Fundamental risk and capital structure

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1 October 2017

Risk-leverage trade-off

Figure: scatter plot of annual $\overline{lev}_i$ vs $\overline{\sigma_{prof}}_i$ for 4-digit SIC industries

- Sound theoretically, robust empirically
- Important in practice, Graham and Harvey [2002]
- But 'risk' has many dimensions...
- And any proxy depends on unobservable cash flow dynamics

Intuition

Let's consider the following two-industry example.

Agriculture
$\sigma_{prof} \approx 0.03 \rightarrow$ lower risk?

Apparel
$\sigma_{prof} \approx 0.08 \rightarrow$ higher risk?

- Finance 101 $\longrightarrow$ lower optimal debt ratio for apparel
- Data: this is false! $\overline{lev}_{apparel} \approx \overline{lev}_{agriculture} \approx 0.25 - 0.30$
- Why? The **nature of the risk** matters, e.g.
  - Agriculture: stable earnings (inelastic demand), transient shocks
  - Apparel: high sales variability (fads), lasting but slow moving shocks
- NB: $\widehat{\rho}_{apparel} > \widehat{\rho}_{agriculture}$ confirms the intuition (more later)

This paper

I develop a **dynamic capital structure model** in which firm's nature of risk results from the exposure of cash flows ($\approx$ profits) to two distinctive – transitory and persistent – shocks.

1. The model documents that:
   - leverage is **negatively related** to persistent shock exposure
   - **profits are persistent** even when persistent shock exposure is low
   - decomposition of fundamental risk allows to obtain **different optimal leverage ratios for the same level of total volatility**

2. The model explains why we **empirically observe**:
   - substantial dispersion in the risk-leverage relationship
   - low dispersion in profit persistence
   - weak association between cash flow persistence and firm characteristics

Intuition about the shocks

Economic intuition about separating shocks

The transitory and persistent components of cash flow process are represented by a **stationary** and a **non-stationary** process.

- **Persistent shocks** – permanently affect prospects of the firms
  $\Rightarrow$ technology improvements, changes to human capital, tastes...

- **Transitory shocks** – their impact subsides over time
  $\Rightarrow$ demand or supply shocks, regulatory shocks requiring real adjustments, changes in production cost structure...

Why persistent & transitory shocks?

Shock separation introduces more degree of freedom into the model.

- More realistic to have non-stationarity in the model – real quantities (sales, book assets) behave as if they were non-stationary.
- Two truly different types of risk:
  - A model with two transitory shocks fails to match multiple correlation-based moments.
  - It is easier to think in terms of 'two extreme cases', more difficult to economically identify two 'similar' shocks.
  - The model is in line with macroeconomic literature.
- NB: in another paper I empirically show how cash flow risk evolves due to firm's product market characteristics.

Persistent and transitory shocks in corporate finance

- Gourio [2008]:
  persistent shocks $\longleftrightarrow$ investment
- Gorbenko and Strebulaev [2010]:
  cash flow $\perp$ firm value, persistent shocks $\longleftrightarrow$ leverage
- Chang, Dasgupta, Wong, and Yao [2014], Décamps, Gryglewicz, Morellec, and Villeneuve [2016], Byun, Polkovnichenko, and Rebello [2016], Gryglewicz, Mancini, Morellec, Schroth, Valta [2017], ...

The model

The model: basics

Discrete-time dynamic investment model in the spirit of Hennessy and Whited [2005] and DeAngelo, DeAngelo, and Whited [2011], ...:

- A representative, infinitely-lived firm chooses capital and debt policy
- Fundamental risk $\longleftrightarrow$ cash flow dynamics

- Decreasing returns to scale
- Convex capital adjustment costs
- Taxes
- Risk-free (net) debt subject to a collateral constraint $P' \leq \omega K'$
- Linear equity financing costs

- NB: we can add other frictions (issuance cost, agency costs etc.) but they do not affect the main mechanism!

The model: modeling fundamental risk

Firm's cash flow process $Z = Z_P \times Z_T$ consists of two shocks.

1. **persistent**: unit root proces

$$\log(Z_P') = \log(Z_P) + \sigma_P \varepsilon_P'$$

2. **transitory**: autoregressive process ($\rho \ll 1$)

$$\log(Z_T') = \rho \log(Z_T) + \sigma_T \varepsilon_T'$$

- The model is solved by value function iteration solution method
- At this stage I only use parameter values from DeAngelo, DeAngelo, and Whited [2011] all parameters

- I study the effect of changing **risk composition**:
  - fundamental volatility: vary σ_P for the same σ_{tot},
  - fundamental persistence: vary ρ for the same σ_{tot} (and/ or σ_P).

