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Debt and income across U.S. firms in a model with trade credit[☆]

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ABSTRACT

We study the relationship between net debt, measured as short-term current liabilities net of cash assets, and income among U.S. corporations. On Compustat firm-level data, we find that operating income rises with net debt quantiles over the range where net debt remains negative, but declines at about the point where net debt becomes positive. We consider a dynamic quantitative partial-equilibrium heterogeneous-firms model with trade credit calibrated to U.S. aggregates. In the model's cross-sectional distribution of firms, operating income rises with net debt quantiles while net debt is negative, and falls at the point where net debt turns positive. Thus the model accounts for the pattern observed in the data. The drop in operating income near the zero-debt level reflects the concentration of delinquent firms there which comes about because of the insurance role of trade credit default.

1. Introduction

Firm-level financial data underpins the empirical identification of patterns of debt and other individual firms' characteristics.[1] The analysis of that type of data through the lenses of macro-finance quantitative models with heterogeneous firms should help further, first in providing interpretation of the relationships observed and, second, in informing modeling improvements.[2] There is currently an active interest in firm-to-firm trade credit within the macro strand of the literature, but these works have not so far held the implied relationships between firm's debt and other financials against data.[3] Bringing together firm-level data and trade-credit quantitative models is thus well deserving of attention.

In order to take a step in this direction, in this paper we consider a version of a model due to Mateos-Planas and Seccia (2024), assess how it may help interpret U.S. evidence over patterns of operating income and debt and, specifically, uncover the possible role of trade credit and trade-credit default, among other factors. Given the model's original intent, our focus here is on debt measured as short-term current liabilities net of cash assets. Our specific questions are how firms' operating profits vary with debt quantiles in the data, to what extent the pattern in the model resembles the data, and what we can then infer about the mechanism, including trade-credit related, behind the observed facts.

Using Compustat data for U.S. non-financial corporations, we find that operating income rises with (net) short-term debt quantiles over the region where (net) debt is negative, but declines at about the point when debt becomes positive. To draw the model's counterpart, we study the stationary equilibrium of a calibrated version of the model targeted to U.S. aggregates.

In the model, there are two relevant mechanisms. First, incentives for the manager to divert resources provide a motivation for more productive firms to dissave and borrow more in order to limit the spare funds subject to an agency problem. Absent this, one would expect more productive firms to borrow less as they are to be short of liquidity less often. Second, as an insurance mechanism, trade-credit delinquency provides the firm the opportunity to avoid bankruptcy, keep up with their bank-debt repayments and reduce their borrowing when hit by adverse shocks. One would then expect low-productivity delinquent firms to be over-represented at low levels of debt.

Based on the stationary cross-sectional distribution of firms in the model, operating income rises with negative-debt quantiles but falls at the turn of the zero-debt position, thus matching the pattern in data.

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1 For a recent example in this literature see Lian and Ma (2021).
2 Instances of such models are Bloom et al. (2018) and Jaimovich et al. (2025).
3 See Reischer (2019), Bocola and Bornstein (2023) and Mateos-Planas and Seccia (2024).

