Corporate resiliency and the choice between financial and operational hedging

Viral V. Acharya,[1] Heitor Almeida,[2] Yakov Amihud,[1] and Ping Liu[3]

[1]NYU Stern School of Business,
[2]UIUC Gies College of Business,
[3]Purdue U Krannert School of Management

כנס האגודה הישראלית לכלכלה 2024

The paper in a nutshell:

We commonly study the **risk** of **financial default** on **debt contracts** with **lenders.**

We add:

There is **risk** of **default** on **delivery contracts** of goods and services to **customers**.

We study how the firm manages these **two commitments** and **default risks,** given their predetermined **borrowing** and **delivery** contracts.

We propose: there's a **tradeoff** between **financial hedging** and **operational hedging** for **financially constrained** firms.

Corporate activities are often **disrupted** by exogenous **shocks**.

During the **Covid-19** pandemic…

- … **inventories** were depleted
- … **supply chains** were disrupted

Firms **failed to deliver** the merchandise and services that they **committed** to supply.

Questions:

> How is corporate **resiliency** – the ability to withstand shocks and **deliver the goods** – affected by **financial default risk**?

> How does **access to financing** affect corporate **resiliency**?

The **macro**economic consequence:

Does **over-leveraging** of corporation **hurt** the **resiliency** of the economy?

The firm's **tradeoff**:

> **Use cash** to **hedge against operational default**—**failure to deliver** on customers' **contracts**—by investing in excess **inventory,** spending on **supply chain diversification**, maintaining **backup capacity**, etc., or

> **Hoard cash** to **hedge against financial default** in case of a **negative** cashflow shock.

We propose:

Higher financial default risk (or **higher credit spread**) → **lower operational hedging.**

Firms shift **cash** to avert **financial default,** depending on the **cost of operational default**.

Main testable result:

➔ A **higher credit spread** (on debt) → a **higher operational spread,** measured by **Markup** = [**price – marginal cost (MC)]**, because **MC rises** with **operational hedging.**

However, if the firm can **pledge** some **future cashflows** (from delivering the goods),

it can borrow (get a loan to ride out a liquidity shortfall), thus **lowering default risk**.

→ Then, the firm will **spend more** on **operational hedging** …

which in turn **increases pledgeability** and **facilitates borrowing** with lower risk.

<u>Prediction</u>:

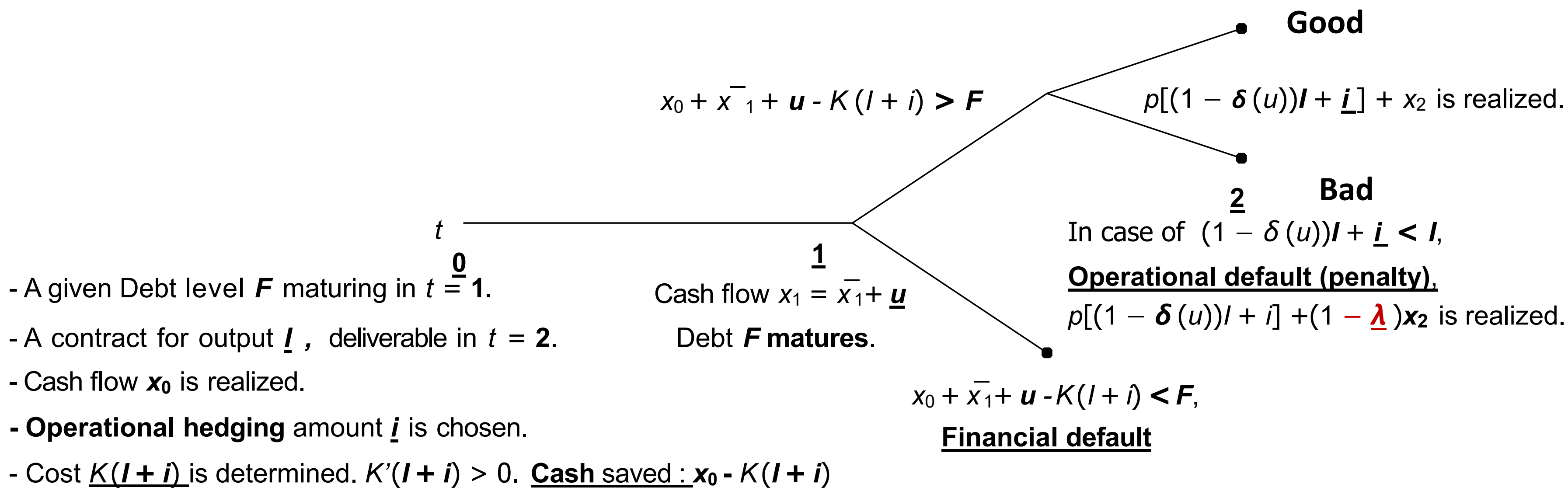
Lower pledgeability (= **greater financial constraint**),

→ **stronger tradeoff** between **financial hedging** and **operational hedging.**

→ **a more positive** relationship between **credit spread** and **operational spread**.