Bellman equation

The model results in the following Bellman equation:

$$V(K,P,Z_T,Z_P) = \max_{K',P'} \Big\{ E(K,K',P,P',Z_T,Z_P) + \Phi(E(K,K',P,P',Z_T,Z_P)) + \frac{1}{1+r}\mathbb{E}_{Z'_T,Z'_P}\left[V(K',P',Z'_T,Z'_P)\right] \Big\},$$

$$\text{s.t. } P' \le \omega K',\ K' = I + (1-\delta)K,$$

$$\log(Z'_P) = \log(Z_P) + \sigma_P \varepsilon'_P,\ \log(Z'_T) = \rho \log(Z_T) + \sigma_T \varepsilon'_T,$$

where cash flow E consists of

$$E(K,K',P,P',Z_T,Z_P) = (1-\tau)Z_T Z_P K^\theta + \tau\delta K - [K' - (1-\delta)K] - \psi/2\left[(K' - (1-\delta)K)/K\right]^2 K + P' - [1 + r(1-\tau)]P$$

and external equity financing cost Φ is modeled by

$$\Phi(E(\cdot)) = [\eta E(\cdot)]\,\mathbb{1}_{E(\cdot)<0}.$$

Model intuition via first-order condition

Taking the first-order condition of the value function and using the envelope condition gives:

$$1 + \eta \mathbb{1}_{E(\cdot)<0} = \xi' + \frac{[1 + r(1-\tau)]}{1+r} \mathbb{E}_{Z'_T, Z'_P} \left[(1 + \eta \mathbb{1}_{E'(\cdot)<0}) \right].$$

- Financial flexibility – DeAngelo, DeAngelo, and Whited [2011].
- Marginal benefit of debt = marginal cost of debt (including losing the option to borrow).
- Real and financial policies are intertwined: investment is the main channel through which shocks affect leverage.
- Persistent shocks matter.

Main mechanisms

Policy functions

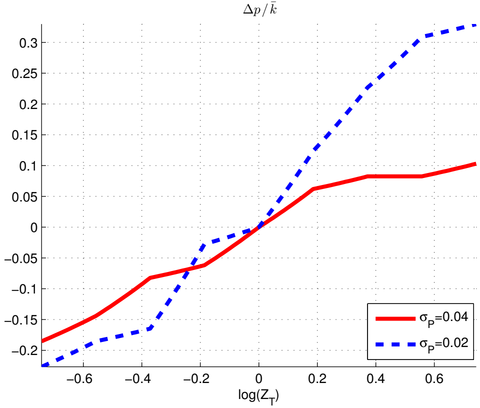

Figure: policy function for **net debt change**; $\sigma_{tot} = 0.15$, $\rho = 0.6$

Implications

- risk composition matters for corporate policies
- small persistent shock exposure $\longrightarrow$ large effect on firm policies
- higher $\sigma_P \longrightarrow$ less sensitivity to Z_T
- here: more reliance on internal financing

Impulse response functions

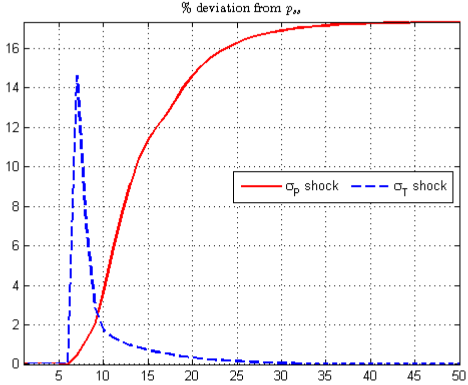

Figure: percent deviation of **net debt** from the steady state; $\sigma_{tot} = 0.15$, $\sigma_P = 0.04$, $\rho = 0.6$

Implications

- permanence
- adjustment time
- magnitude
- 'smoothness'

Fundamental risk and capital structure

Fundamental risk and leverage

Two main channels:

1. Fundamental volatility channel (σ_{tot} and σ_P)
   - higher total volatility $\rightarrow$ larger investment expenditure is optimal $\rightarrow$ firm preserves debt capacity
   - lower volatility $\rightarrow$ firm's cash flows are more predictable $\rightarrow$ less valuable option to borrow

2. Fundamental persistence channel (ρ and σ_P)
   - higher persistence $\rightarrow$ cash flow more path dependent and investment more profitable
   - higher persistence $\rightarrow$ firm policies are more sensitive to underlying shocks

Persistent shocks affect **both** volatility and persistence. Higher exposure increases investment size and makes its profitability more lasting.

