investment are given, respectively, by $k_t \equiv K_t/H_t = \theta - z^*(A_t)$ and $z_t \equiv Z_t/H_t = z^*(A\_t)$.

iii. The function z^* is strictly decreasing. That is, the share of long-term investment decreases with a positive innovation in productivity.

Perfect Credit Markets

Intuition: Opportunity cost effect

- Opportunity cost of long-term investment is higher in booms than in recessions
  - Mean reversion in the business cycle makes short-term profits more pro-cyclical
  - Return to short-term investment depends more on short-term profits, so likely to be more procyclical than return to long-term investment
  - Composition of investment is likely to shift towards a higher share of long-term investment during recessions than during booms

Imperfect Credit Markets

Proposition 2 Suppose that credit constraints are sufficiently tight that the liquidity risk is non-zero in all states of nature.

i. The equilibrium exists and is unique.

ii. There exists a continuous function z such that the equilibrium composition of investment is given by $k_t = \theta - z(A_t, \mu)$ and $z_t = z(A_t, \mu)$.

iii. This function satisfies $z(A, \mu) < z^*(A)$ for all (A, μ) and is decreasing in μ. That is, credit constraints depress the share of long-term investment below its complete-market value, and the more so the tighter they are.

iv. Suppose further that $\phi > 1 - \rho$. Then $z(A, \mu)$ is increasing in A. That is, the share of long-term investment increases with a positive innovation in productivity.

Imperfect Credit Markets

Intuition: Liquidity risk effect

- Share of long-term investment is lower than under complete markets
  - Liquidity shock introduces a positive wedge between the marginal products of the long-term and the short-term investment
  - Positive probability that the long-term investment will get disrupted
  - Precautionary motive for short-term investment
  - As credit constraints become tighter, the probability of disruption increases and the precautionary motive gets reinforced

- Liquidity-risk effect: positive productivity shock improves the availability of liquidity and reduces the probability of disruption
  - Opposite direction of opportunity-cost effect
  - Liquidity-risk effect dominates if and only if ϕ (cyclical elasticity of liquidity risk) is sufficiently high relative to $1-\rho$ (non-persistence of business cycle)

Main Prediction

Main prediction Other things equal, tighter credit constraints make it more likely that the share of long-term investment increases with a positive productivity shock.

- Propositions 1 and 2 together imply that the share of long-term investment turns from countercyclical under complete markets to procyclical when credit constraints are tight and liquidity risk is sufficiently procyclical

- Even when the probability of disruption is positive for a subset of states, the liquidity-risk effect remains, contributing to procyclicality

Propagation and Amplification

Proposition 3

i. There exist functions h^* and h such that $H_{t+1}/H_t = h^*(A_t)$ when markets are complete and $H_{t+1}/H_t = h(A_t, \nu_{t+1}, \mu)$ when markets are incomplete.

ii. Suppose the liquidity risk is bounded away from zero. Then the endogenous component of productivity growth is lower under incomplete markets than under complete markets, more so the lower μ or the lower the innovation in productivity.

iii. Suppose further that $\phi > 1 - \rho$. Then the endogenous component of productivity growth increases with the beginning-of-period productivity under incomplete markets, whereas it decreases with it under complete markets.

Auxiliary predictions

iv. In the short run, tighter credit constraints amplify the response of output to exogenous business-cycle shocks.

v. In the long run, they lead to lower mean growth.