In a liquid, well functioning capital market, there's **high** pledgeability and a **weaker tradeoff**.

We study these **tradeoffs** – **theoretically** and **empirically**.



The timeline of the model

At $\boldsymbol{t = 1}$, a **shock** $\boldsymbol{u}$ to cash flow and **production** capacity at $\boldsymbol{t = 2}$ (e.g., the Covid-19 shock.)

$\boldsymbol{\delta(u)}$ represents **operational risk**, decreasing ($\boldsymbol{\delta'(u) < 0}$) and convex in $\boldsymbol{u}$.

It **reduces productive capacity** in case of a shock that **lowers** $\boldsymbol{u}$ and reduces output $\boldsymbol{I} \to (1 - \delta(u))\,\boldsymbol{I}$

$\boldsymbol{\lambda} \in (0, 1)$ is the **loss** in franchise value when the firm fails to deliver.

The firm **maximizes expected shareholder value,** considering the loss from **operational** and **financial** defaults.

Optimal hedging

Firm **maximizes expected shareholder value** after considering the loss from operational and financial default.

The optimal choice of **operational** hedging i depends on the size of **financial** and **operational** default boundaries.

There are **three** cases, for a given F and the distribution of the shock u:

u_F = **financial** default **threshold =** minimum shock that enables to **repay** F in full and avoid financial default.

u_O = **operational** default **threshold =** minimum shock that enables to **deliver** its contractual amount of goods and avoid operational default:

First-best (benchmark) case, $u_F = 0$: No liquidity risk. **Debt** is **irrelevant** when determining operational hedging i.

In general: Smaller **u** – more cash or investment is needed to avoid financial default.

Second-best case: **High** F. $0 < u_O \leq u_F$: Financial default is greater. Need more cash to avoid financial default. **Low operational hedging**. (**Operational** default is **less relevant** when determining operational hedging i.)

Second-best case: **Low** F . $0 < u_F < u_O$: **Focus of our paper . Operational** default is the **greater** threat.

Optimal operational hedging i^* **decreases in F**.

The firm's objective functions in three cases

- First best

$$\max_i \left\{ \int_0^\infty \left[\underbrace{x_0 + \bar{x}_1 + u + x_2}_{\text{cash flow from assets}} - \underbrace{K(I+i)}_{\text{production cost}} + \underbrace{p[(1-\delta(u))I+i]}_{\text{income from customer contract}} \right] g(u)\,du \right.$$
$$\left. - \underbrace{\int_0^{u_O} \lambda x_2 g(u)\,du}_{\text{operational default cost}} \right\}$$

- Second-best: $(u_F \geq u_O)$

$$\max_i \left\{ \underbrace{\int_{u_F}^\infty \left[(u - u_F) + p[(1-\delta(u))I+i] + x_2 \right] g(u)\,du}_{E} \right\}$$

- **Second-best: $(u_F < u_O)$**

$$\max_i \left\{ E - \int_{u_F}^{u_O} \lambda x_2 g(u)\,du \right\}$$

Operational default: at t = **2**, the firm **defaults** on its **customer** contract if $u < u_O$ (= operational default threshold)

$$\underbrace{(1-\delta(u_O))I+i}_{\text{production+inventory}} = \underbrace{I}_{\text{commitment}}$$

In **operational default**, the firm **loses** a fraction λ of its franchise value x_2, retaining only $(1-\lambda)x_2$,

>>The operational default threshold u_O ***decreases*** in **operational hedging**, i. (recall, $\delta'(u) < 0$)

Financial default: at t = **1**, the firm **defaults** on its **financial** obligation if $u < u_F$ (= financial default threshold)

$$\underbrace{x_0+\bar{x}_1+u_F}_{\text{cash flows}} - \underbrace{K(I+i)}_{\text{production cost}} = \underbrace{F}_{\text{debt}}$$

In **financial default** in t = 1, the firm loses the cashflow from customer contracts: $p\,[(1-\delta(u))\,I+i]$ + the franchise value, x_2.

>> The **financial default** threshold u_F ***increases*** – greater financial default risk – in **operational hedging** i.

Diverting cash to operational hedging (higher i) → **increase in financial default** likelihood → **higher credit spread**.

Credit spread = (F / Market value of debt) -1.

Operational spread or **Markup** = [$p - K'(I+i)$]. It **decreases** in i since $K'(I+i) > 0$.

➔ **Higher Credit spread** (or risk) → an incentive to **reduce operational hedging** i → **higher Markup**.

Since financial default occurs when $x_0 + \bar{x}_1 + \boldsymbol{u} < \boldsymbol{F} + K(I + i)$,

then…

Higher *F* (face value of debt) → higher $\boldsymbol{u_F}$ → higher likelihood of $\boldsymbol{u} < \boldsymbol{u_F}$ (= default)

→ operational default at $t = 2$ is **less** relevant

→ **lower operational hedging (lower *i*) & higher operationa spread** [$p - K'(I + i)$]

→ **higher op. spread.**

With **lower *F***, $\boldsymbol{u_F} < \boldsymbol{u_O}$ **,** and the firm considers the **tradeoff** between **financial hedging** and **operational hedging**.

