Empirical determinants of zombification in petrochemical firms. The case of Colombia

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Abstract

Corporations with persistently negative profitability, excessive leverage, and declining real revenue growth, are colloquially referred to as "zombie firms" due to their economically unviable nature. Such financially distressed entities operate in both developed economies and emerging markets. This paper quantifies the financial performance of zombie firms within Colombia's petrochemical cluster using a five-component methodology. The research applies a probit regression, a comparative analysis of financial constraint indices, an investment-cash flow sensitivity model, a corporate flow of funds analysis, and a cash flow sensitivity of cash model. The probit model establishes that indebtedness, minimal asset tangibility, and inadequate operating cash flow function as the primary statistically determinant predictors of zombie status. The comparative analysis of financial constraint indices confirms the superior discriminatory power of the Whited-Wu index over the Kaplan-Zingales and Size-Age alternatives for classifying these corporations. Furthermore, the investment-cash flow sensitivity model establishes that zombie firms systematically curtail capital expenditures in response to their distressed nature, a behavior not observed in their solvent counterparts. The corporate flow of funds analysis derives a structural explanation: an inability to generate internal cash flow and volatility in working capital primarily cause the financing deficit of underperforming entities, whereas these factors are not determinant for solvent corporations. Finally, the cash flow sensitivity of cash model confirms that a precautionary motive dictates the cash accumulation policies of zombie firms, a behavior absent in financially viable entities.

1. Introduction

The phenomenon of "zombie firms," a nomenclature introduced by Caballero et al. (2008) during their examination of Japan's economic stagnation in the 1990s, denotes corporate entities incapable of servicing their debt obligations through current profitability over an extended temporal horizon. The prevalence of such firms, as a proportion of the aggregate non-financial corporate sector, has shown a marked upward trajectory in the aftermath of the Global Financial Crisis, particularly across advanced economies.

This economic anomaly has garnered attention in both academic discourse and policy formulation spheres due to its potential to hamper sectoral growth and productivity maximization. The persistence of zombie firms disrupts the Schumpeterian process of creative destruction and obstructs market entry for more efficient, nascent enterprises. These non-viable entities effectively sequester resources that could otherwise be deployed by financially robust firms and exert a vitriolic impact on macroeconomic growth trajectories. When zombie companies with sunk costs make investments to augment their capital intensity, they can divert resources that could have otherwise been used by more productive and profitable companies. The resultant market distortion manifests in a crowding-out effect on more productively efficient firms as the latter compete for finite factor inputs, including financial capital, human capital, and credit facilities.

Firms classified as "zombies," characterized by their inability to cover fixed costs despite the presence of substantial sunk costs, persist in operations notwithstanding their allocative inefficiency and prolonged unprofitability. By retaining excess labor capacity, zombie firms contribute to wage rigidities and impede efficient labor reallocation to more promising sectors.

The notion of creative destruction, a cornerstone of evolutionary economics, encapsulates the perpetual process of industrial renewal and the metamorphosis of incumbent firms. The modern marketplace might operate as a catalyst for long-term economic expansion by dismantling barriers to entry for novel, more efficient market participants, along with a concomitant reallocation of resources to more productive entities that impels enterprises to reinvent their business models or risk obsolescence. Zombie firms present a stark contradiction to these market principles. These entities, which cannot service their debt obligations through operational cash flows, continue operations solely through external support mechanisms. Their continued existence creates market distortions that affect resource allocation efficiency. The etiology of the zombie firm phenomenon is rooted in structural inefficiencies pertaining to capital allocation. The persistence of zombie firms introduces frictions into the market mechanism which causes suboptimal resource allocation and a slowdown of aggregate productivity growth. This inefficiency manifests through various channels in the broader economic ecosystem.

The perpetuation of financially distressed enterprises through artificial support mechanisms distort market efficiency. These zombie firms, unable to meet debt service requirements with standard operational cash flows, receive sustained financial support that contravenes basic market principles. The banking sector allocates scarce capital resources to these underperforming entities, which directly reduces the availability of credit for more productive enterprises. The ramifications extend beyond individual firm performance and creates a compounding effect: banks forgo

the opportunity to fund innovative market entrants while simultaneously sustaining inefficient incumbents. Artificially supported firms maintain market share and productive capacity that should, under normal market conditions, transfer to more efficient operators. This disruption of natural market mechanics creates artificial price pressures and impedes the optimal reallocation of resources.