Fundamental volatility and average leverage

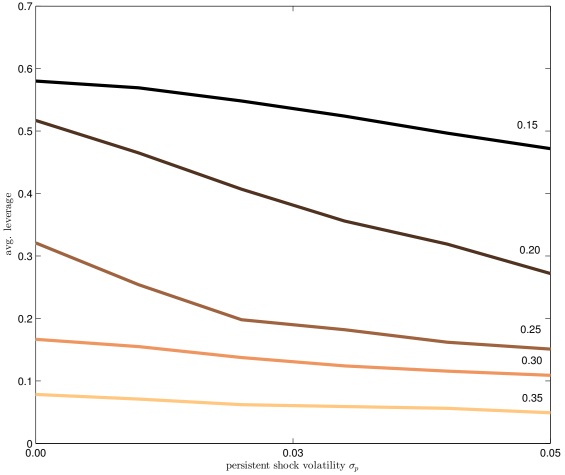

Figure: average leverage vs. volatility composition; $\rho = 0.60$

Implications

- neg. relationship between leverage and persistent shock exposure
- the same leverage, different 'risk' and vice-versa
- total volatility determines the influence of σ_P

Fundamental volatility and leverage dynamics

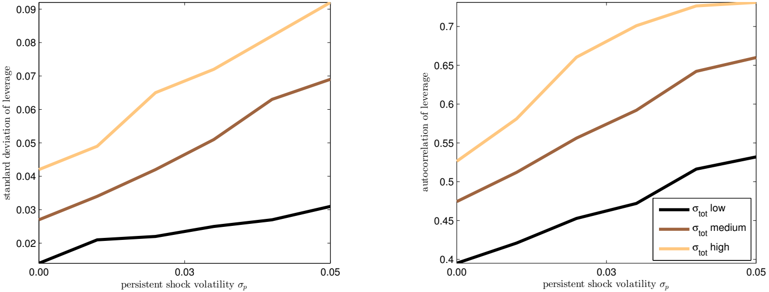

Figure: leverage dynamics when varying the volatility composition; $\rho = 0.60$

Implications

- persistent shock exposure increases leverage variation
- higher sensitivity of leverage variation to σ_P when σ_{tot} high
- leverage persistence more sensitive to σ_P than σ_{tot}

Decomposing fundamental persistence – motivation

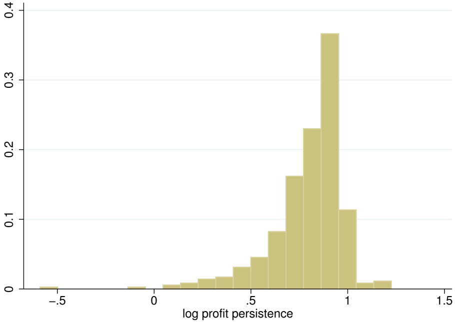

Figure: average persistence parameters $\widehat{\rho}$ of $\log(\tilde{\Pi})$ for 4-digit SIC industries

- standard models: comparative statics of ρ result in large changes in model-implied moments
- data: $\widehat{\rho}$ negatively skewed and clustered around high value with next to none explanatory power for firm characteristics empirical evidence
- what could explain the discrepancy? **risk composition**

Fundamental persistence – the two sources

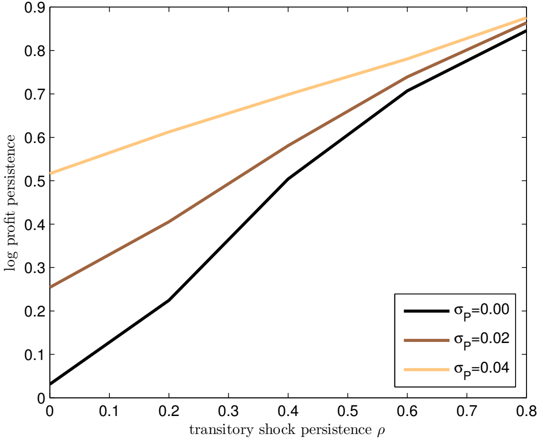

Figure: log profit persistence vs. ρ and σ_P; $\sigma_{tot} = 0.15$.

Implications

- both ρ and σ_P are important for persistence
- profits may be persistent even when $\rho = 0$ and σ_P is small
- the same level of persistence but different ρ
- σ_{tot} is important!

Implications for studying leverage variation

1. The one-to-one link between total volatility and leverage is broken.
2. Composition of profit persistence is informative about leverage.

- Firms with the same observable $\widehat{\sigma}$ can adopt markedly different policies depending on risk composition.

- Similarly, firms with the same observable $\widehat{\rho}$ may behave differently depending on risk composition.

$\Rightarrow$ Risk composition could help explain more variation in leverage ratios (as a fixed effect), but *incremental* explanatory power of shock characteristics may vary.

Take-aways

Firm's fundamental risk is an important determinant of capital structure.

1. Persistent and transitory shock have different implications for corporate policies and imply specific cash flow dynamics.
2. Risk composition helps explain some of the observable capital structure heterogeneity in the data.