At the margin, **operational** hedging ***i*** …

- *Raises* the expected cost of **financial** default by **raising** the financial default boundary, $\boldsymbol{u_F}$.
- *Lowers* the expected cost of **operational** default by **lowering** operational default boundary, $\boldsymbol{u_O}$.

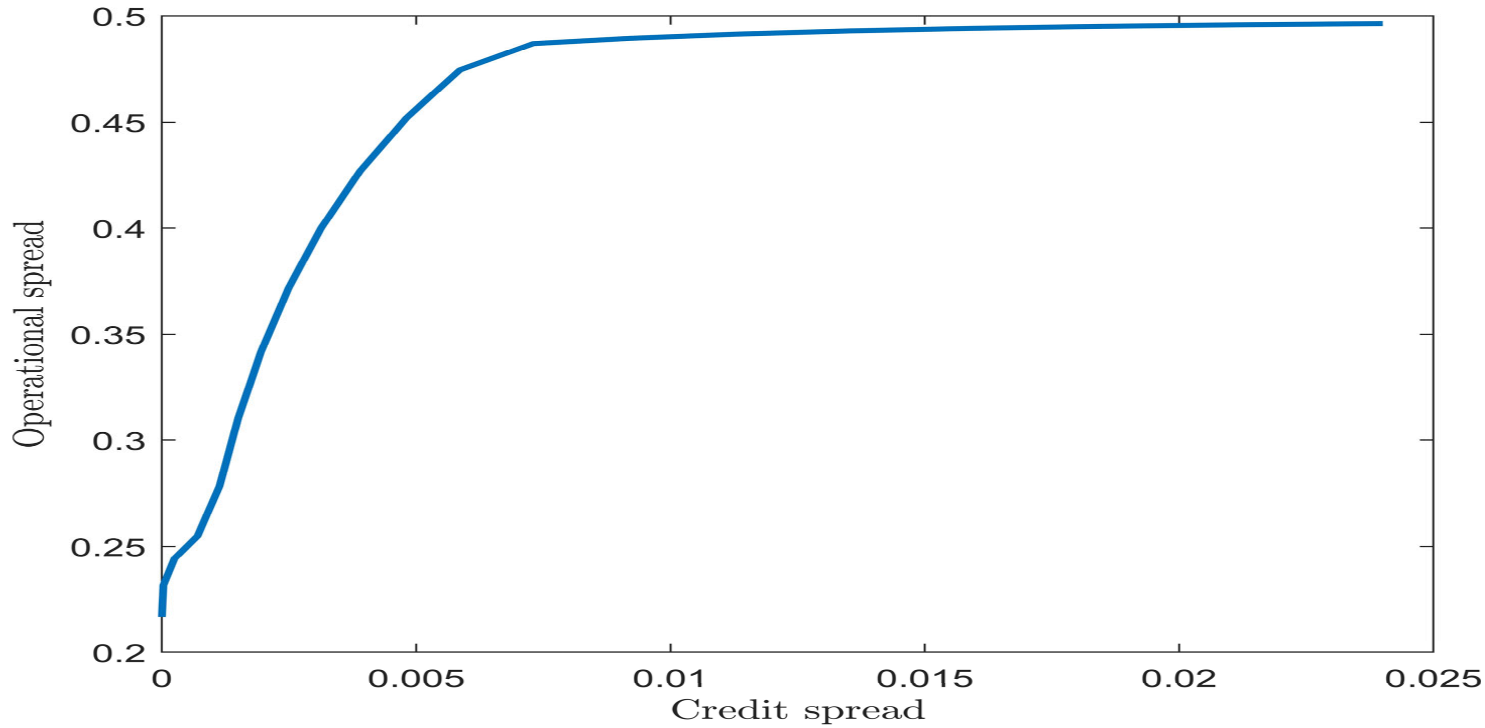
→ Higher optimal ***i*** when $u_F < u_O$ than when $u_F \geq u_O$.

When ***F*** is sufficiently **low**, **operational default** risk is the firm's **main concern** → higher ***i .***

In general,…

the first-order condition says that the firm chooses the hedging policy ***i**** such that

the **markup** equals the marginal increase of the expected financial default cost.



Model-implied relationship between **credit spread** and **markup**

Credit spread = (*F* / Market value of debt) -1 = **bond yield** (benchmark = **0**)

Operational spread or **Markup** = [***p*** **–** ***K'(I + i)***]. **Decreases** in ***i*** since *K'(I + i)* > 0.

➔ Higher Credit spread → lower operational hedging *i*, lower *K'(I + i)*

→ higher Markup.