The prevalence of zombie firms correlates with periods of economic stagnation. Their presence creates artificial competition that prevents the ascension of more efficient market participants. This market friction impedes the natural cycle of business renewal and jeopardizes market dynamism. In theory, a financial crisis should act as a cleansing mechanism within the market, facilitating the exit of non-performing entities However, empirical evidence, particularly from severe economic downturns such as the 2008 Global Financial Crisis, reveals that this purging mechanism was compromised during periods of acute economic distress (Banerjee and Hofmann, 2018).

The market executes a cleansing process to remove inefficient firms and yet several factors impair this mechanism. Information asymmetries between market participants persist. The debt overhang phenomenon blocks the efficient allocation of capital and central banks' accommodative monetary policies, combined with regulatory forbearance, allow non-viable firms to continue operations, in an attempt to alleviate immediate economic disruption during crises.

Financial institutions, in an endeavor to circumvent the recognition of losses on their balance sheets, persistently extend credit facilities to underperforming corporate entities, a practice colloquially referred to as "evergreening" of loans. This is characterized by the rollover or restructuring of existing debt obligations, often at below-market rates, to firms that would otherwise be classified as non-performing.

The quintessence of the zombie's firms concept resides in the anomalous and persistent juxtaposition of technical insolvency with operational continuity. The phenomenon has generally arisen as a result of a particular confluence of circumstances. The first is an expansive phase accompanied by a substantial accretion in private sector leverage, that abruptly halts. The subsequent phase is a recessionary period characterized by asset price deflation and a concomitant surge in non-performing loans (NPLs). In both the US and the European Union, the rise of EZs predated the onset of the Global Financial Crisis

A high share of zombie firms in an economy is a matter of concern in the long run because it can lead to a decline in aggregate productivity through two channels, credit misallocation and zombie congestion. The credit misallocation channel arises mechanically because keeping zombie firms alive reduces aggregate productivity, but it also takes place through a crowding-out effect if zombie lending tightens the credit constraints of high-productivity firms (Faria-e Castro et al., 2021). The zombie congestion channel occurs if a high survival rate of zombie firms distorts competition in both product and input markets because those firms obtain credit in better terms and conditions than the rest of companies. This phenomenon reduces profits for healthy firms, lowers their investment and employment growth, discourages the entry of new companies and corrodes total factor productivity in zombie-dominated industries.

In practice, to identify zombie firms correctly is not a straightforward task. Accordingly, the

previous literature has used a myriad of proxies of zombie firms, ranging from receiving credit at subsidized rates or the inability to pay interest expenses from operating income—sometimes coupled with market valuations such as the Tobin's q or negative sales growth during several years to the persistent lack of profitability and high leverage or firms with negative equity in the previous year. Those definitions are problematic as they are prone to misclassify financially distressed firms as zombie firms. The typical classifications used in the literature often mislabel companies with temporarily low revenues relative to interest payments as zombie firms. However, many of these firms ultimately recover and regain financial health. In the same vein, based on a sample of US publicly traded corporations it's necessary to differentiate between distressed firms and those actually receiving zombie loans (i.e., loans at subsidized rates) from their banks (El Ghoul et al., 2020).

In essence, the aforementioned problem hinges on two basic premises: (i) financial distress is a necessary but not sufficient condition for a company to become a zombie firm; (ii) there are no zombie firms in the absence of zombie lending. Therefore, research that relies exclusively on firm-level data is unlikely to identify zombie firms correctly. In addition to firm-level data to measure companies' financial soundness, bank–firm level data that contain information on the lending relationships between credit institutions and their corporate borrowers are also required. Acharya et al. (2022) explain the zombie firm phenomenon mainly through the loans to financially weak firms and banks' greater incentives for risk-taking, both explained by lower interest rates. Furthermore, there is a paucity of empirical evidence regarding the severity of financial constraints among listed firms in emerging markets. This lacuna in the literature is particularly significant given the heterogeneity in capital market frictions and institutional environments between developed and developing countries.

