Debt Dilution, Debt Covenants, and Macroeconomic Fluctuations

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- Is the finance sector aware of such an issue? If so, does it matter for macro?
  - Yes, they do. They invented debt covenants. And yes, it matters for macro.

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- *Fun Fact:* One of the earliest recorded instances of debt covenants is found in the **Code of Hammurabi**, a set of ancient Babylonian laws from around 1754 BCE

Debt Covenants

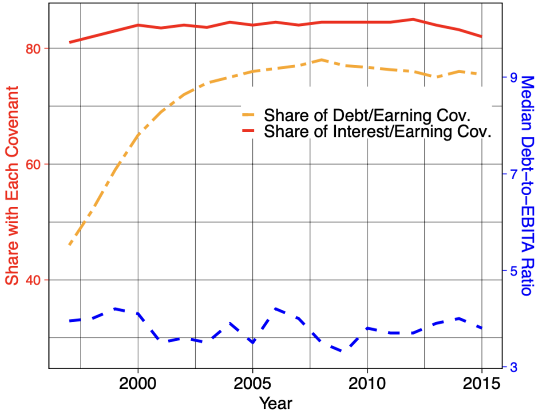

Figure 1: Debt Covenant Conditions

Panel A: Do Debt Covenants Bind?		
Annual Violation Rate	Data	Source
Threshold Reached	23%	Own Calculation
Text-Based SEC-filling	10%	Adler (2020)
During 08-09 GFC	33%	CR&F (2022)
Panel B: Selected Firm Characteristics from Adler (2020)		
Median Measure	Violation	Non-Violation
Investment Rate	3.3%	4.3%
Debt-to-EBITA	464.4%	182.9%
Leverage	46.0%	26.4%
EBITA/Asset	10.6%	16.4%
Cash Flow/Assets	5.3%	10.4%
Market-to-Book Value	117.2%	149.9%
Log Net Worth	5.9	6.4

Table 1: Debt Covenant Violations

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  - Level: **Long-run levels of capital, output, and consumption are increased**

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- We add debt covenants: **a small penalty on borrowers upon violation**
- We modify capital quality shocks to be realized in either current or future cash flows
- Everything else is standard

Firm Setup

- DRS Production: $y_{it} = z_t(k_{it}^{\psi} l_{it}^{1-\psi})^{\zeta}$, $\psi, \zeta \in (0, 1)$

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- Debt Covenants: $\frac{\text{EBITDA}_{it}}{b_{it}} \geq \frac{1}{\eta}$; If violated, financial penalty of χb_{it}

Firms' Recursive Problem

- End-of-Period Net Worth $n(z_{it}, k_{it}, b_{it}, \epsilon^n_{it}, \epsilon^f_{it})$:

$$n_{it} = (1-\tau)[\underbrace{y_{it} + \epsilon^n_{it} k_{it} - w_t l_{it}}_{\text{EBITDA}_{it}}] + \underbrace{[1 + (1-\tau)(\epsilon^f_{it} - \delta)]k_{it}}_{\text{capital stock}} - \underbrace{[(1-\tau)c + \gamma + \chi \cdot \mathbf{1}_{CV}]b_{it}}_{\text{debt burden}} - f \tag{1}$$

- Shareholder Value $n_{it-1} + V(b_{it-1}, S_{t-1})$:

$$\begin{cases} n(z_{it}, k_{it}, b_{it}, \epsilon^n_{it}, \epsilon^f_{it}) + V((1-\gamma)b_{it}, S_t) & \text{if } \epsilon^n_{it} \geq \epsilon^c_{it}, \left(\frac{\text{EBITDA}_{it}}{b_{it-1}} \geq \frac{1}{\eta} \middle| \text{Financially Healthy}\right) \\ n(z_{it}, k_{it}, b_{it}, \epsilon^n_{it}, \epsilon^f_{it}) + V((1-\gamma)b_{it}, S_t) & \text{if } \epsilon^d_{it} - \epsilon^f_{it} < \epsilon^n_{it} < \epsilon^c_{it}, \text{ (Covenant violation)} \\ 0 & \text{if } \epsilon_{it} \leq \epsilon^d_{it}, \text{ (Default)} \end{cases} \tag{2}$$