If the firm can **pledge** to creditors at ***t* = 1** a **fraction** $\boldsymbol{\tau}$ from period-**2** cash flow due to contract settlement, it will **borrow** in Period **1** if there is a **shortfall**.

→ **Lower financial default** risk,

→ **Increased operational hedging**.

➔ **Lower pledgeability (**$\boldsymbol{\tau}$**)** → **lower optimal operational hedging** → **higher Markup**.

➔ **Larger effect of Credit spread on Markup** (operational spread).

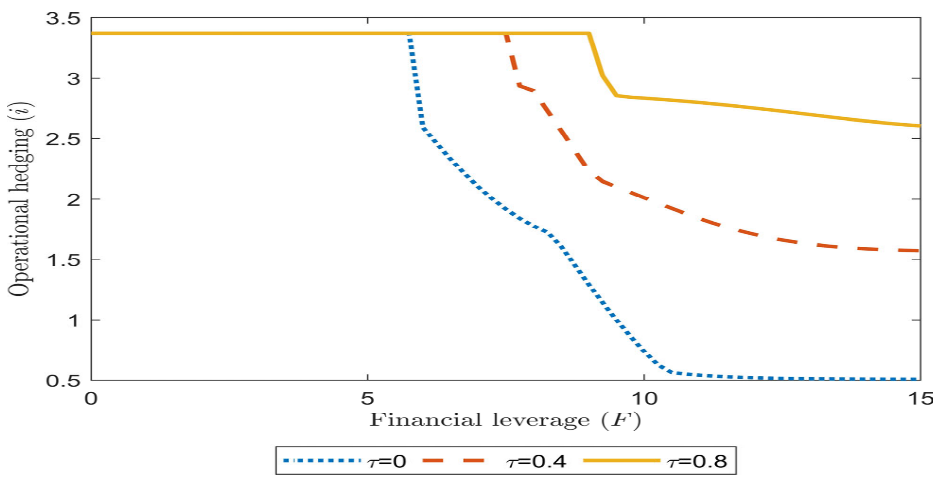
Empirically: **lower** pledgeability ($\boldsymbol{\tau}$) means **higher** financial **constraint**.

Prediction: Greater **financial-constraint** → a **stronger tradeoff** between **Markup** and **credit spread**.

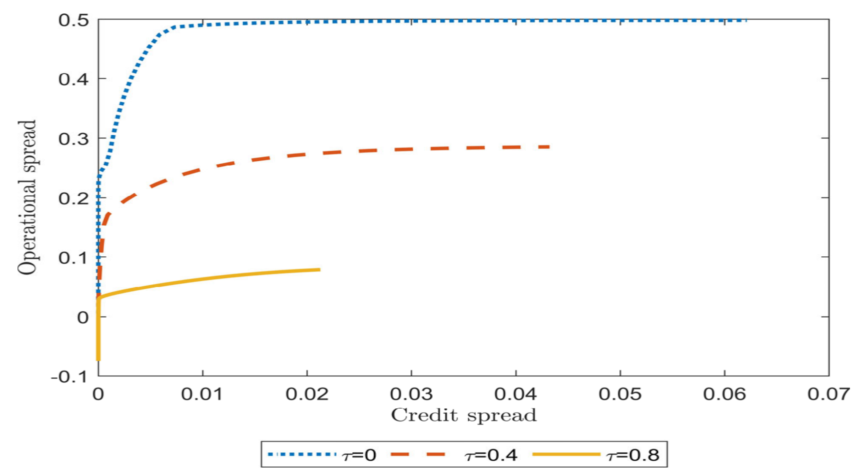
The big picture: A well-functioning capital market improves economic resiliency.

The effect of **pledgeability** – **higher τ** – on optimal operational hedging, ***i***, and the **Credit spread-Operational spread** relationship (employing numerical analysis)

(a) *Optimal* ***i*** and ***F***



(b) Credit spread & operational spread



Operational hedging ***i*** **decreases** with debt level ***F***

→ **Operational spread increases** in debt level **F** and in **credit spread.**

This relationship is **stronger** for **lower pledgeability** (***τ***) or **greater financial constraint.**

Empirical research questions:

(1) Does **higher credit** spread **lower operational** hedging → **higher operation spread**?

(2) Is relationship (1) **stronger** for **financially-constrained** firms? Or in times of **illiquid markets?**

We proxy a higher **credit spread** by **–(Z-score),**

using Altman's (1968) **Z**-score, which **declines** with a higher **default probability**.

Operational hedging is measured by **Markup** = (Sales-Cost of Goods Sold) / Sales.

Lower ***i*** → lower *K'(I + i)* → **higher** operational spread = [***p – K'(I + i)***], proxied by the **Markup**.

Two hypotheses:

Markup increases in **–(Z-score)**, and **more** so for **financially-constrained** firms, and when **markets** are **illiquid**.

Data: From **COMPUSTAT. Quarterly** data from 1973 to April 2020.