This study contributes to the extant corpus of knowledge through a two-pronged approach. Primarily, it documents the pervasiveness of non-viable enterprises, colloquially termed "zombie firms," within the context of an emergent market economy, specifically Colombia, where empirical data has hitherto been lacking. Secondarily, through comprehensive empirical analysis, it extends this strand of research by examining how microeconomic and financial determinants partially explain the proliferation of zombie firms within this geographic sphere. This is particularly pertinent in emerging markets where access to external finance is limited, firms rely mostly on internal sources of capital, and investment and financing decisions are more inter-temporal and interdependent.

2.   Variables and Methodology

The research employs an unbalanced panel dataset, focusing on privately held entities registered with the Cartagena Chamber of Commerce during the fiscal years 2021 through 2023. The comprehensive population for the analysis, encompassing 1126 non-financial corporations within the manufacturing sector. The fluctuation in the number of enterprises across the temporal spectrum can be attributed to various corporate events, including but not limited to liquidations, mergers and acquisitions (M&A), and dissolutions. Due to these limitations, the total number

of companies differs from the original number of companies, resulting in an unbalanced panel dataset. Firms with null total debt and total assets, as well as book, market, and financial leverage ratios outside the [0,1] interval, are excluded from the sample. Firms reporting zero cash holdings are similarly omitted. Outliers are identified and removed utilizing the stem-and-leaf methodology.

In this empirical research, zombie firms are characterized by persistently negative operating cash flows relative to interest obligations and chronic inability to service debt, relying on continuous loan rollovers. While the definition of zombie firms remains subject to debate in the literature, they are generally quantified based on profitability metrics and the magnitude of credit subsidies received. A broad definition classifies firms with an interest coverage ratio below unity for three consecutive fiscal periods as zombies. A more narrow definition incorporates additional criteria related to subdued future performance expectations.

The Organisation for Economic Co-operation and Development (OECD) operationalizes the definition of a zombie firm as an entity reporting an interest coverage ratio below unity for three consecutive fiscal years. The interest coverage ratio, calculated as the quotient of operating income to interest expense, is a widely utilized metric among credit analysts for assessing a firm's debt servicing capacity. In accordance with this framework, the present study classifies entities as zombies in 2023 if their interest coverage ratio fell below one for three consecutive quarters.

This empirical investigation utilizes a sample of firms from two sectors in Bolivar, Colombia, spanning the period 2019–2023. The variables employed to quantify the various characteristics of zombie firms are delineated in Table 1. This Table provides a comprehensive explanation of the factors incorporated in the analysis, along with their anticipated directional relationships, underpinned by theoretical and empirical substantiations.

The age criterion is implemented to differentiate between genuine zombie firms and nascent innovative enterprises, which is indistinguishable based solely on profitability metrics. The three-year persistence window for financial weakness partially mitigates concerns regarding cyclical economic influences on the prevalence of zombie firms. The robustness of zombie firm identification is further examined through a modified version of the definition proposed by Caballero et al. (2008), as elucidated in the preceding section.

Specifically, this analysis defines a firm as eligible for zombie classification if it has been operational for a minimum of 10 years as of 2013 with interest coverage ratios below unity for three consecutive years (McGowan et al., 2018).

The dependent variable is operationalized as a binary indicator, assuming a value of '1' if an entity is categorized as a zombie firm and '0' otherwise, in accordance with the methodology delineated in the preceding section.

Table 1
Description of independent variables

Metric	Formula	Description
Operating Income to Interest Expense Ratio	ICR = Operating income / Interest expense	The Operating Income to Interest Expense Ratio quantifies a company's capacity to meet its interest obligations using its operating income.
Current Ratio	Current Ratio = Current Assets / Current Liabilities	This ratio assesses the company's short-term liquidity by comparing current assets to current liabilities.
Acid Test Ratio	Acid Test Ratio = (Cash + Cash Equivalents + Marketable Securities + Accounts Receivable) / Current Liabilities	This liquidity ratio excludes inventories to provide a more stringent measure of a company's ability to meet short-term liabilities with its most liquid assets.
Asset Turnover	Asset Turnover = Sales / Total Assets	This ratio measures how many monetary units of sales are generated per monetary units of assets.
Tangibility	Tangibility = Tangible Assets / Total Assets	This ratio measures the extent of a company's tangible assets as a percentage of total assets.
CAPEX to Assets	CAPEX to Assets = CAPEX / Total Assets	Measures the proportion of capital expenditure relative to total assets and measures how much is invested in growth versus maintaining current assets.

