Concentrated Debt Maturity Profiles, Rollover Risk, and Macroeconomic Consequences

Philip Coyle
University of Wisconsin - Madison

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Motivation: Firms issue debt with staggered maturity dates

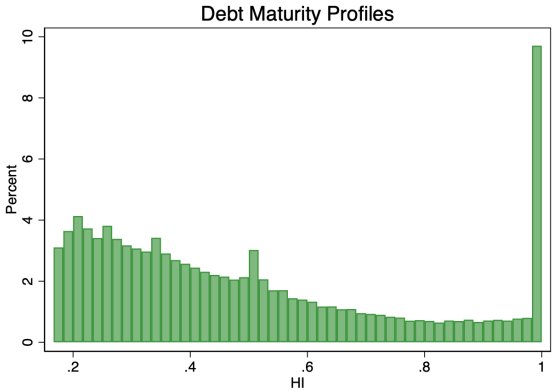
Firms fund investment projects with debt that has varying maturity dates

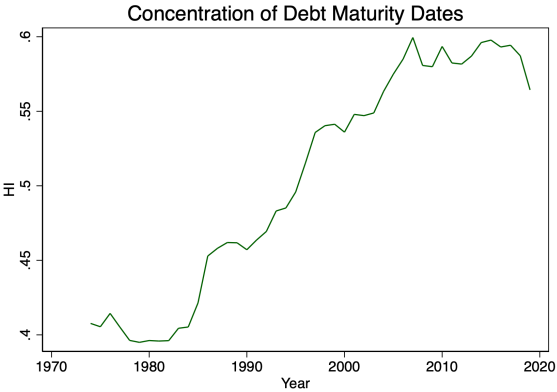
- Fixed cost of issuing debt $\longrightarrow$ issue debt with same maturity date to economize on fixed cost
- Servaes and Tufano (2006) surveys CFOs: firm's stagger maturity dates to mitigate rollover risk
  - Debt Rollover: Firm borrows new debt to repay old debt

Trade-off characterize firm's **debt-maturity profile** (how spread out are maturity dates across time)

- Concentrated debt-maturity profile: a large share of firm's existing debt comes due at a single point in time
- Dispersed debt-maturity profile: at any point in time, a small share of firm's existing debt comes due

Debt maturity profiles in cross-section and over time





Industry Breakdown

Cross-Section by decades

$HI = \sum_{m=1}^{M} s_m^2$: Herfindal-esq Index ($s_m$ is share of long-term debt due in m years)

Source: Compustat.

Why are firms heterogeneous in their debt-maturity profiles?

Preview of results

- Stylized 4 period model to highlight trade-off firm faces: issuance cost v. rollover risk
  - Concentrated debt profile $\longrightarrow$ $(-)$ issuance cost, $(+)$ rollover risk
  - Dispersed debt profile $\longrightarrow$ $(+)$ issuance cost, $(-)$ rollover risk

- Increasing debt profile getting more concentrated over time: 1978 Bankruptcy Reform and introduction of debt renegotiation (Ch. 11 Bankruptcy)
  - Debt renegotiation decreases cost of rollover crisis for concentrated debt profile firms

Do concentrated debt-maturity profiles impact firm and aggregate outcomes during aggregate (negative) credit supply shocks?

Preview of results

- Firms: concentrated debt maturity profiles $\rightarrow \uparrow$ risk of bankruptcy & $\downarrow$ investment
  - Credit shock $\longrightarrow$ increase in interest rates making it more expensive to roll-over debt
  - Firms must cut back on investment and/or liquidate projects or default as a result

- Aggregate: rising debt-maturity profile concentration trend $\longrightarrow \uparrow$ sensitivity of investment and financial stability (through firm default) to credit shocks
  - Investment falls by additional 2.65% - 4.88% in response to 1 pp credit shock in 2010s than in 1970s

Literature

Debt Maturity and Rollover Risk:

- Diamond (1991); Leland and Toft (1996); Leland (1998); Diamond and He (2014); DeMarzo and He (2016); Dangl and Zechner (2016); Geelen (2019)
- Choi, Hackbarth, and Zechner (2018, RFS; 2021, JFQA)