- Exclude firms in the financial and utilities industries (SIC codes 6000-6999, 4900-4949).
- Exclude firm-quarters for firms involved in major mergers (COMPUSTAT footnote code AB).

We calculate **Z-score**, **Inventory**/Sales ratio, and the **control variables**: (1) Q, (2) cash holdings, (3) cash flow, (4) tangible assets, (5) size, **(6-8) market power** measures: (i) top 3 industry seller dummy, (ii) sales/Industry sales, (iii) Herfindahl index. (Herfindahl is eliminated when using Ind*Yr-Qtr FE.)

Supply chain data:

From **Factset** Revere Relationship database: **relationship-level data** between firms, starting on 4-2003.

For each relationship, it contains…

- Identities of the related parties
- Type of the relationship
- Firms' geographic origins (country and state/province combination)

<u>Test 1</u>: Is **Markup = (Sales-CGS)/Sales** a **valid** measure of the **Operational Spread,** [$p - K'(I + i)$]?
Does it **decline** in the firm's **operational hedging activity?** (Because marginal costs incease.)

We use **two measures** of **operational hedging activity**:

1) **Inventory**, using Inventory/Sales ratio. Higher inventory → more operational hedging.

2) **Supply chains hedging:** the first **principal component score** from a PCA using the variables:
(i) ln(1 + number of **suppliers**)
(ii) ln(1 + number of supplier **regions**)
(iii) ln(1 + number of **out-of-region** suppliers).
The PCA is done for each quarter.

Validation test (1):

Does **Markup decline** in our measures of **operational hedging**? –**Yes**.

	Markup	**CGS/Assets**
Supply chain hedging	-0.0050 (2.17)	0.00075 (2.58)
Inventory/Sales	-0.043 (2.87)	0.041 (3.15)
The model includes: Control Variables (incl. two market-power variables), Firm FE, Year*Year-qtr FE		
Number of observations	114,887	114,858
R^2	0.754	0.969

Markup declines and **CGS/Assets** increases with **higher** spending on **supply chain hedging** and **inventory**.

(The CGS/Assets model includes Sales/Assets as control.)

Conclusion: **Markup** is a reasonable **summary measure** of the **firms' operational hedging activities**.

Validation test (2)

In **recessions**, do our measures of **operational hedging** **mitigate** the negative shocks to **ΔSales/Assets? –YES.**

A cross-firm regression:

ΔSales/Assets = (average during the recession qtrs) – (average of 8 qtrs beforehand, skipping 4 pre-recession qtrs)

on **pre**-recession **operational hedging variables** (inventory & supply chain hedging)**.**

Included: control variables and FF-48 industry **FE**.

NBER Recessions	Inventory/Sales	Supp Chain Hedg. PCA
1973Q4 – 1975Q1	**0.032 (2.00)**	
1979Q4 – 1980Q2	**0.015 (2.14)**	
1981Q2 – 1982Q2	**0.010 (1.43)**	
1989Q4 – 1991Q1	**0.016 (4.04)**	
2001Q1 – 2001Q3	**0.018 (4.50)**	
2007Q4 – 2009Q2	**0.011 (2.20)**	**0.018 (1.96)**

Conclusion: **Pre-recession** spending on **operational hedging mitigated** the negative shock to **sales**.

Main test:

Does **operational spread, Markup, increase in** the **Credit spread** or **–(Z-score)**? – **Yes.**

Our prediction: Greater cash needs → **lower** operational hedging → **higher** [$p - K'(I + \boldsymbol{i})$].

	Markup	CGS/Assets
-(Z-score)	0.0029 (5.47)	-0.00054 (6.83)
Control variables	Yes	
Firm FE	Yes	
Industry*Year-qtr FE	Yes	
Number of observations	564,418	561,177
R^2	0.634	0.951

(The CGS model includes Sales/Assets.)

The **control** variables include **market power** variables; Industry FEs also account for differences in market power by industry.

Does Operational Hedging increase in credit risk during NBER recessions? –Yes.

	Markup	CGS/Assets	Inventory/ Assets	SCH
-(Z-score)***Recession**	0.0016 (3.14)	-0.00025 (2.50)	-0.0016 (3.20)	-0.00072 (0.31)
-(Z-score)	0.0028 (5.38)	-0.00053 (6.88)	-0.0027 (5.74)	0.012 (6.00)
The models include: Control Variables (incl. Market Power), Firm FE, Industry*Year-qtr FE				
Number of observations	554,348	551,691	543,351	112,336 (one episode)
R^2	0.636	0.950	0.730	0.862

(The CGS/Assets model includes Sales/Assets as control.)

There are **6 recessions** between 1973 and 2009. SCH has only one recession (2008-9).

Markup increases and **CGS/Assets** declines in credit spread by more in times of financial constrains (recessions).

Conclusion: **Operational hedging declines** when firms become **financially constrained**.