Methodology for identification of zombie firms

In order to identify zombie firms, the following procedure was implemented:

Let the minimum required interest payment for each firm each year, $R^*_{i,t}$, be defined as in Equation 1:

$$R^*_{i,t} = rs_{t-1}BS_{i,t-1} + \left(\frac{1}{5}\sum_{j=1}^{5} rl_{t-j}\right)BL_{i,t-1} + rcb_{min\ over\ last\ 5\ years,t} \times Bonds_{i,t-1}, \qquad (1)$$

where $BS_{i,t}, BL_{i,t}$, and $Bonds_{i,t-1}$ are short-term bank loans (less than one year), long-term bank loans (more than one year), and total bonds outstanding (including convertible bonds (CBs) and warrant-attached bonds), respectively, of firm i at the end of year t; and rs_t, rl_t, and $rcb_{min\ over\ the\ last\ 5\ years,t}$ are the average short-term prime rate in year t, the average long-term prime rate in year t, and the minimum observed coupon rate on any convertible corporate bond issued in the last five years before t.

The estimation of the lower bound is constrained by inherent data limitations. The available information regarding corporate debt structures is restricted to broad categories of debt instruments, including: short-term bank borrowing, long-term borrowing due in one year and remaining long-term bank borrowing, bonds outstanding due in one year and remaining bonds outstanding, and commercial paper outstanding. In other terms, the exact interest rates on specific loans, bonds, or commercial paper and exact maturities of any of these obligations are unknown. Finally, the interest payments include all interest, fee, and discount expenses, including those related to trade credit are computed.

The underlying methodology consists in selecting interest rates that are exceptionally advantageous for the borrower, so that R^* is demonstrably lower than the rates typically accessible to most firms in a non-subsidized market environment (absence of explicit or implicit subsidies).

It is further assumed that these convertible bonds are issued during periods of interest rate troughs within the specified five-year window, $rcb_{min\ over\ the\ last\ 5\ years,t}$.

The model hypothesizes that firms employ convertible bonds as their debt instrument of choice. These securities carry lower interest rates due to the embedded conversion option, which provides potential equity upside to the bondholder.

To categorize firms, the actual interest payments made by the firms ($R_{i,t}$) is compared with a hypothetical lower bound. This differential is subsequently normalized by the total borrowing at the beginning of the period ($B_{i,t-1} = BS_{i,t-1} + BL_{i,t-1} + Bonds_{i,t-1} + CP_{i,t-1}$), where $CP_{i,t-1}$ is the amount of commercial paper outstanding for the firm i at the beginning of the period t. This procedure ensures unit comparability with interest rates.

Accordingly, the resulting variable, $x_{i,t} \equiv (R_{i,t} - R_{i,t}^*)/B_{i,t-1} = r_{i,t} - r_{i,t}^*$ is referred to as the interest rate spread. This measure is "conservative" and minimize the risk of false positives because it's assumed that the minimum interest rates are extremely advantageous to the firm and because the interest payment, $R_{i,t}$, includes broader range of interest expenses on items beyond the notion of total borrowing, such as interest expenses on trade credit, as per Calvo's approach.

The procedure employed to construct r^* of detecting all forms of subsidized lending or financial assistance that lowers the current period's interest payments, including debt forgiveness, interest rate concessions, debt for equity swaps, or moratoriums on interest rate payments.

If a credit intermediary extends new loans at prevailing market interest rates, which are subsequently utilized to pay off past loans and to retire existing debt obligations, the gap variable will not capture this. In instances where a financial institution acquires assets from a client at prices exceeding fair market value, this form of indirect financial support will not be reflected in the designed metric.