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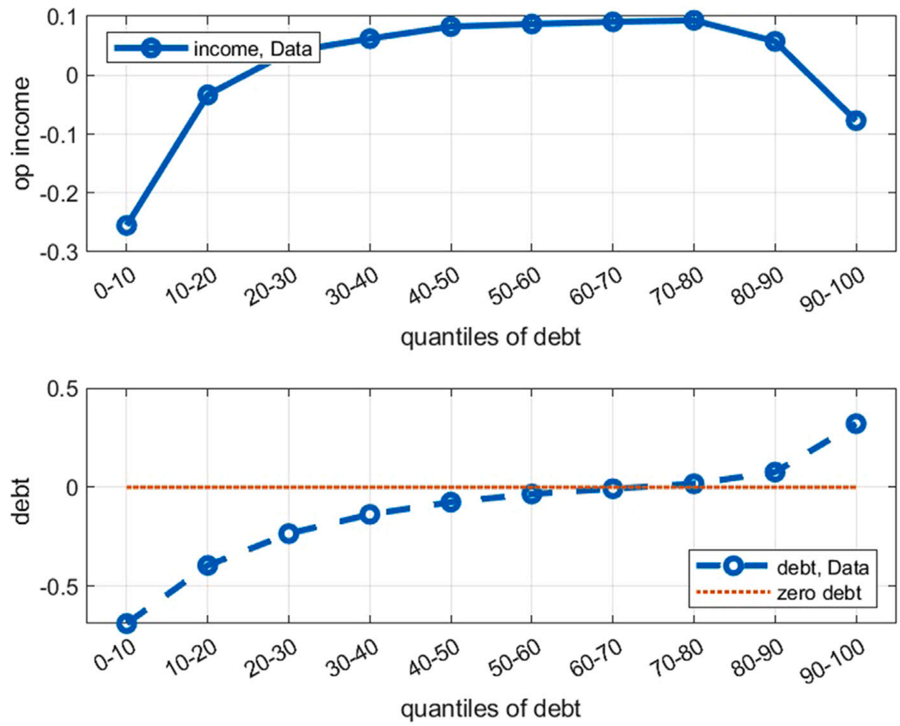

Fig. 1. Compustat Data - Variables sorted by debt decile.

The downturn of operating income near the zero-debt level reflects the concentration of delinquent firms there which comes about because of the insurance role of trade credit.

2. Data and evidence

We analyze the patterns of net debt and operating income utilizing individual firm annual data from Compustat, for the period of 1980–2023. We measure debt as short-term liabilities net of cash assets. Our measure of operating income is earnings before interest, taxes, depreciation, and amortization (EBITDA). We choose to normalize both these variables by the book value of assets. The sample is cleaned with standard criteria. The final sample is an unbalanced panel with 22,907 firms and 239,989 firm/year observations.[4]

The top section of Fig. 1 provides the average operating profits of firms by decile categories of net debt. We observe that operating income increases with net debt over the bottom 80% of the net debt distribution followed by a decline. The bottom section of Fig. 1, which displays the level of net debt deciles, reveals that the turnaround in the slope of operating income occurs near the zero debt position. In other words, operating income rises with debt over the region where net debt is negative, then declines at about the point when debt becomes positive. This finding is robust within firm size quantiles.

[4] Similar to Corbae and D'Erasmo (2021), we exclude utility firms (SIC codes of 4900–4999), financial firms (SIC codes of 6000–6999), and firms operating in residual categories (SIC codes of more than 9000). We also exclude firms located in Canada. Observations with nonpositive/missing book values of assets, or negative/missing values of short-term liabilities or cash assets, or missing values for operating income are deleted. Similar to Hennessy and Whited (2007) and Corbae and D'Erasmo (2021), we censorize the bottom and top 2 percent of the debt ratios. We also censorize the bottom 3 percent and top 0.1 percent of operating income ratios.

3. Model

We consider a partial-equilibrium model of firms and lenders. Here we lay down the assumptions, define the equilibrium, and present the determination of parameter values for its quantitative implementation.