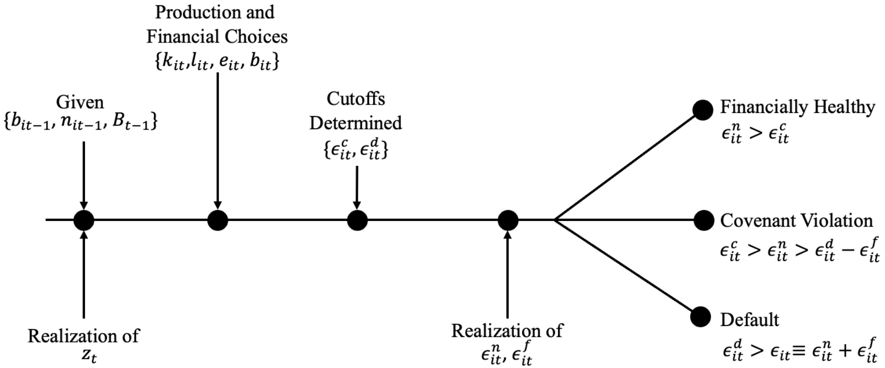
- Covenant Violation and Default Cutoffs:

$$(y_{it} - \epsilon^c_{it} k_{it} - w_t l_{it}) \times \eta - b_{it} = 0 \tag{3}$$

$$n(z_{it}, k_{it}, b_{it}, \epsilon^d_{it}) + E_{S_t|S_{t-1}}\Big[V((1-\gamma)b_{it}, S_t)\Big] = 0 \tag{4}$$

Firms' Recursive Problem

Figure 1: The Timing of A Firm's Decision



Creditor' Problem

- Liquidation Value in Default:

$$n_{it}^d = (1-\xi)\left(\underbrace{(1-\tau)[y_{it} - w_t l_{it}\ ]}_{\text{Earning less capital loss}_{it}} + \underbrace{[1-(1-\tau)\delta]k_{it}}_{\text{capital value}} + \underbrace{(1-\tau)\epsilon_{it}^d k_{it}}_{\text{capital quality loss}}\right) \tag{5}$$

- Long-term Debt Price:

$$Q_{it} = \Bigg[\underbrace{\int_{-\infty}^{\epsilon_{it}^d} \frac{n_{it}^d}{b_{it}} d\Phi(\epsilon_{it})}_{\text{default}} + \underbrace{\int_{\epsilon_{it}^d}^{\infty} (\gamma + c) + (1-\gamma)E_t\left[Q\left((1-\gamma)b_{it}, S_t\right)\right] d\Phi(\epsilon_{it})}_{\text{non-default}}\Bigg] \cdot \frac{1}{1+r} \tag{6}$$

Firm Policy

- We compute the continuation value $V(b_{it-1}, S_{t-1})$ recursively, redefine $\tilde{e}_{it} = (n_{it-1} + e_{it}) \geq -\tilde{e}$

$$V(b_{it-1}, S_{t-1}) = \max_{\phi(b_{it-1}, S_{t-1})} - \tilde{e}_{it}$$

$$+ \frac{1}{1+r} E_{S_t|S_{t-1}} \left[\int_{\epsilon^d_{it}}^{\infty} \left(n(a_t, k_{it}, b_{it}, \epsilon^n_{it}, \epsilon^f_{it}) + V((1-\gamma)b_{it}, S_t) \right) d\Phi(\epsilon_{it}) \right]$$

$$n(z_{it}, k_{it}, b_{it-1}, \epsilon^n_{it}, \epsilon^f_{it}) = (1-\tau)[y_{it} + \epsilon^n_{it} k_{it} - w_t l_{it}] + [1 + (1-\tau)(\epsilon^f_{it} - \delta)]k_{it} - [(1-\tau)c + \gamma + \chi \cdot \mathbf{1}_{CV}]b_{it} - f$$

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$$k_{it} = \tilde{e}_{it} + (b_{it} - b_{it-1}) Q_{it}$$

$$Q_{it} = \left[\int_{-\infty}^{\epsilon^d_{it}} \frac{n^d_{it}}{b_{it}} d\Phi(\epsilon_{it}) + \int_{\epsilon^d_{it}}^{\infty} (\gamma + c) + (1-\gamma) E_t \left[Q\left((1-\gamma)b_{it}, S_t\right) \right] d\Phi(\epsilon_{it}) \right] \cdot \frac{1}{1+r}$$