The next empirical strategy for identifying the set of zombie firms from the calculated interest rate gaps is delineated. The baseline procedure classifies a firm i as a zombie for year t whenever its interest rate gap is negative ($x_{i,t} < 0$). The rationale underpinning this method is predicated on the conservative philosophy inherent in the construction of r^*. Under the assumption r^* is a perfectly measured lower bound, then the logical inference is that only firms receiving some form of subsidy or preferential treatment could report a negative gap.

The problem with this method is the threshold sensitivity. Firms with interest rate gaps marginally above zero ($x_{i,t} \approx 0+$) are classified as non-zombies, despite, hypothetically benefiting from near-subsidized rates. The dichotomous nature of the classification eschews valuable information about the degree of "zombification" in borderline cases.

To identify the financial and operational determinants of zombification, this study employs a probit model for panel data. The probit model is suitable for this analysis because the dependent variable is binary, taking the value of 1 if a firm is classified as a "zombie" and 0 otherwise. The model estimates the probability that a firm i at time t is a zombie, conditional on a set of explanatory variables.

The firm is classified as a "Zombie" if is paying an effective interest rate $r_{i,t}$ that is lower than the theoretical minimum market interest rate $r_{i,t}^*$. This condition implies the receipt of subsidized financing, such as an 'evergreen' loan or another form of financial accommodation, which constitutes the defining attribute of a non-viable corporation. If this occurs the interest rate gap is negative.

The firm is classified as a "non-zombie" if is paying an effective interest rate $r_{i,t}$ equal to or greater than the theoretical minimum market interest rate $r_{i,t}^*$. Such a condition denotes that the corporation operates under conventional market financing terms and does not benefit from the subsidized capital. This occurs if the interest rate gap is non-negative (zero or positive).

The latent variable model underlying the probit specification is shown in Equation 2:

$$y_{it}^* = \mathbf{X}_{it}'\boldsymbol{\beta} + \alpha_i + \epsilon_{it} \tag{2}$$

Where:

y_{it}^* is an unobserved latent variable representing the underlying propensity of firm i to be a zombie at time t.

$\mathbf{X}_{it}$ is a vector of explanatory variables for firm i at time t, including financial ratios such as Asset Turnover, Asset Tangibility, Debt-to-Equity Ratio, Cash Flow Operating Ratio, and others as detailed in Table 1.

$\boldsymbol{\beta}$ is the vector of coefficients to be estimated.

α_i represents unobserved firm-specific effects.

ϵ_{it} is the error term, assumed to follow a standard normal distribution.

The dependent variable for the Probit model is constructed as in Equation 3:

$$y_{it} = \begin{cases} 1 & \text{if } x_{i,t} > 0 \text{ (the firm is not a zombie)} \\ 0 & \text{if } x_{i,t} \leq 0 \text{ (the firm is a zombie)} \end{cases} \tag{3}$$

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Identification of Financial Constraints and Estimation of Investment–Cash Flow Sensitivities

Despite the preponderant role of financial constraint identification strategies in estimating the impact on firms' real decisions, a consensus on the optimal approach remains elusive. Endogenous switching regression models have been used in an attempt to address static and dynamic misclassification problems. However, these models are sensitive in the selection of initial values for the financial constraint variable or the specification of outcome and selection equations.

Hadlock and Pierce (2010) proposed a parsimonious index of financial constraints that incorporates in taxonomy model firm size and age as explanatory variables. Their work critiqued extant index-based measures of financial constraints and asserted that the indices developed by Kaplan and Zingales (1997) and Whited and Wu (2006), along with their derivatives, failed to accurately predict financial constraint status when benchmarked against qualitative managerial statements. They advocated for the utilization of size and age as determinants of financial constraint.

Kaplan and Zingales (1997) advanced the field by estimating an ordered logit model to validate their classification scheme, which was predicated on qualitative statements from Chief Executive Officers. Their methodology employed a five-tier ordinal classification system, with the spectrum ranging from financially unconstrained firms at the lower bound to severely constrained entities at the upper bound.