Still largely work in progress...

- **How much** of variation in corporate policies can risk composition actually explain? $\longrightarrow$ I structurally estimate the model.
- Where does fundamental risk come from? $\longrightarrow$ In another paper I show that it's largely determined by product market characteristics.
- Open Q: Do **investment dynamics** reflect capital adjustment costs or persistent shocks? What about risk composition and **returns**?

Appendix: Solution method

Introducing the non-stationary shock results in unbounded state-space for capital – as in Gourio [2008, 2012] we can 'detrend' the variables by a scaling factor $Z_P^{1/(1-\theta)}$.

For example, this implies the following law of motion for capital:

$$K' = K(1-\delta) + I \iff$$

$$k' = \frac{K'}{Z_P'^{1+\theta}} = \frac{K'}{Z_P^{\frac{1}{1-\theta}}} \frac{Z_P^{\frac{1}{1-\theta}}}{Z_P'^{\frac{1}{1-\theta}}} = \left(k(1-\delta) + i\right) \exp\left(-\sigma_P \varepsilon_P' / (1-\theta)\right),$$

where $k = K/Z_P^{\frac{1}{1-\theta}}$ and $i = I/Z_P^{\frac{1}{1-\theta}}$.

Similar transformation is carried out for debt dynamics, expressed by $\Delta P := P' - P$. This transformation is necessary so as not to optimize over $p'(\varepsilon_P')$. The problem is ultimately solved by value function iteration.

Appendix: model calibration

Interest rate	r	0.02
Corporate tax rate	τ	0.35
Production function curvature	θ	0.75
Capital depreciation rate	δ	0.15
Convex capital adjustment cost	ψ	0.10
Linear cost of external equity issuance	η	0.15
Collateral constraint	ω	0.60
Persistence of transitory shock Z_T	ρ	0.00–0.80
Total volatility	σ	0.15–0.35
Volatility of persistent shock Z_P	σ_P	0.00–0.05

Note that $\sigma_{tot} = \sqrt{\sigma_P^2 + \sigma_T^2}$.

Appendix: $\widehat{\rho}$ and firm characteristics

Average...	Firms		4D-SIC industries			
	$\rho(\pi/k)$	$\rho(\log(\Pi))$	$\overline{\rho}(\pi/k)$	$\overline{\rho}(\log(\Pi))$	$\rho_{agg}(\pi/k)$	$\rho_{agg}(\log(\Pi))$
Book leverage	-0.018	-0.002	0.009	-0.108	-0.032	-0.139
Investment	-0.007	-0.033	0.047	-0.009	0.082	0.058
Market-to-book	0.016	0.037	-0.002	0.040	0.032	0.076
Size	0.013	0.029	0.070	0.085	0.011	-0.156
Asset tangibility	-0.006	-0.025	0.020	-0.045	0.031	-0.039
Collateral	-0.002	-0.002	-0.037	-0.058	-0.038	-0.127
Volatility of log real profits	-0.022	-0.028	-0.095	-0.191	-0.159	-0.128
Vol. of agg. log real profits	—	—	-0.059	-0.167	-0.312	-0.155

Table: Correlations between firm characteristics and estimated profit persistence. ρ is estimated as the persistence parameter from an AR(1) fit of log real profits $\log(\Pi)$ or profitability π/k for each firm and then averaged over all firms in an industry. Industry-specific persistence parameters ρ_{agg} are estimated using the aggregate industry-level data.

Appendix: $\widehat{\rho}$ and firm characteristics

	Firms		4D-SIC industries			
	$\overline{\rho}(\pi/k)$	$\overline{\rho}(\log(\Pi))$	$\overline{\rho}(\pi/k)$	$\overline{\rho}(\log(\Pi))$	$\rho_{agg}(\pi/k)$	$\rho_{agg}(\log(\Pi))$
$\widehat{\rho}$	-0.001	0.001	-0.004	-0.007	-0.009	-0.011
t-stat	-1.89	1.30	-0.74	-0.69	-0.75	-0.86
Incr. $\overline{R}^2$ of $\widehat{\rho}$	0.001	0.000	0.002	0.001	0.001	0.000
$\overline{R}^2$	0.262	0.262	0.313	0.332	0.332	0.333
Industry dummy	Yes, 4D-SIC	Yes, 4D-SIC	Yes, 2D-SIC	Yes, 2D-SIC	Yes, 2D-SIC	Yes, 2D-SIC
N	6387	6387	353	353	353	353

Table: Coefficients from cross-sectional regressions of average book leverage on average leverage factors (size, profitability, asset tangibility, market-to-book, volatility of log real profits) and estimated profit persistence $\widehat{\rho}$.