3.1. Assumptions and equilibrium

There is a continuum of final-goods firms. Output from a firm is determined as $e^{\epsilon}x^{\gamma}$, with x the quantity of intermediate input, and ϵ the idiosyncratic (log of) productivity following a N_{ϵ}-state Markov chain with transition probabilities $\psi_{\epsilon}(\epsilon'|\epsilon)$ that approximates a process of the form $\epsilon' = \rho_{\epsilon}\epsilon + \eta'$ with $\eta' \sim N(0, \sigma_{\eta})$ via the method in Tauchen (1986).[5] There is a fixed operating cost c_F per period. In any given period, the firm chooses the amount of input x at given unit price p before the realization of the shock. A given proportion τ of inputs is purchased on within-period trade credit, the remaining fraction $1-\tau$ representing cash inputs. After the shock is observed, the firm can issue one-period debt $b' > 0$ at a discount price q, or save cash assets, that is negative debt $b' < 0$, at a discount price Q_0, decide whether to repay suppliers' trade credit, and whether to liquidate. Delinquency on input payments implies a penalty flag $\nu = 1$ and a corresponding loss of a proportion of output $\tilde{\nu} > 0$ in future periods, with the probability of forgiveness and having the penalty flag cleared, conditional on not incurring further delinquency, denoted λ. Liquidation leads to exit, and bankruptcy if $b > 0$. Exiting firms are replaced by new entrants who draw their initial idiosyncratic shock from the stationary distribution $\overline{\psi}_{\epsilon}$. Under bankruptcy or delinquency, the residual value of the firm is paid to creditors, banks and trade-credit suppliers. If the residual value is negative the firm ceases to operate.

[5] We use the conventional 'prime' notation to indicate a next period variable, e.g., ϵ is current; ϵ' is next period's.

Table 1
Direct parameters.

Parameter	Value	Observation
Discount price	$Q = 0.9615$	4% annual return
Subjective discount rate	$\rho = 0.9615$	4% annual return
Liquid return	$Q_0 = 1.025 \times Q$	2.5% spread
Curvature final goods	$\gamma = 0.60$	Mateos-Planas & Seccia 2024, factor shares
Persistence	$\rho_\epsilon = 0.653$	Corbae et al 2021, Compustat estimates
Volatility innovation	$\sigma_\eta = 0.20$	Corbae et al 2021, Compustat estimates
Number of productivity states	$N_\epsilon = 61$	

Table 2
Calibrated parameters and target moments.

Parameters	Value	Moments	Data	Model
Fixed cost c_F	0.760	Fraction in bankruptcy	0.02	0.02
Side project η	0.078	(net) debt to operating inc	−0.61	−0.61
Penalty size $\bar{v}$	0.153	Fraction in debt	0.35	0.35
Penalty forgiveness λ	0.332	Fraction with positive op inc	0.75	0.74
Input price p	0.271	Trade-credit loss rate	0.07	0.07
Input sales on trade credit τ	0.290	Trade credit to GDP	0.18	0.17

A firm maximizes the expected value of dividends over an infinite horizon discounted at rate ρ. A firm faces the standard constraint that it cannot issue new shares, i.e., non-negative dividends, during its life in operation, although negative dividends might occur for firms that are liquidating as they have to meet the cost of cash inputs. A firm is also constrained not to pay positive dividends or retain profits when liquidating or becoming delinquent. Importantly, debt has seniority over trade credit sales. The preceding description means that cash sales are naturally senior to bank debt. The firm also faces an agency problem.[6] Lacking commitment, the manager has incentives to divert some of the firm's liquid capacity to purchase cash inputs into a side project using the same production function as in the current firm but scaled by a factor η. The liquid funds available for diversion consist of the sum of the firm's saved cash, if any, plus the spare unused available bank credit line. If there is no diversion, the manager earns the wage w_m at the firm (a component of c_F).

Lenders extend one-period loans to final-goods firms. There is a contract for each type of loan in terms of size b' and characteristics of the firm (ϵ, v). Competition means the discount prices of debt reflect the default risk (and possible debt recovery). Intermediaries hold cash deposits from firms at discount price Q_0, and use the funds to purchase risk-free securities at the market discount price Q, with a constant intermediation spread between the two.

An equilibrium satisfies two conditions: Decision rules for borrowing/saving and repayments maximize final-goods firms' objective given debt prices; debt prices satisfy zero profits for lenders given the decision rules of final-goods firms. The equilibrium generates a stationary distribution of firms over their individual characteristics at the start of a period (ϵ_{-1}, b, v). The Appendix spells out the formal elements of the model in recursive form, including the Bellman equations and maximization problems, and the risk-based determination of debt prices.