Aggregation, Households, Equilibrium, Constrained Efficiency

- Aggregation: $\{b = B, l = L, k = K\}$
- Households: Labor supply curve $w_t = L_t^{\theta}$; Consumption $C_t = Y_t - \delta k_t$
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- Equilibrium: Aggregate state: $S = (z', B)$
- Constrained Efficiency: A social planner maximizes the total value

$$\begin{aligned} W(b_{it-1}, S_{t-1}) = \max_{\phi(b_{it-1}, S_{t-1})} & -\tilde{e}_{it-1} + b_{it-1} Q_{it-1} \\ & + \frac{1}{1+r} E_{S_t|S_{t-1}} \left[\int_{\epsilon_{it}^d}^{\infty} \left(n(a_t, k_{it}, b_{it}, \epsilon_{it}^n, \epsilon_{it}^f) + V((1-\gamma) b_{it}, S_t) \right) d\Phi(\epsilon_{it}) \right] \end{aligned} \tag{7}$$

Parameterization

Table 2: Externally Fixed Parameters

Parameter	Description	Value	Source/Targets
		(a).General Environment	
β	Discount factor	0.97	Annual frequency
r	International risk-free rate	0.0309	$r = 1/\beta - 1$
θ	Inverted Frisch elasticity	0.25	King and Rebelo (1999)
τ	Corporate tax rate	0.40	Gomes, Jermann, and Schmid (2016)
		(b).Production Technology	
ψ	Capital share	0.33	Standard as in Bloom et al. (2018)
ζ	Decreasing returns-to-scale	0.75	Standard as in Bloom et al. (2018)
δ	Depreciation rate	0.10	Annual rate of 10%
ρ_z	Persistence	0.909	Standard as in Khan and Thomas (2008)
		(c).Financial Market	
γ	Debt repayment rate	0.1284	Maturity $1/\gamma = 6.47$ years
τ	Debt coupon	0.0309	Debt coupon= r
η	Debt-to-earnings ratio threshold	4.00	Market threshold as in Lian and Ma (2021)
ξ	Default cost	0.469	Liquidation cost as in Kermani and Ma (2023)

Parameterization

Table 3: Internally Fitted Parameters and Model Fit

Param.	Description	Value	Targets	Data	Model
f	Fixed operation cost	0.151	Leverage ratio	33%	33%
χ	Covenant violation cost	0.015	Covenant violation rate	23%	23%
σ_z	Productivity shock vol.	0.006	Volatility of U.S. GDP	2.8%	2.8%
σ_ϵ^n	Cash flow shock vol.	0.326	Frequency of negative EBIT	18%	18%
σ_ϵ^f	Future capital quality shock vol.	0.795	Credit spread	2.0%	2.0%

Notes: This table lists the parameters we internally fitted and the corresponding matched moments in the data. Though the fitted parameters are jointly determined, they are closely tied to specific moments. We first choose the productivity shock volatility $\sigma_z = 0.0006$ to generate a relative GDP volatility of 3.2%. We then choose the capital quality shock volatility $\sigma_\epsilon^n = 0.293$ and the fixed operation cost $f = 0.169$ to match the average leverage of 34% roughly and the frequency of negative EBITDA of 15%. We target a default rate of about 3.2% with the future capital quality shock volatility $\sigma_\epsilon^f = 0.782$.[8] Finally, we match an annual covenant violation rate of 18% by choosing the covenant violation cost $\chi = 0.015$.