Debt Maturity, Firm Dynamics, and Aggregate Shocks:

- Almeida et. al (2012), Crouzet et al. (2016); Jungherr and Schott (2021, RED), Geelen, Hajda, Morellec, Winegar (2022)
- Khan and Thomas (2013, JPE); Ottonello and Winberry (2020); Jungherr, Meier, Reinelt, Schott (2022)

Contribution:

- Document new secular trend about rising debt-maturity profile concentration
- Study debt-maturity profiles rather than average debt maturity
- Relating debt-maturity profiles to firm and aggregate outcomes (investment and bankruptcy)

Baseline environment

- Discrete time, 4 period model ($t = 0, 1, 2, 3$) & risk free rate is 0
- Firm has productive assets in place k, has production technology $f(x) = x^{\alpha}$, and produces each period
- Firm invests in project of size $I > k^{\alpha}$ that returns in $t = 3$
  - Need to borrow $b = I - k^{\alpha}$
  - Firm borrows from competitive lending industry and makes take-it-or-leave-it offers
- Firm can invest in 1-period bonds, 2-period bonds or both
  - Bond issuance cost: c_I
  - Firm will need to roll debt over before investment returns are realized
- In each rollover period ($t = 1$ & $t = 2$), the lending market will freeze with probability λ
- If firm cannot roll-over debt, it must repay debt-holders out of production income or liquidate the investment project and sell off current assets to repay

Debt profiles of the firm

Concentrated Debt Profile:

- $t = 0$: Firm issues a 2-period bond $b_{02} = I - k^{\alpha}$
- $t = 2$: Rolls over b_{02} into a 1-period bond $b_{23} = I - k^{\alpha}$

Dispersed Debt Profile:

- $t = 0$: Firm issues a 1-period bond $b_{01} = (I - k^{\alpha})/2$ and a 2-period bond $b_{02} = (I - k^{\alpha})/2$
- $t = 1$: Rolls over b_{01} into a 2-period bond $b_{13} = (I - k^{\alpha})/2$
- $t = 2$: Rolls over b_{02} into a 1-period bond $b_{23} = (I - k^{\alpha})/2$

Trade-offs:

- Concentrated debt profile saves on fixed issuance cost but exposes firm to rollover risk
- Dispersed debt profile pays extra issuance cost but firm hedges against rollover risk

Timing of debt rollover by debt profile

Figure: Dispersed Debt Maturity Profile

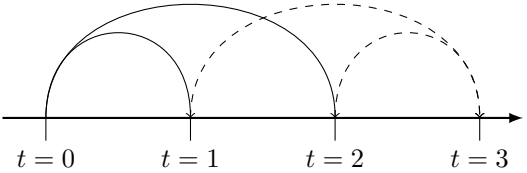
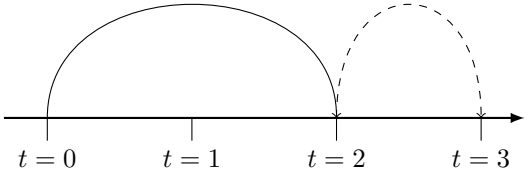


Figure: Concentrated Debt Maturity Profile



Assumption on parameters

Investment Project is NPV positive

$$\underbrace{(I+k)^{\alpha}+(I+k)}_{\text{Project Returns}} > \frac{I}{(1-\lambda)^2}$$

Interim cash-flows are sufficient to repay half of debt amount but not full debt amount

$$\frac{I-k^{\alpha}}{2} < \underbrace{k^{\alpha}}_{\text{Interim cash-flows}} < I-k^{\alpha}$$

Firm must fully liquidate if interim cash-flows cannot cover debt-repayment

$$\frac{I-2k^{\alpha}}{k+I} < \underbrace{\chi}_{\text{Fire sale price}} < \frac{I-2k^{\alpha}}{I}$$

Solving the firm's problem

Firm's Only Choice: Should it have a concentrated or dispersed debt-profile?