3.2. Quantitative setting

A model's period corresponds to one year. The parameters assigned directly are the seven shown in Table 1.[7] The remaining six parameters will be chosen so the model moments match a number of empirical targets as shown in Table 2.[8] The empirical targeted moments are derived from aggregate and firm-level data. For debt and operating income, using firm-level data from Compustat for the period 1980–2014, we measure debt in the data as current liabilities net of savings following the same definition as in the empirical analysis in Section 2. The trade-credit loss rate is the ratio of receivables doubtful over the sum of all receivables based on Compustat 1980–2016, and the ratio of trade credit to GDP is informed by Fed and BEA aggregate time series on receivables and GDP. Finally, the target for the bankruptcy rate is based on the related literature.[9]

Since our interest is in cross-sectional implications, we begin by considering the distribution of net debt positions from the model and display it in Fig. 2. There is a marked concentration of firms near the zero debt position which, to a large degree, appears to be related to trade credit. Firms with moderate levels of current bank debts (relative to trade credit) can, by becoming delinquent on trade credit, obtain relief and thus be able to payback those debt obligations and also diminish their need to borrow further from banks, hence their contribution to the concentration of firms near zero-debt positions. The firms undertaking those choices, one would guess, must be ones hit by adverse productivity shocks. The question is whether this mechanism, together with the others built into the model, can rationalize our evidence in Section 2 on the pattern of income by debt.

4. Income and debt in model and data

To draw the implications of the model, we consider the stationary distribution and, just as we did on Compustat data in Section 2, sort firms by net debt deciles, and calculate average operating profits within each debt group. Note that all the variables can be interpreted as ratios to capital, akin to our evidence, since capital is uniform in the model. Average operating income is displayed against the debt quantile categories in the top section of Fig. 3. Operating income is increasing in debt over the bottom 60% of the debt distribution at which point operating income decreases. The middle section of Fig. 3, displaying the debt decile levels, shows that the downturn in operating income occurs near the zero debt position. The profile of operating income sorted by debt in the model therefore compares well with its data counterpart displayed in Fig. 1 earlier.

We can explain its two features. First, the positive relationship between net debt and income while net debt remains negative must reflect the incentives for the manager to divert funds. They provide the extra motivation for more productive firms to dissave/borrow in order

[6] See Arellano et al. (2019).

[7] See Mateos-Planas and Seccia (2024) for details about and justification for these and the other calibration targets and parameters. (The non-reported Gumbel dispersion parameter for type I extreme-value shocks used in computation is small enough to be seemly innocuous.)

[8] The manager's salary w_m can be fixed arbitrarily, to 0.25 for instance, since it cannot be identified separately from η.

[9] The mid range of Ottonello and Winberry (2020) and Corbae and D'Erasmo (2021).