Data

- Long-term investment rate, z_t
  - Share of structural investment in total private investment
  - 21 OECD countries over 1960-2000 (OECD Economic Outlook Database 2005)
- Exogenous disturbance, ν_t
  - Net-export-weighted changes in international prices of 42 commodities (International Financial Statistics Database of the IMF)
  - TFP shocks in the model should be interpreted broadly as supply and demand shocks that cause variations in firm profits
  - Terms-of-trade shocks more likely to be exogenous to the economy

Data

- Credit tightness, μ
  - Ratio of private credit to GDP
  - Also use total liquid liabilities and stock market capitalization relative to GDP in robustness checks (Levine et al 2000)
  - Mean 0.66
  - St dev 0.36 in the panel, 0.22 over time, 0.27 across countries
- Controls
  - Rule of law (La Porta et al 1998)
  - Demographic variables (PWT)
  - Schooling (Barro and Lee 1996)
  - Policy measures (Levine et al 2000)

Impact of Shocks on Investment

$$\frac{LTI_{it}}{I_{it}} = const + \alpha \cdot credit_{it} + \sum_{j=0,1,2} (\delta_j + \gamma_j \cdot credit_{it}) \cdot shock_{i,t-j} + \beta \cdot X_{it} + \omega_i + \omega_t + \varepsilon_{it}$$

- The dependent variable is the share of structural investment in total investment
- Financial development is moving lagged average of private credit over 5 years
- Moving lagged average of GDP per capita as control
- Expect $\gamma < 0$

Impact of Shocks on Investment

	Baseline specifications			Shocks less than 100%		
	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable: share of private structural investment in total private investment						
priv credit	0.0135	0.0153	0.0141	0.0189	0.0185	0.0180
	(0.32)	(0.36)	(0.33)	(0.41)	(0.40)	(0.39)
priv credit $*shock_t$	−0.0087	−0.0079	−0.0069	−0.0350	−0.0521	−0.0594
	(−2.08)**	(−1.89)*	(−2.39)**	(−2.14)**	(−2.45)**	(−2.16)**
priv credit $*shock_{t-1}$	0.0024	0.0033	0.0039	−0.0422	−0.0517	−0.0627
	(0.96)	(1.78)*	(1.53)	(−2.00)*	(−2.11)**	(−1.85)*
priv credit $*shock_{t-2}$	0.0004	−0.0025	−0.0011	−0.0465	−0.0807	−0.1214
	(0.15)	(−0.90)	(−0.33)	(−1.71)	(−2.32)**	(−2.39)**
comm share $*shock_t$			−0.0001			0.0001
			(−1.28)			(0.09)
comm share $*shock_{t-1}$			−0.0001			0.0000
			(−1.82)*			(−0.04)
comm share $*shock_{t-2}$			−0.0001			−0.0036
			(−1.19)			(−2.00)*
Controls						
shocks, income	Yes	Yes	Yes	Yes	Yes	Yes
country & year FE	Yes	Yes	Yes	Yes	Yes	Yes
income & rulelaw interactions	No	Yes	Yes	No	Yes	Yes
abs(shock) ≤ 1	No	No	No	Yes	Yes	Yes
R-squared	0.788	0.790	0.791	0.784	0.786	0.787
# countries	21	21	21	21	21	21
N	728	728	728	603	603	603

Impact of Shocks on Investment

- Financial development positively correlated with overall development
  - Column 2 includes interactions of income per capita and the overall rule of law with the three shock terms to isolate the independent effect of credit availability
- Natural resource producers may be more sensitive to commodity shocks and have lower financial development
  - Column 3 controls for the interaction of commodity price shocks with a country's share of commodities in net exports
- Columns 4–6 show results hold in the sample for which the commodity price shock does not exceed 100% in absolute value
  - Extremely large shocks may signal structural changes in the economy
  - Response might be non-linear with extreme shocks

Robustness

- Results robust to alternative financial development measures
  - Shocks may trigger slow changes in the level of private credit
  - Use measures that vary only in the cross-section