Expected Value of having a Concentrated Debt Profile: Derivation

$$V_C = 3k^\alpha + k + (1-\lambda)(I+k)^\alpha - \lambda(1-\chi)(I+k) - c_I$$

Expected Value of having a Dispersed Debt Profile: Derivation

$$V_D = 3k^\alpha + k + (I+k)^\alpha - 2c_I$$

Benefits of a Dispersed Debt Profile:

$$\Delta V \equiv V_D - V_C = \underbrace{\lambda\left[(I+k)^\alpha + (1-\chi)(I+k)\right]}_{\text{Benefit}} - \underbrace{c_I}_{\text{Cost}}$$

When does a firm choose a concentrated vs dispersed debt-profile?

Benefits of a Dispersed Debt Profile: $\Delta V = \lambda \left[(I+k)^{\alpha} + (1-\chi)(I+k) \right] - c_I$

- Increasing in . . .
  - Probability of rollover crisis: $\partial \Delta V / \partial \lambda > 0$
  - Firm size: $\partial \Delta V / \partial k > 0$
  - Profitable investment projects: $\partial \Delta V / \partial I > 0$
  - Production Technology: $\partial \Delta V / \partial \alpha > 0$
  - "Leverage": $\partial \Delta V / \partial (I/k) > 0$
- Decreasing in . . .
  - Debt issuance cost: $\partial \Delta V / \partial c_I < 0$
  - Recovery value in liquidation: $\partial \Delta V / \partial \chi < 0$

Explaining the trend: environment with renegotiation

If firm cannot roll-over debt, it can choose to **liquidate** or **renegotiate** debt contract with lender

- Renegotiation of debt contract: forgo debt-repayment in current period and offer lender higher share of investment returns
- New contract returns determined by Nash bargaining (firm bargaining power: θ)
- Outside option for firm and lender are value under liquidation
- Renegotiation requires cost c_{11}

Mapping liquidation and renegotiation to the real world:

- Chapter 7 bankruptcy (Liquidation) & Chapter 11 bankruptcy (Renegotiation)
- Bankruptcy Reform Act of 1978 introduced Chapter 11 bankruptcy
- Ch 11 revamped reorganization $\longrightarrow$ firms can more efficiently renegotiate debt contracts and forgo liquidation

Solving the firm's problem with renegotiation

Expected Value of having a Dispersed Debt Profile:

$$V_D = 3k^\alpha + k + (I+k)^\alpha - 2c_I$$

Expected Value of having a Concentrated Debt Profile:

Solution to Nash bargaining problem

$$V_C^R = \begin{cases} 3k^\alpha + k + (1-\lambda)(I+k)^\alpha - \lambda(1-\chi)(I+k) - c_I - \lambda c_{11} & \text{if } \theta < \underline{\theta} \\ 3k^\alpha + k + (I+k)^\alpha - (1-\theta)\lambda[(I+k)^\alpha + I + k] - c_I - \lambda c_{11} & \text{if } \theta \in [\underline{\theta}, \overline{\theta}] \\ 3k^\alpha + k + (I+k)^\alpha - c_I - \lambda c_{11} & \text{if } \theta > \overline{\theta} \end{cases}$$

Remarks about renegotiation:

- Dispersed firm never renegotiates because never liquidates
- Concentrated firm renegotiates $\iff \theta \geq \theta^* \equiv [\chi(I+k) + c_{11}]/[(I+k)^\alpha + I + k]$

Renegotiation encourages firms to pick concentrated debt profiles

Benefits of a Dispersed Debt Profile:

$$\Delta V \equiv V_D - V_C = \begin{cases} \lambda\left[(I+k)^{\alpha} + (1-\chi)(I+k)\right] - c_I & \text{if } \theta < \theta^* \\ \lambda(1-\theta)\left[(I+k)^{\alpha} + (I+k)\right] - c_I + \lambda c_{11} & \text{if } \theta \geq \theta^* \end{cases}$$

How does renegotiation change debt profile trade-off?