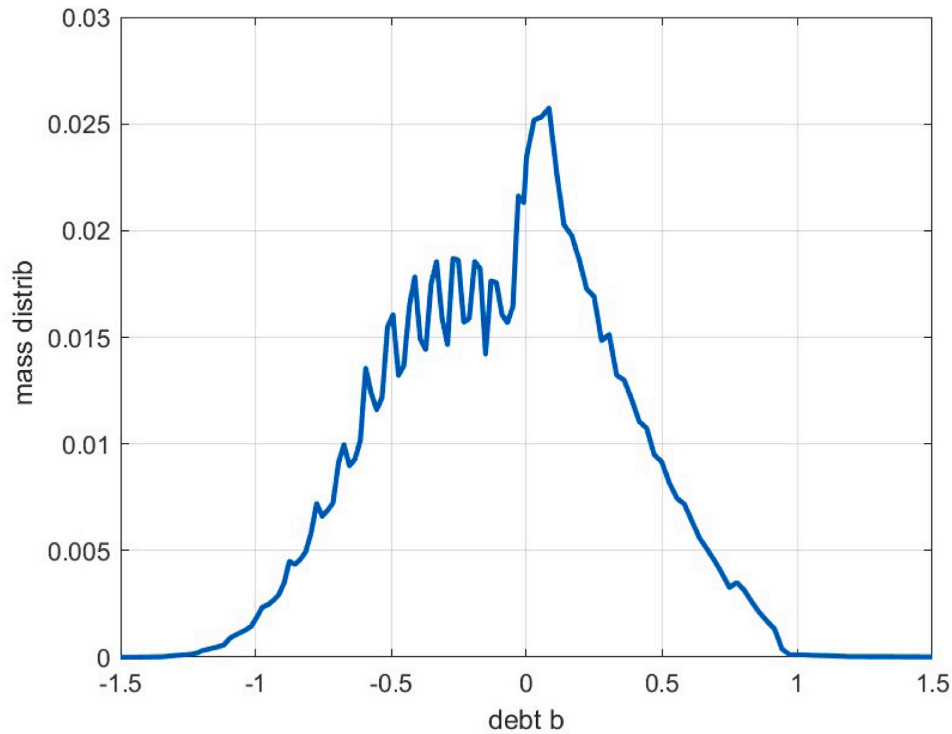

Fig. 2. Baseline model - The frequency distribution of (net) debt.

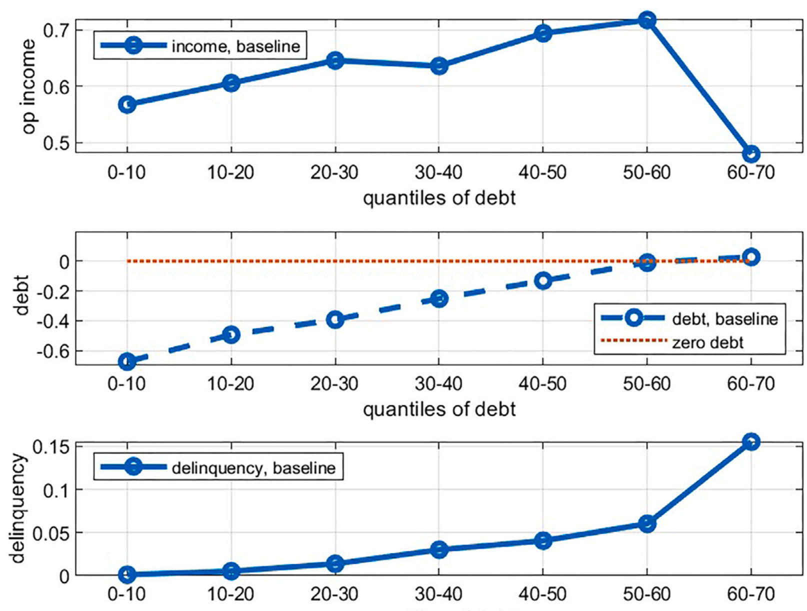

Fig. 3. Baseline Model - Variables sorted by debt decile.

to limit the value of spare funds subject to the agency problem. Second, the drop in operating income about the zero net debt position will be due to the existence of trade credit. The sharp rise in the delinquency rate at that point, displayed in bottom section of Fig. 3, is suggestive of that connection. We had already discussed at the end of Section 3 the possibility of delinquency driving a clustering of firms near the zero debt mark.

We now verify that the mechanism is quantitatively relevant and may explain the turning point where income drops with debt. Consider a counterfactual model economy without trade credit, i.e., setting $\tau = 0$. We only re-calibrate the manager's diversion parameter η to 0.0895 so that the model still matches the aggregate debt target. In the top section of Fig. 4, the solid blue line is for the baseline profile of operating income sorted by debt already shown in Fig. 3, and the dashed orange line is for the counterfactual no-trade-credit economy. Both economies share the same increasing slope for the bottom 60% of the debt distribution. However, the economy without trade credit has the same increasing pattern continuing over higher quantiles, and