It is not **Market Power** that causes the positive **operational spread-Credit spread relationship.**

Chevalier & Scharfstein (1994), Gilchrist et al., 2017): Firms with **market power** (MP)…

… raise prices and **Markup** when they have **high credit risk**, especially in recessions.

They raise **short-run profit** at the cost of hurting their future market share and long-term profitability.

Their prediction: A **stronger positive** effect of –(Z-score) on Markup for firms with **MP.**

The evidence is **not consistent** with the **MP-based** theory.

	Markup	
	MP = Top 4 industry sellers	MP = Sales/Industry sales
-(Z-score)***MP*Recession**	-0.00034 (0.14)	0.00048 (0.02)
-(Z-score)***MP**	-0.0027 (2.25)	-0.075 (3.75)
-(Z-score)*Recession	0.0016 (3.13)	0.0017 (3.20)
-(Z-score)	**0.0028 (5.38)**	**0.0028 (5.38)**
The model includes: Control variables, incl. MP variables, Firm FE, Industry*Year-qtr FE		

Financial constraints and the Markup-Credit spread relationship – the 2008 Great Financial Crisis

The **2008** crisis → **negative** shock to τ (pledgeability) → **stronger Markup-Credit spread relationship**

Following Chodorow-Reich (2014), we use **firms' exposure to lenders** affected by the crisis.

Data on bank lenders of our sample firms: from the LPC-Dealscan database.

The impact of the subprime mortgage crisis on lenders' abilities to extend credit to the borrowers:

(1) **Changes in loan supply** for a firm's lenders between the 9-month period from 10-2008 to 6-2009, and average of the 18-month period containing 10-2005 to 6-2006 and 10-2006 to 6-2007.

(2) Bank's **exposure to Lehman** Brothers through the **fraction** of a bank's syndication portfolio where Lehman Brothers had a lead role.

(3) Banks' **exposure to toxic mortgage-backed securities**: the **correlation** between banks' daily stock return and the return on the ABX AAA 2006-H1 index.

Average crisis exposure measure over **all lenders of the firm**, **weighted** by loan size.

Was there a **stronger positive effect of Credit spread (–Z score) on Markup**

for **firms affected by the 2008 Great Financial Crisis?** – **YES**

Two years (8 qtrs) **before** & **after** the **Lehman crisis**: Q3-2006—Q2-2008, Q1-2009—Q4-2020.

The **–(Z**-score) is for the end of **2007**.

	Markup		
Lender's financial exposure→	%# loan reduction	Lehman exposure	ABX exposure
–(Z-score)*Lender exposure	**0.086 (2.53)**	**0.160 (2.22)**	**0.084 (3.11)**
Lender exposure	-0.699 (1.54)	-0.969 (1.41)	-0.902 (2.20)
The model includes: Control variables, Control vars*Lender exposure, Firm FE, Industry*Year-quarter FE. There are 20 firm-quarters.			

Conclusion: A more **positive Markup-Credit spread relationship** for firms that became financially **constrained.**

Consistent with theory.

Was there a **stronger negative effect of Credit spread (–Z score) on CGS/Assets**

for **firms affected by the 2008 Great Financial Crisis?** -- **YES**

	CGS/Assets		
Lender's financial exposure→	%# loan reduction	Lehman exposure	ABX exposure
–(Z-score)*Lender exposure	**-0.030 (-2.73)**	**-0.058 (-2.76)**	**-0.027 (-3.38)**
Lender exposure	0.017 (0.10)	-0.149 (0.67)	0.019 (0.15)

The model includes: Control variables, Control vars*Lender exposure, Firm FE, Industry*Year-quarter FE.

There are 20 firm-quarters

Conclusion: **CGS/Assets declined** for firms that became financially **constrained**

→ cut in Operational Hedging (and other costs)