- $\theta < \theta^*$: no benefits to renegotiating debt.
  - Returns received from renegotiation do not exceed Ch. 11 cost
  - Trade-off between debt-profile choice does not change
- $\theta \geq \theta^*$: benefits to renegotiating debt
  - Returns received from renegotiation exceed Ch. 11 cost
  - Firm more likely to choose concentrated debt-profile

Data

Frequency and Date Range: Annual, 1974 - 2019

Compustat: (for balance sheet data)

- Measuring Debt Maturity Profile Concentration:
  - Detailed data on long-term debt due in 1, 2, . . . , 5 years
  - 2 Measures of concentration:
    1. s_1: Share of long-term debt coming due in 1 year
    2. $HI_w = \sum_{m=1}^{M} (1/m \cdot s_m)^2$: Weighted Herfindal-esq Index
- Firm Outcomes
  - Investment: $\Delta log(k_{j,t+1})$
  - Altman's Z-Score: measure of near-term bankruptcy risk ($\downarrow$ Z-Score $\longrightarrow$ $\uparrow$ bankruptcy risk) More

Credit Supply Shocks: Excess Bond Premium (Gilchrist and Zakrajsek, AER 2012)

- Decomposition of GZ-Credit Spread into:
  - i Aggregate "default risk" component
  - ii Aggregate "credit supply shocks" (EBP)

What firm characteristics correlate with its debt maturity profile?

	s_1	HI_w
Size	-0.0106***	-0.0107***
	(0.0019)	(0.0018)
Age	0.0005***	0.0004***
	(0.0001)	(0.0001)
Market to Book	-0.0031**	-0.0021
	(0.0016)	(0.0015)
Leverage	-0.0619***	-0.0510***
	(0.0085)	(0.0078)
Profitability	-0.0606***	-0.0620***
	(0.0138)	(0.0131)
Cash	0.0839***	0.0737***
	(0.0139)	(0.0130)
Tangibility	-0.0293**	-0.0196*
	(0.0121)	(0.0112)
Profit Volatility	0.1587***	0.1921***
	(0.0379)	(0.0359)
Average Maturity of Debt	-0.0241***	-0.0205***
	(0.0005)	(0.0005)
Observations	72504	72504
R^2	0.501	0.497
Fixed Effects	Industry & Year	Industry & Year

Model correctly predicts the following:

- Size
- Market to Book
- Profitability
- Leverage

Effects of debt maturity profile concentration on investment

Regression: $\Delta log(k_{j,t+1}) = \beta \text{ctrn}_{j,t-1} \times ebp_t + \Gamma' Z_{j,t-1} + \alpha_{FE} + e_{j,t}$

	Investment	Investment
s_1 × ebp	-0.0355**	
	(0.0178)	
HI_w × ebp		-0.0445**
		(0.0227)
Observations	68708	68708
R^2	0.106	0.106
Firm Controls	Yes	Yes
Fixed Effects	Industry & Year	Industry & Year

Takeaway: Firms that roll-over *all* debt during credit shock correlate with ↓ investment by $3.5 - 4.5\%$ (compared to firms that roll-over *none*)

Firm Controls

Effects of debt maturity profile concentration on bankruptcy risk

Regression: $AltmanZ_{j,t} = \beta \text{ctrn}_{j,t-1} \times ebp_t + \Gamma' Z_{j,t-1} + \alpha_{FE} + e_{j,t}$

	Altman's Z-Score	Altman's Z-Score
s_1 × ebp	-0.5213**	
	(0.2187)	
HI_w × ebp		-0.4643*
		(0.2751)
Observations	66505	66505
R^2	0.424	0.424
Firm Controls	Yes	Yes
Fixed Effects	Industry & Year	Industry & Year

Takeaway: Firms that roll-over *all* debt during credit shock correlate with ↑ bankruptcy risk (0.5 Z-score lower)

Aggregate debt maturity profile concentration & aggregate investment

Regression: $\Delta log(K_{t+1}) = \beta \text{Ctrn}_t \times ebp_t + \Gamma' Z_t + e_t$

	Investment	Investment
s_1 × ebp	-0.9615**	
	(0.4289)	
HI_w × ebp		-0.6420*
		(0.3168)
Observations	41	41
R^2	0.619	0.606

Takeaway: Aggregate investment falls by additional 3.65 - 4.88% in response to 1 pp credit shock in 2010s than in 1970s.