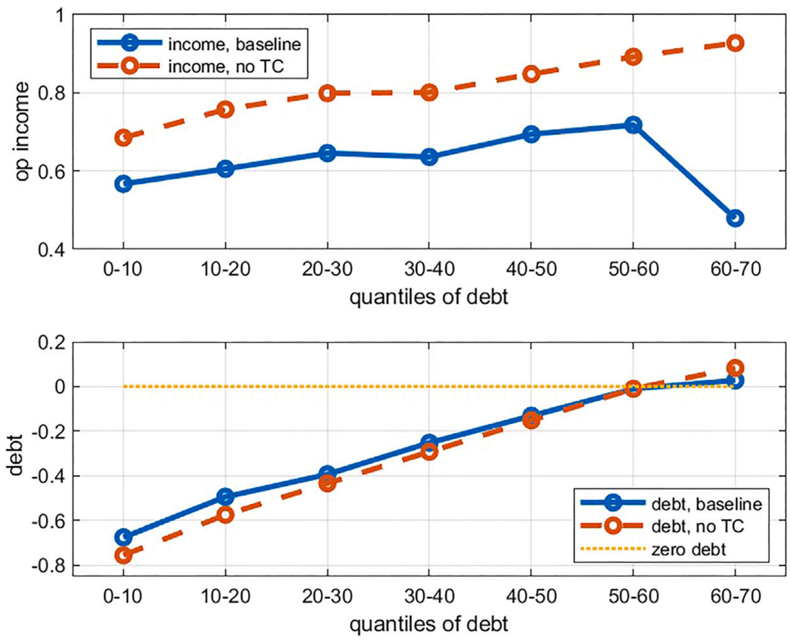

Fig. 4. Baseline and No-trade-credit (no TC) Models - Variables sorted by debt decile.

cannot therefore account for the decrease in income near the zero-debt position observed both in the data and in the model with trade credit.

5. Final remarks

Our quantitative theory accounts for characteristics of the observed cross-sectional variation of firms' operating income over short-term net debt. We have specifically highlighted that trade credit might be important for understanding the inflection point in the slope of the debt/income profile.

While the model is promising in that it captures some features of the data well, this paper is only a step towards a better understanding of the observed cross-sectional variation of firms' characteristics. Further work bringing together quantitative theory and firm-level data thus awaits.

Appendix. Details of model

It is convenient to cast the equilibrium in recursive form. The final-goods firm's individual state before shocks are realized consists of (ϵ_{-1}, b, v). After shocks are realized, in the second part of the period, the individual state becomes (ϵ, b, v, x), which includes the level of input x chosen in the first part of the period. The discount price of bank debt is a function $q^{ND}(b', \epsilon, v)$ if there is currently no delinquency, and $q^x(b', \epsilon)$ if there is delinquency. The equilibrium generates a stationary distribution of firms over individual characteristics (ϵ_{-1}, b, v) at the start of the period which we denote μ.

Firms

There are two stages to the firm's problem. Denote by $V(\epsilon, b, v, x)$ the value function in the second stage, after the realization of the shock, and by $W(\epsilon_{-1}, b, v)$ the value in the first stage before the current shock is observed. In the second stage, the decision needs to evaluate the value from 3 different courses of action: repayment, delinquency and liquidation.