The specification of their ordered logit model incorporated a comprehensive set of financial variables as regressors, including cash flow-to-capital ratios, Tobin's Q, leverage, dividend payout, dividend restrictions, unrestricted retained earnings, cash holdings, and unutilized lines of credit.

The results of their ordered logit estimation provided substantive quantitative support for their qualitative classification methodology. However, their findings are discordant when compared to the subsequent research of Hadlock and Pierce (2010).

Lamont et al. (2001) then linked these categories to accounting variables from Compustat, including cash flows, Q, leverage, dividends, and cash. Baker et al. (2003) proposed a modified KZ index, excluding Q to account for potential stock mispricing captured by Q. Despite this modification, Baker et al. (2003) demonstrated that coefficient estimates remained consistent with Lamont et al. (2001). Thus, unless otherwise specified, the modified version of the KZ index from Baker et al. (2003) is used. This index, as presented by Baker et al. (2003), is expressed as a linear equation using cash flow, leverage, dividends, and cash.

The equation for the KZ index, as presented by Baker et al. (2003), is expressed as follows in Equation 4:

$$KZ\ Index_{i,t} = -1.002 \times Cash\ flow_{i,t} + 3.139 \times Leverage_{i,t} \tag{4}$$

In this context, "Cash flow" denotes the combination of a firm's operating income and depreciation, divided by the firm's total assets at the beginning of the year. "Leverage" is calculated by dividing the firm's total debt by its total assets from the previous year. "Dividends" refer to the total dividends paid out by the firm. Finally, "Cash" represents the sum of a firm's total cash holdings and marketable securities, both scaled by the firm's total assets at the beginning of the

year.

Whited and Wu (2006) used a structural investment model to construct a financial constraints index. Specifically, they employ a generalized method of moments estimation of an investment Euler equation. Their proposed index comprises a linear combination of six factors as shown in Equation 5:

$$
\begin{aligned}
W_W\ Index_{i,t} = & -0.091 \times Cash\ flow_{i,t}\ -\ 0.062 \times Dividend\ Dummy_{i,t} \\
& +\ 0.021 \times Leverage_{i,t}\ -\ 0.044 \times Size_{i,t}
\end{aligned}
\tag{5}
$$

Cash flow reflects the operating income and depreciation relative to the firm's total assets at the beginning of the year. The Dividend Dummy variable is a binary indicator that takes the value of one if the firm pays cash dividends and zero otherwise. Leverage represents long-term debt divided by total assets, while Size is measured as the natural logarithm of total assets. ISG denotes the three-digit industry's sales growth, and SG represents the firm's sales growth. The original variable definitions from Whited and Wu (2006) are employed to calculate the WW index.

Hadlock and Pierce (2010), to evaluate corporate financial conditions and constructed the SA index. They collected qualitative information from financial reports for a randomly selected sample of listed U.S. firms and classified each firm-year into one of five categories of financial constraints, consistent with the methodology of Kaplan and Zingales (1997). Their analysis showed that firm size and age constitute strong predictors of financial constraints. The SA index, is calculated using the formula in Equation 6:

$$
SA\ Index_{i,t} = -0.737 \times Size_{i,t} + 0.043 \times Size_{i,t}^2 - 0.040 \times Age_{i,t}
\tag{6}
$$

In this specification, $Size_{i,t}$ corresponds to the logarithm of total assets of firm i in year t. The negative coefficient assigns lower constraint scores to entities with larger balance sheet magnitudes, while the positive quadratic term introduces curvature that attenuates the effect of size beyond certain thresholds and captures the diminishing marginal informational content of scale. $Age_{i,t}$ denotes the elapsed years since incorporation, where the negative sign embeds the empirical regularity that firms with longer survival histories secure more favorable access to credit markets due to established reputation and verified solvency paths.

The coefficient estimates originate from regressions calibrated on U.S. corporate data, intended to synthesize parsimonious predictors into a scalar proxy for credit market tightness. Unlike indices constructed from cash flow sensitivities or investment regressions, the SA index extracts structural attributes—organizational scale and antiquity—that are less volatile across the business cycle and offer a more stable yardstick of financing capacity.