Fin devt measure	Private credit$_{1960-2000}$			Liquid liabilities		Market capitalization	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Dependent variable: share of private structural investment in total private investment							
fin devt				−0.054	−0.053	−0.003	−0.002
				(−0.93)	(−0.91)	(−0.05)	(−0.04)
fin devt ∗*shock*$_t$	−0.012	−0.044	−0.066	−0.058	−0.089	−0.019	−0.027
	(−2.89)***	(−2.39)**	(−2.27)**	(−3.43)***	(−3.11)***	(−0.55)	(−0.77)
fin devt ∗*shock*$_{t-1}$	0.003	−0.052	−0.052	−0.062	−0.073	−0.043	−0.055
	(1.26)	(−1.76)*	(−1.58)	(−3.10)***	(−2.90)***	(−1.48)	(−1.43)
fin devt ∗*shock*$_{t-2}$	0.000	−0.087	−0.113	−0.054	−0.095	−0.053	−0.066
	(−0.10)	(−4.79)***	(−4.89)***	(−1.56)	(−2.61)**	(−1.25)	(−1.25)
Controls							
shocks, income	Yes	Yes	Yes	Yes	Yes	Yes	Yes
country & year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
income & rulelaw interactions	No	No	Yes	No	Yes	No	Yes
abs(shock) ≤ 1	No	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.782	0.776	0.777	0.752	0.756	0.783	0.786
# countries	21	21	21	19	19	19	19
N	764	639	639	537	537	374	374

Total Investment

- Lower levels of financial development do not predict a stronger impact of commodity-price shocks on the share of investment in total GDP
- Results for composition of investment are robust to controlling for overall rate of investment to GDP (proxy for supply of savings)

Dependent variable	Total investment/GDP					Structural inv/total inv				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
investment/GDP						0.000	0.001	0.001	0.001	0.002
						(0.10)	(0.44)	(0.50)	(0.52)	(0.61)
priv credit	3.43	2.42	2.49	2.52		0.013	0.016	0.015	0.014	
	(1.76)*	(1.05)	(1.13)	(1.13)		(0.32)	(0.36)	(0.34)	(0.33)	
priv credit $*shock_t$	−0.18	1.61	2.53	1.72	−0.02	−0.009	−0.037	−0.056	−0.062	−0.055
	(−0.60)	(1.10)	(1.52)	(1.21)	(−0.01)	(−2.13)**	(−2.22)**	(−2.42)**	(−2.18)**	(−3.41)***
priv credit $*shock_{t-1}$	0.41	2.54	3.26	1.82	2.43	0.002	−0.045	−0.056	−0.065	−0.055
	(3.57)***	(1.90)*	(2.45)**	(1.46)	(1.56)	(1.03)	(−2.20)**	(−2.14)**	(−1.92)*	(−2.05)*
priv credit $*shock_{t-2}$	−0.61	0.10	3.00	3.22	1.21	0.001	−0.047	−0.085	−0.126	−0.102
	(−2.31)**	(0.05)	(1.61)	(1.54)	(0.60)	(0.18)	(−1.76)*	(−2.41)**	(−2.46)**	(−4.17)*
comm share $*shock_t$				−0.12					0.000	
				(−0.72)					(0.20)	
comm share $*shock_{t-1}$				−0.20					0.000	
				(−3.92)***					(0.17)	
comm share $*shock_{t-2}$				0.08					−0.004	
				(0.86)					(−2.02)*	
Controls										
shocks; income; country & year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
income & rulelaw interactions	No	No	Yes	Yes	Yes	No	No	Yes	Yes	Yes
abs(shock) ≤ 1	No	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes
R-squared	0.732	0.739	0.746	0.748	0.729	0.788	0.786	0.787	0.789	0.786
# countries	21	21	21	21	21	21	21	21	21	21
N	728	603	603	603	630	728	603	603	603	603

Impact of Shocks on Growth

$$\Delta y_{it} = const + \alpha \cdot credit_{it} + \beta \cdot y_{it-2} + \sum_{j=0,1,2} \left(\delta_j + \gamma_j \cdot credit_{it}\right) \cdot shock_{i,t-j} + \omega_i + \omega_t + \varepsilon_{it}$$

- The dependent variable is annual GDP per capita growth for country i in time t
- Financial development is moving lagged average of private credit over 5 years
- Twice-lagged GDP per capita as control
- Expect $\gamma < 0$

- Control for concurrent and lagged total investment as shares of GDP
  - Effects not channeled through the level of aggregate investment
  - Isolate productivity improvements above and beyond capital accumulation