Repayment - When honoring all obligations, borrowing/savings b' solves

$$\begin{aligned} V^{ND}(\epsilon, b, v, x) \; &= \; \max_{b' \in \mathbb{R}} \left\{ \text{cih}(\epsilon, v, b, x) + q(b', \epsilon, v) b' + \rho \mathbb{W}'(\epsilon, v, b') \right\} \qquad \text{(A.1)} \\ \text{s.t.} \;\; & \text{cih}(\epsilon, v, b, x) \equiv (1 - v) z e^{\epsilon} x^{\gamma} - c_F - px - b, \\ & q(b', \epsilon, v) \equiv \begin{cases} q^{ND}(b', \epsilon, v) & b' \geq 0 \\ Q_0 & b' < 0, \end{cases} \\ & \mathbb{W}'(\epsilon, v, b') \equiv \mathbf{I}_{v>0} \Big(\lambda W(\epsilon, b', 0) + (1-\lambda) W(\epsilon, b', \tilde{v}) \Big) \\ & \qquad + \mathbf{I}_{v=0} W(\epsilon, b', 0), \\ & \text{cih}(\epsilon, v, b, x) + q(b', \epsilon, v) b' \geq 0, \\ & \mathbf{I}_{b'<0} Q_0 \, (-b') + B^*(\epsilon, v) - \mathbf{I}_{b' \geq 0} q^{ND}(b', \epsilon, v) b' \leq M(\epsilon, v), \\ & B^*(\epsilon, v) \equiv \max_{b' \geq 0} q^{ND}(b', \epsilon, v) b', \\ & \eta (1 - v) z e^{\epsilon} (M(\epsilon, v)/p)^{\gamma} = w_m. \end{aligned}$$

The first three conditions define cash in hand cih, the price q of borrowing or cash savings, and the expected continuation value $\mathbb{W}'$. The fourth condition is the constraint that dividends cannot be negative. The fifth condition is the participation constraint: the total amount of liquid resources left at the end of the period (the left hand side) cannot exceed the level that would induce diversion by the manager $M(\epsilon, v)$ (the right hand side). The next two conditions define $B^*(\epsilon, v)$ as the total credit line available to the firm, and $M(\epsilon, v)$ as the level of funding that makes the manager indifferent between the profits from the side project, with productivity parameter η, and the wage at the firm w_m.

Delinquency - When repudiating payments for trade-credit input supplies, the firm determines borrowing b' and the supplier's recovery r^x according to

$$\begin{aligned} V^x(\epsilon, b, v, x) \; &= \; \max_{b', r^x \geq 0} \left\{ \text{cih}(\epsilon, v, b, x) + q^x(b', \epsilon) b' - r^x + \rho \mathbb{W}'(\epsilon, b') \right\} \qquad \text{(A.2)} \\ \text{s.t.} \;\; & \text{cih}(\epsilon, v, b, x) \equiv (1 - v) z e^{\epsilon} x^{\gamma} - c_F - (1 - \tau) px - b, \\ & \mathbb{W}'(\epsilon, b') \equiv W(\epsilon, b', \tilde{v}), \\ & b' \geq 0, \\ & \text{cih}(\epsilon, v, b, x) + q^x(b', \epsilon) b' - r^x = 0, \\ & \mathbf{I}_{b'<0} Q_0 \, (-b') + B^*(\epsilon) - \mathbf{I}_{b'>0} q^x(b', \epsilon) b' \leq M(\epsilon, v), \\ & B^*(\epsilon) \equiv \max_{b' \geq 0} q^x(b', \epsilon) b', \\ & \eta (1 - v) z e^{\epsilon} (M(\epsilon, v)/p)^{\gamma} = w_m. \end{aligned}$$

The constraints are analogous to those for the problem under repayment.

Liquidation - There are two possible situations. The first is when cash-in-hand, $(1 - v) z e^{\epsilon} x^{\gamma} - c_F - (1 - \tau) px + \mathbf{I}_{b<0}(-b)$, is non-negative, in which case the value of the firm is zero and the residual is recovered by debt creditors as r^b. The second case is when cash-in-hand is negative, meaning that the firm's output (plus possible reserves) would not cover the fixed cost and the cost of cash inputs, and the firm must therefore cease production altogether, with no recovery, while the firm must still cover the incurred cost of the cash inputs. We represent the firm's failure to produce by the indicator $d^f(\epsilon, b, v, x) = 1$. When, otherwise, cash in hand is positive then $d^f(\epsilon, b, v, x) = 0$. In sum,