Whited and Wu (2006) have raised pertinent concerns regarding the temporal and cross-sectional stability of parameters in financial constraint models. Notwithstanding these caveats, adherence to extant literature is recommended when constructing financial constraint indices. It is noteworthy that for all three indices under consideration, a higher numerical value is indicative of elevated financial constraints. In order to classify firms as financially constrained or unconstrained the following heuristic is employed: entities are designated as financially constrained if their index

value falls within the upper quintile of the annual index distribution, while those in the lower four quintiles are categorized as unconstrained.

Investment-cash flow sensitivities

To empirically validate the hypothesis that certain firms are financially constrained financial a model for investment-cash flow sensitivities for show first unknown zombie firms that report negative and positive cash flows utilizing the econometric specification proposed by Schauer et al. (2019), shown in Equation 7:

$$Investment_{i,t} = \beta_1 CashFlows_{i,t} + \beta_2 Q_{i,t-1} + \beta_3 FinZom_{i,t} + \gamma\, CashFlows_{i,t} \times FinZom_{i,t} + \delta_i + \vartheta_t + \varepsilon_{i,t} \tag{7}$$

Where $i \in \{1, \ldots, N\}$ denotes individual firms and $t \in \{1, \ldots, T\}$ represents time periods. The dependent variable, $Investment$, is operationalized as the change in tangible assets plus depreciation, normalized by lagged total assets. $CashFlows$ is defined as the ratio of operating cash flows to lagged total assets. Given the focus on privately held firms, Tobin's Q is proxied with industry-specific sales growth. $FinZom$ is a binary variable, equal to one for firms classified as "zombies" based on their reported financial status, and zero otherwise.

The interaction term $CashFlows \times FinZom$ test for heterogeneous sensitivities across subgroups. To mitigate omitted variable bias, firm-specific fixed effects (δ_i) and time fixed effects ((g_t)) are incorporated. The idiosyncratic error term is denoted by $\varepsilon_{i,t}$. In accordance with the recommendations of Petersen's (2009), firm-clustered standard errors robust to heteroskedasticity are employed.

A Flow of Funds Framework for the Corporate Cash Flow Identity

An additional model constructed in this section is a flow of funds framework that captures the cash flow identity of a firm. It essentially shows how a firm finances its activities (dividends, investments, and changes in working capital) through cash flows, debt issuance, and equity issuance.

It is possible to use flow of funds data to provide a partially aggregated form of the accounting cash flow identity as in Equation 8:

$$DEF_t = DIV_t + I_t + \Delta W_t - C_t = \Delta D_t + \Delta E_t. \tag{8}$$

Where:

- DIV_t: cash dividends in year t;

- I_t: net investment in year t (i.e., capital expenditures + increase in investments + acquisitions + other use of funds − sale of PPE or investment);

- ΔW_t: change in working capital in year t (i.e., change in operating working capital + change in cash and cash equivalents + change in current debt);

- C_t: cash flow after interest and taxes (i.e., income before extraordinary items + depreciation and amortization + extraordinary items and discontinued operations + deferred taxes + equity in net loss-earnings + other funds from operations + gain (loss) from sales of PPE and other investments);

- R_t: current portion of the long-term debt in year t;

- ΔD_t: net debt issued in year t (i.e., long-term debt issuance – long-term debt reduction);

- ΔE_t: net equity issued in year t (i.e., sale of common stock – stock repurchases).

The left side of the equation represents the firm's uses of funds, which include cash dividends paid to shareholders, net investment in capital expenditures, acquisitions, and other investments, as well as changes in working capital to address operating liquidity needs. This side also subtracts the firm's internal source of funds, which is the cash flow generated from operations after accounting for interest and taxes. Essentially, this captures how much the firm spends on dividends, investments, and working capital, minus the cash it generates internally.

On the right side of the equation, the model represents the external sources of funds that the firm relies on to cover its financial needs. This includes net debt issued, which is the difference between new debt taken on and debt repayments, as well as net equity issued, which is the difference between new equity raised and stock repurchases. These external sources of financing are what the firm turns to when its internal cash flow is insufficient to cover its spending.