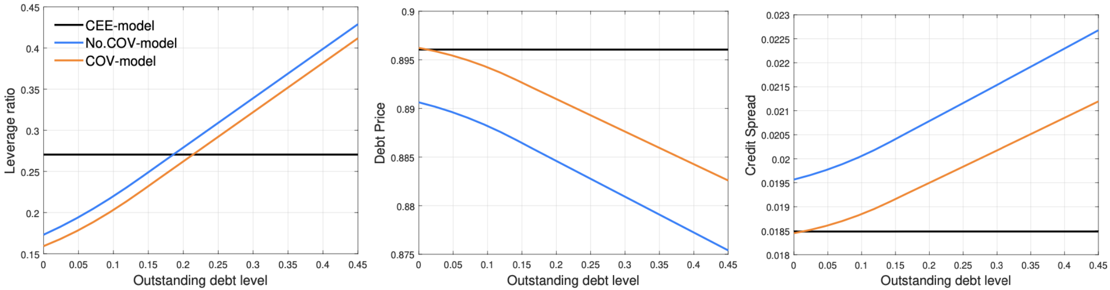
Parameterization

Table 4: Alternative Models: Fitted Parameters and Model Fit

Description Calibration	Param.	COV (baseline)	NoCOV (same mom.)	NoCOV (no recali.)	CEE (no recali.)
Fixed operation cost	f	0.151	0.164	0.151	0.151
Covenant violation cost	χ	0.015	n.a.	n.a.	n.a.
Productivity shock vol.	σ_z	0.006	0.006	0.006	0.006
Cash flow shock vol.	σ_ϵ^n	0.326	0.652	0.326	0.326
Future capital quality shock vol.	σ_ϵ^f	0.795	0.652	0.795	0.795
Moments	**Data**				
Leverage ratio	33%	33%	33%	37%	27%
Covenant violation rate	23%	23%	n.a.	n.a.	n.a.
U.S. volatility of GDP	2.8%	2.8%	3.1%	2.8%	2.6%
Frequency of negative EBITA	18%	18%	n.a.	n.a.	n.a.
Credit Spread	2.0%	2.0%	2.0%	2.2%	1.8%

Debt Dilution Mitigation

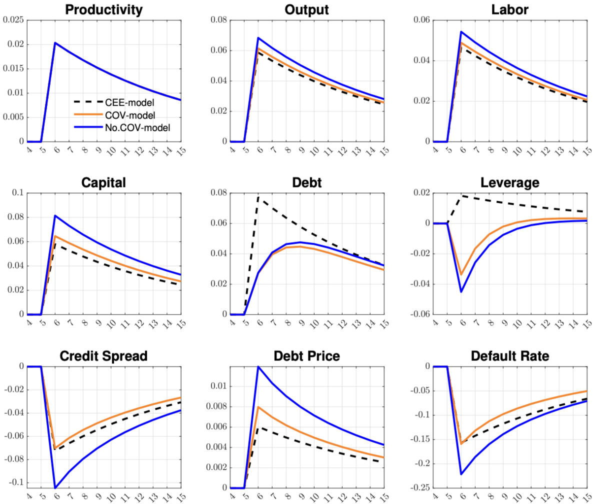
Figure 3: Debt Dilution Mitigation with Debt Covenants



Notes: These figures show whether the level of existing debt affects the leverage policy, debt prices, or credit spreads in three alternative models. The *CEE model* indicates the constrained efficiency model in which a social planner maximizes the total firm value. The *NoCOV model* indicates an alternative model without debt covenants. The *COV model* indicates our baseline model with debt covenants. The calibration and model fit of all three models is presented in Table 5.

Business Cycle Stabilization

Figure 5: Impulse Response Functions to a +2% TFP Shock



Business Cycle Asymmetry Reduction

Table 5: Asymmetry in the Peak Responses to TFP Shocks: *(Recession/Boom-100%)*

Model	Output	Capital	Leverage	Credit Spread	Debt Price	Default Rate
CEE.	0%	0%	-84%	14%	20%	46%
Cov.	0%	4%	40%	14%	20%	46%
No.Cov.	7%	14%	56%	36%	29%	55%

Notes: This table calculates the asymmetries in the peak responses to TFP shocks across three models. The peak responses are displayed in Figures 4 and 5. CEE model: the constrained efficiency model without debt dilution. NoCOV model: the model with debt dilution but without debt covenants. COV model: the model with debt dilution and debt covenants.

Long-run Level Effects

Table 6: Long-run Effects of Debt Covenants

Model	Output		Capital		Consumption	
	Mean	S.D.	Mean	S.D.	Mean	S.D.
CEE model	0.659	0.026	1.115	0.042	0.548	0.024
COV model	0.653	0.028	1.089	0.050	0.544	0.027
NoCOV model	0.639	0.031	1.036	0.062	0.536	0.031

Notes: This table calculates the mean and standard deviation of output, capital, and consumption in each model. CEE model: the constrained efficiency model without debt dilution. NoCOV model: the model with debt dilution but without debt covenants. COV model: the model with debt dilution and debt covenants.

Conclusion

- We build a business cycle model with (dilutable) long-term debt and debt covenants
- The key mechanism is **debt covenants significantly reduce debt dilution**
- Micro: covenant violation happens often, but costly defaults are largely mitigated
- The macroeconomic effects:
  - Cycle: **Business cycle volatility is reduced**
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Work-In-Progress

- Micro-foundation of violation: Empirical facts of firm-level responses
- Micro-foundation of violation: Shift of control rights + heterogeneous firms
- Aggregate effects Decomposition: Bank + firm responses