$$V^b(\epsilon, b, v, x|S) = \begin{cases} 0 & \text{if } m(\epsilon, v, x) \geq 0 \\ -(1-\tau)px + \mathbf{I}_{b<0}(-b) & \text{otherwise} \end{cases} \tag{A.3}$$

$$d^f(\epsilon, b, v, x) = \begin{cases} 0 & \text{if } m(\epsilon, v, x) \geq 0 \\ 1 & \text{otherwise} \end{cases}$$

$$\text{s.t. } m(\epsilon, v, x) \equiv (1-v)ze^{\epsilon}x^{\gamma} - c_F - (1-\tau)px + \mathbf{I}_{b<0}(-b).$$

Choice of repayment option - The optimal choice among the three options in the second stage gives decision rules $d^x(\epsilon, b, v, x)$ and $d^b(\epsilon, b, v, x)$ as the solution to

$$V(\epsilon, b, v, x) = \max\left\{ V^{ND}(\epsilon, b, v, x), V^x(\epsilon, b, v, x), V^b(\epsilon, b, v, x) \right\}. \tag{A.4}$$

The demand for inputs - We now turn to the first stage within the period, before the realization of the shocks. Taking V as given by (A.4), there the optimal choice yields the decision rule $x = x(\epsilon_{-1}, b, v)$ that solves

$$W(\epsilon_{-1}, b, v) = \max_x \sum_{\epsilon} \psi_{\epsilon}(\epsilon|\epsilon_{-1}) V(\epsilon, b, v, x). \tag{A.5}$$

Lenders

Lenders and intermediation - Lenders use firm's decision rules and shock transition probabilities to infer the probability of debt default. They also take into account the recovery of the residual value of the firm. The price of debt can be written $q^{ND}(b', \epsilon, v) = Q(1 - \Lambda^{ND}(b', \epsilon, v))$ when there is no delinquency today, and $q^x(b', \epsilon) = Q(1 - \Lambda^x(b', \epsilon))$ when there is delinquency, where $\Lambda^{ND}(\cdot)$ and $\Lambda^x(\cdot)$ denote the corresponding forecasts of default losses, or expected default, which depend on the default rules $d^b(\cdot)$ and the recovery $r^b(\cdot)$ expressed as a rate over debt due b'.

The expressions for Λ^{ND} And Λ^x follow. For a firm not defaulting, let the lender's expected recovery rate

$$rec^b(\epsilon', b', v') \equiv \frac{r^b(\epsilon', b', v', x(\epsilon, b', v'))}{b'}.$$

Therefore expected default $\Lambda^{ND}(\cdot)$ can be written

$$\begin{aligned} &\Lambda^{ND}(b', \epsilon, v) \equiv \\ &\mathcal{I}_{v>0} \sum_{\epsilon'} \psi_{\epsilon}(\epsilon'|\epsilon) \left\{ (1-\lambda) d^b(\epsilon', b', \tilde{v}, x(\epsilon, b', \tilde{v}))(1 - rec^b(\epsilon', b', \tilde{v})) \right. \\ &\left. + \lambda d^b(\epsilon', b', 0, x(\epsilon, b', 0))(1 - rec^b(\epsilon', b', 0)) \right\} \\ &+ \mathcal{I}_{v=0} \sum_{\epsilon'} \psi_{\epsilon}(\epsilon'|\epsilon) \left\{ d^b(\epsilon', b', 0, x(\epsilon, b', 0))(1 - rec^b(\epsilon', b', 0)) \right\}. \end{aligned}$$

The expected default for a firm incurring delinquency is

$$\Lambda^x(b', \epsilon) = \sum_{\epsilon'} \psi_{\epsilon}(\epsilon'|\epsilon) \left\{ d^b(\epsilon', b', \tilde{v}, x(\epsilon, b', \tilde{v}))(1 - rec^b(\epsilon', b', \tilde{v})) \right\}.$$

Data availability

Stata and Fortran code will be made available on request, and should also be online soon.

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