Aggregate Controls Controls More on State-Dependence

Aggregate debt maturity profile concentration & aggregate bankruptcy risk

Regression: $AltmanZ_t = \beta \text{Ctrn}_t \times ebp_t + \Gamma' Z_t + e_t$

	Altman's Z-Score	Altman's Z-Score
$s_1 \times$ ebp	-10.0662*	
	(5.2324)	
$HI_w \times$ ebp		-12.1139***
		(4.3182)
Observations	41	41
R^2	0.746	0.762

Takeaway: Financial Stability is more sensitive to credit shock in 2010s than in 1970s.

Conclusion

Model:

- Firms face trade-off between inefficient liquidation from rollover risk and issuance cost
- Introduction of renegotiation technology (Ch. 11 Bankruptcy) $\longrightarrow$ increases efficiency & more firms choose concentrated debt-profiles

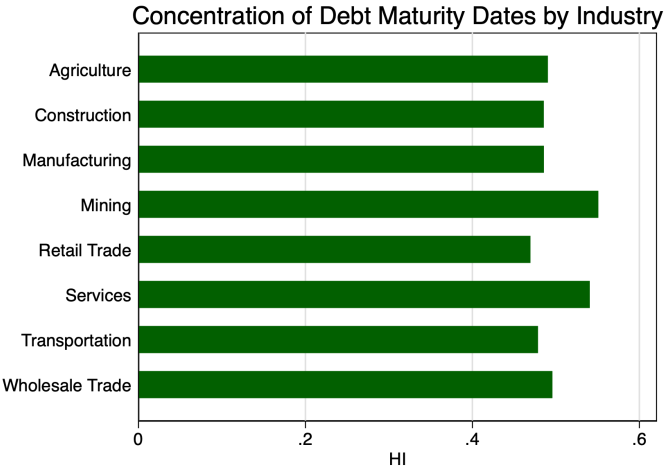
Data:

- Firms with concentrated debt-maturity profiles decrease investment and increases bankruptcy risk most during credit shocks
- Increasing trend in debt-maturity profile concentration amplifies effect of credit shocks on aggregate investment and financial stability

Next Steps:

- Alternative explanations for trend?
- Beef up model: dynamic model with investment choice & risky debt
- Data robustness: using CapitalIQ and/or Mergent FISD

Debt Maturity Profiles by Industry



$HI = \sum_{m=1}^{M} s_m^2$ (Herfindal-esq Index where s_m is share of long-term debt due in m years)

Source: Compustat.

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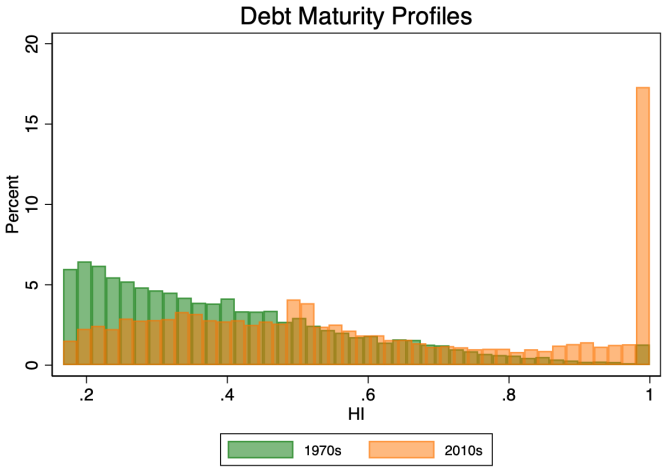
Cross-Sectional Heterogeneity in Debt Maturity Profiles by Decades



$HI = \sum_{m=1}^{M} s_m^2$ (Herfindal-esq Index where s_m is share of long-term debt due in m years)

Source: Compustat.