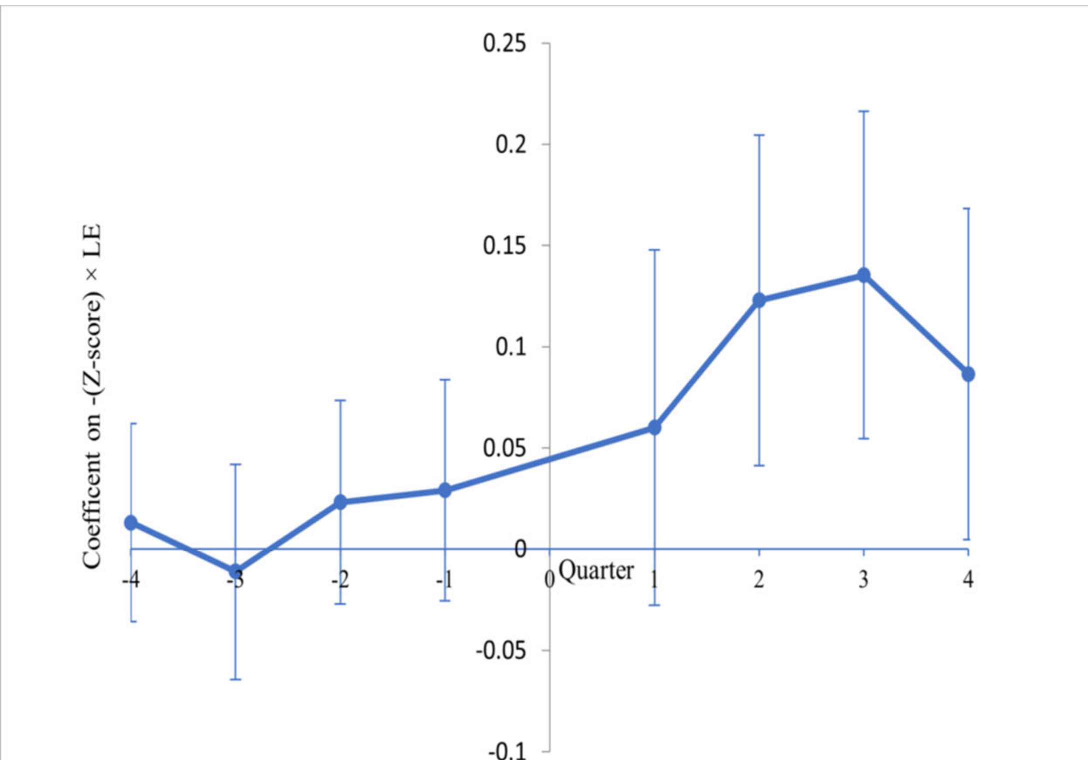
Parallel trend test:

The Markup-Credit spread relationship, conditional on lender exposure, around the 2008 crisis

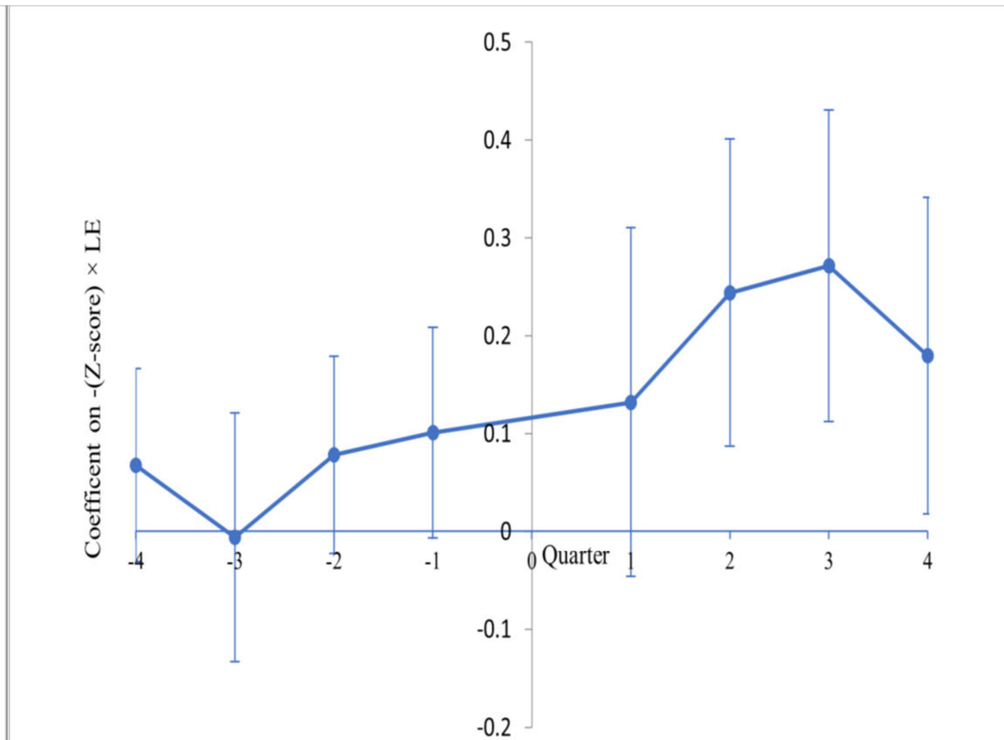
The model includes (1) lender exposure, (2) control variables, (3) Controls*Lender exposure, (4) firm FE, (5) **Industry***Year-qtr FE.

	%# loan reduction	Lehman exposure	ABX exposure (residential mortg.)
-(Z-score)*LE_{-4}	0.013 (0.52)	0.068 (1.36)	0.014 (0.70)
-(Z-score)*LE_{-3}	-0.011 (-0.41)	-0.006 (-0.09)	-0.004 (-0.18)
-(Z-score)*LE_{-2}	0.023 (0.88)	0.078 (1.53)	0.034 (1.62)
-(Z-score)*LE_{-1}	0.029 (1.00)	0.101 (1.84)	0.036 (1.64)
-(Z-score)*LE_{+1}	0.060 (1.33)	0.132 (1.45)	0.062 (1.68)
-(Z-score)*LE_{+2}	0.123 (2.93)	0.244 (3.05)	0.117 (3.66)
-(Z-score)*LE_{+3}	0.135 (3.29)	0.272 (3.35)	0.128 (4.00)
-(Z-score)*LE_{+4}	0.086 (2.05)	0.180 (2.20)	0.093 (2.91)
-(Z-score)*LE_{+5+}	0.083 (1.93)	0.170 (1.87)	0087 (2.56)