Impact of Shocks on Growth

	Baseline specifications				Controlling for total investment/GDP			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dependent variable: annual GDP per capita growth								
priv credit	−0.004	−0.008	−0.008		−0.005	−0.009	−0.009	
	(−0.45)	(−0.75)	(−0.75)		(−0.55)	(−0.92)	(−0.93)	
priv credit $*shock_t$	0.000	0.006	0.008	0.024	−0.001	0.006	0.009	0.023
	(−0.13)	(0.39)	(0.49)	(1.49)	(−0.59)	(0.46)	(0.59)	(1.38)
priv credit $*shock_{t-1}$	−0.005	−0.030	−0.031	−0.035	−0.004	−0.027	−0.030	−0.033
	(−4.63)***	(−2.38)**	(−2.16)**	(−2.90)***	(−3.22)***	(−2.19)**	(−2.12)**	(−3.00)***
priv credit $*shock_{t-2}$	−0.003	−0.005	0.001	−0.015	−0.002	−0.002	0.004	−0.010
	(−1.56)	(−0.59)	(0.11)	(−1.60)	(−1.28)	(−0.25)	(0.41)	(−0.92)
Controls								
shocks; $income_{t-2}$; country & year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
$abs(shock) \leq 1$	No	Yes	Yes	Yes	No	Yes	Yes	Yes
comm share interactions	No	No	Yes	No	No	No	Yes	No
R-squared	0.410	0.456	0.457	0.455	0.425	0.468	0.469	0.466
# countries	21	21	21	21	21	21	21	21
N	727	602	602	629	727	602	602	629

Volatility and Growth

- When idiosyncratic liquidity risk increases with aggregate volatility, the causal effect of volatility on growth should be more negative the tighter the credit constraints
  - Cost of business cycles may be higher in financially underdeveloped countries
- Repeat Ramey and Ramey (1995) regression with the addition of private credit and its interaction with volatility
  - Results consistent and economically significant
  - 1 st dev improvement in private credit would reduce the negative growth impact of 1% rise in volatility by 0.14%

Volatility and Growth

	No investment			With investment		
	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable: average GDP per capita growth, 1960–2000						
initial income	−0.003	−0.010	−0.011	−0.006	−0.009	−0.010
	(−1.51)	(−3.79)***	(−4.37)***	(−3.78)***	(−3.97)***	(4.42)***
growth volatility	−0.161	−0.257	−0.137	−0.172	−0.218	−0.134
	(−2.35)**	(−2.46)**	(−1.27)	(−3.15)***	(−2.37)**	(−1.40)
private credit	0.014	−0.005	0.064	−0.004	−0.015	0.036
	(1.20)	(−0.35)	(2.37)**	(−0.43)	(−1.33)	(1.43)
volatility ∗private credit	0.520	0.757	0.458	0.441	0.575	0.375
	(2.23)**	(2.50)**	(1.50)	(2.36)**	(2.14)**	(1.37)
investment/GDP				0.001	0.001	0.001
				(7.59)***	(4.45)***	(4.03)***
Controls						
pop growth, sec enroll	No	Yes	Yes	No	Yes	Yes
Levine et al. policy set	No	Yes	Yes	No	Yes	Yes
private credit^2	No	No	Yes	No	No	Yes
F-test (volatility terms)	0.046	0.027	0.309	0.008	0.047	0.322
F-test (credit terms)	0.000	0.002	0.000	0.003	0.102	0.011
R-squared	0.356	0.529	0.584	0.591	0.644	0.673
N	106	73	73	106	73	73

Conclusion

- Proposed novel propagation mechanism for the impact of financial frictions on the cyclical composition of investment, growth and volatility
  - The share of long-term investment turns from countercyclical under complete markets to procyclical under sufficiently tight credit constraints
  - Through this channel credit frictions can lead to both lower mean growth and amplified volatility
- Provided supporting empirical evidence using OECD panel data