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Altman's Z-Score

Key idea:

- index based on observable variables that helps to predict likelihood of bankruptcy

Definition: $z = 1.2x_1 + 1.4x_2 + 3.3x_3 + 0.6x_4 + 0.999x_5$

- $x_1 =$ working capital (current assets - current liability) to total assets
- $x_2 =$ retained earnings to total assets
- $x_3 =$ ebit (earnings before interest and taxes) to total assets
- $x_4 =$ market value of equity to total liabilities
- $x_5 =$ sales to total assets

Widely used by practitioners as a predictor of default within the next two years

- $z \geq 2.99$: "non-distressed" firms
- $z \leq 1.81$: "distressed" firms
- $z \in (1.81, 2.99)$ "zone of ignorance"

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Concentrated Firm Cash Flow Derivation

Path	Probability	Cash Flows
1.	λ	$k^\alpha + k^\alpha + \chi(I+k) - (I-k^\alpha)$
2.	$(1-\lambda)$	$k^\alpha + k^\alpha + (I+k)^\alpha + (I+k) - (I-k^\alpha)$

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Dispersed Firm Cash Flow Derivation

Path	Probability	Cash Flows
1.	λ^2	$k^\alpha - (I - k^\alpha)/2 + k^\alpha - (I - k^\alpha)/2 + (I + k)^\alpha + (I + k)$
2.	$\lambda(1 - \lambda)$	$k^\alpha - (I - k^\alpha)/2 + k^\alpha + (I + k)^\alpha + (I + k) - (I - k^\alpha)/2$
3.	$(1 - \lambda)\lambda$	$k^\alpha + k^\alpha - (I - k^\alpha)/2 + (I + k)^\alpha + (I + k) - (I - k^\alpha)/2$
4.	$(1 - \lambda)^2$	$k^\alpha + k^\alpha + (I + k)^\alpha + (I + k) - (I - k^\alpha)$

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Solution to Nash Bargaining Problem

Let $R = (I + k)^{\alpha} + I + k$ and R_f be the firm's return

$$\max_{R_f} \left\{ R_f^{\theta} (R - R_f)^{(1-\theta)} \right\} \qquad st \quad R_f \geq 2k^{\alpha} - (1 - \chi)I$$

$$R_l \equiv R - R_f \geq I - k^{\alpha}$$

Solution:

$$R_f = \begin{cases} 2k^{\alpha} - (1 - \chi)I & \text{if } \theta < \underline{\theta} \\ \theta R & \text{if } \theta \in [\underline{\theta}, \overline{\theta}] \\ R - I + k^{\alpha} & \text{if } \theta > \overline{\theta} \end{cases} \qquad R_l = \begin{cases} R - 2k^{\alpha} - (1 - \chi)I & \text{if } \theta < \underline{\theta} \\ (1 - \theta)R & \text{if } \theta \in [\underline{\theta}, \overline{\theta}] \\ I - k^{\alpha} & \text{if } \theta > \overline{\theta} \end{cases}$$

where

$$\underline{\theta} = \frac{2k^{\alpha} - (1 - \chi)I}{R}$$

$$\overline{\theta} = 1 - \frac{I - k^{\alpha}}{R}$$

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Firm controls in regressions

- ctrn: Concentration Measure (s_1 or HI_w)
- Size: log of total assets
- Age: years since IPO
- Market-to-Book: market value to book value
- Leverage: total debt to total assets
- Profitability: earnings before interest and depreciation to total assets
- Cash: cash and cash equivalent to total assets
- Tangibility: capital stock to total assets
- Profit volatility: 10 year rolling standard deviation in profitability
- Average maturity: average time-to-maturity of long-term debt stock
- Debt-interest coverage ratio: debt and interest due this year to EBIT

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Aggregate controls in regressions

- Ctrn: Concentration Measure (s_1 or HI_w)
- ebp: Excess Bond Premium
- GDP Growth Rate: $\Delta log(GDP_t)$
- Credit-Spread: $BAA - AAA$ Spread
- Yield-Curve: $10 - 1$ Year Treasury Rate
- Debt-interest coverage ratio: Aggregated debt and interest due this year to EBIT

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State-Dependence of EBP Shock

Table: Average Concentration: 1970s v. 2010s

	1970s	2010s
s_1	0.1145	0.1533
HI_w	0.0461	0.1221

$\bar{ebp} = 1$ pp

Table: Calculating State-Dependence of EBP Shock

$(\bar{s_1}^{2010s} - \bar{s_1}^{1970s}) \cdot \bar{ebp} \cdot \beta_{s_1} = -3.65\%$
$(\bar{HI_w}^{2010s} - \bar{HI_w}^{1970s}) \cdot \bar{ebp} \cdot \beta_{HI_w} = -4.88\%$

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