Drawing of the quarterly coefficients **Markup** on **–Z score**

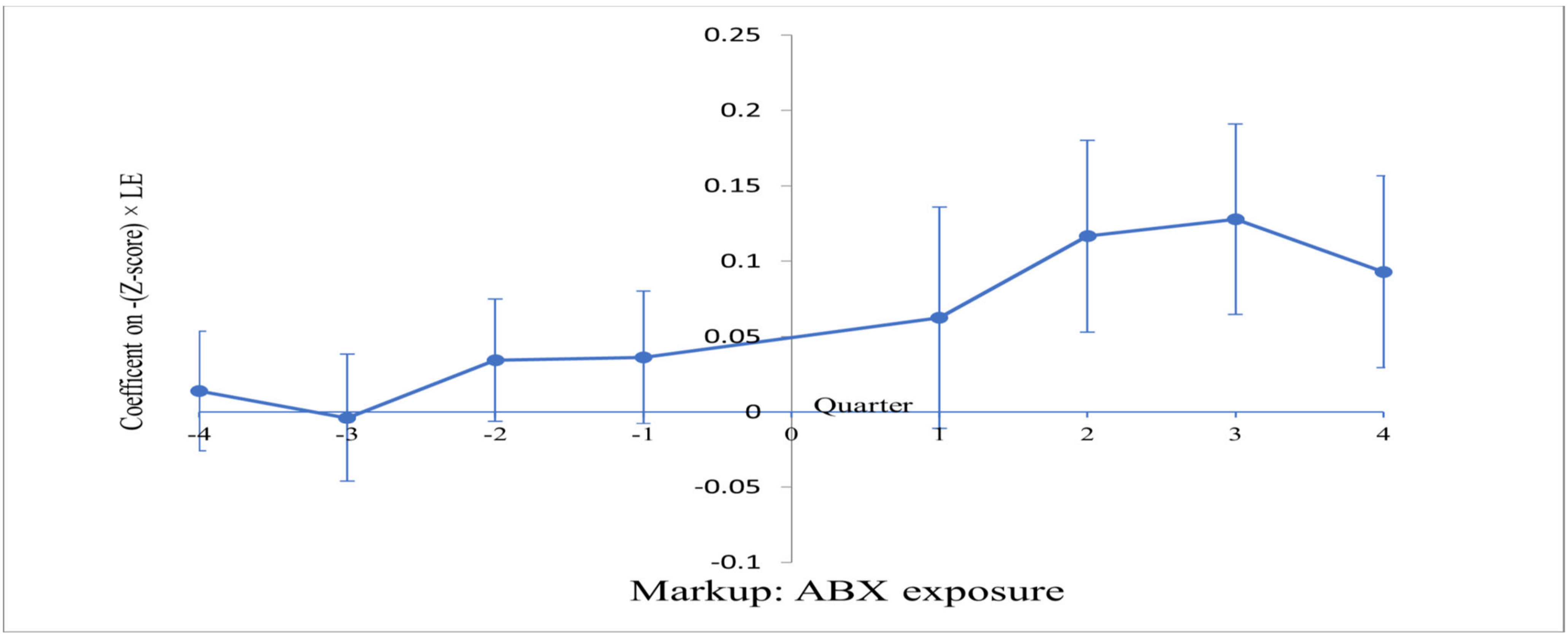


Markup: % # Loan reductions



Markup: Lehman exposure

Drawing of the quarterly coefficients **Markup** on **–Z score**



Conclusion

We study the **allocation** of **corporate liquidity** associated with the **tradeoff** between the need to reduce **financial risk** and **operational risk**.

Theoretically, this **tradeoff** is manifested in a **positive** relationship between **credit spread** and **operational spread**, especially for **financially-constrained** firms.

Empirically, the evidence supports this tradeoff:

Greater financial risk reduces operational hedging, especially

- In episodes of low market liquidity (recessions)
- For firms that become financially-constrained firms (during the 2008-9 crisis)/

The takeaway: **Over-leveraging** and **illiquid capital markets hurt operational resiliency**, i.e., the ability to ride our **real shocks.**

<u>Macroeconomic takeaways</u>:

1. Over-leveraging reduces the economy's **resilience** to operational shocks.

2. Over-leveraging and **constrained capital → lower operational resiliency.**

3. A **liquid**, well functioning capital market → **higher** pledgeability, **weaker** (or no) **tradeoff,**

➔ **greater resilience.**

Indeed, the **increase in liquidity** during the **Covid-19** shock was a wise policy.

Future extension: Study the effects on **stock returns**.