The equation essentially states that the financial deficit—the gap between the firm's spending and its internal cash flow—must be financed through external means, either by issuing debt or equity. A positive financial deficit quantifies a capital shortfall; the corporation rectifies this shortfall by securing external financing. A negative deficit, conversely, constitutes a capital surplus that the corporation can deploy for debt amortization or equity repurchases. In contrast to the accounting definition, the current portion of long-term debt is considered part of the financing deficit beyond its role in the change in working capital. Following this argument, the relevant flow of funds deficit is defined as in Equation 9:

$$DEF_t^{SSM} = DIV_t + I_t + \Delta W_t + R_t - C_t + \varepsilon_{it}. \tag{9}$$

Cash flow sensitivity of cash

Due to emerging criticism regarding the ability of the Investment-cash flow sensitivities to accurately capture financial constraints on both empirical and theoretical grounds, Almeida et al. (2004) proposed cash flow sensitivity of cash as an alternative measure for this purpose. This new measure predicts the change in cash and marketable securities based on the amount of cash flow generated by firms. According to their findings, there should be a strong positive relationship between cash flow and changes in cash holdings for financially constrained (FC) firms. As these firms cannot easily rely on external financing, they tend to hoard cash to capitalize on positive investment opportunities. In contrast, unconstrained firms should not exhibit such a relationship.

In light of the methodological limitations inherent to models that gauge investment-cash flow sensitivities, the scholarly work of Almeida et al. (2004) did advance an alternative metric: the cash flow sensitivity of cash. This methodological approach did establish a framework to measure financial constraints through the examination of cash retention patterns. The theoretical underpinning of this approach rests upon a fundamental distinction in corporate behavior. Firms that face financial constraints do allocate cash flows to cash reserves, thus creating a direct relationship between cash generation and cash accumulation. This behavior stands in stark contrast to unconstrained firms, which do not exhibit such a systematic relationship.

Equation 10 presents the empirical specification used to test this proposition by quantifying the determinants of corporate cash holdings. The model's structure adapts the specification from Almeida et al. (2004) and incorporates covariates representing the various claims on corporate financial resources. This construction isolates the cash flow sensitivity effect from other operational and financial demands facing the corporations:

$$\Delta Cash\ holdings_{i,t} = \beta_0 + \beta_1 \cdot Cash\ flow_{i,t} + \beta_2 \cdot Sales\ growth_{i,t} + \beta_3 \cdot Size_{i,t}$$
$$+ \beta_4 \cdot \Delta INV_{i,t} + \beta_5 \cdot Debt\ maturity_{i,t} + \beta_6 \cdot \Delta Net\ assets_{i,t} + f_i + t + v_{i,t}$$

$$(10)$$

$\Delta Cash\ holdings_{i,t}$ = this term quantifies the variation in a firm's cash and marketable securities during period t, scaled by total assets. A positive value denotes an accumulation of cash reserves, while a negative value denotes a depletion. The model's objective is to explain this variation.

$\beta_1 \cdot Cash\ flow_{i,t}$: this term comprises the firm's operating cash flow, measured as operating income plus depreciation and amortization. The coefficient β_1 measures the cash flow sensitivity of cash; it quantifies the portion of each dollar of cash flow that a firm retains. A positive β_1 value characterizes a financially constrained firm that accumulates cash because it lacks ready access to external capital markets. Unconstrained firms should show a low or statistically indistinguishable β_1.

$\beta_2 \cdot Sales\ growth_{i,t}$: this term is the year-over-year percentage change in the firm's sales. It functions as a proxy for the firm's investment and growth opportunities. A firm with more attractive growth prospects retains more cash to finance future projects. A positive coefficient is the anticipated outcome, particularly for constrained firms.

$\beta_3 \cdot Size_{i,t}$: this term is the natural logarithm of the firm's total assets. It controls for the firm's scale. A larger firm operates with more diversification and better access to credit, allowing it to function with proportionally smaller cash balances. A negative coefficient is the standard expectation.

$\beta_4 \cdot \Delta INV_{i,t}$: this term measures the change in a firm's inventory levels, scaled by assets. It acts as a proxy for investment in working capital. An expansion of inventory consumes cash. The analysis expects a negative coefficient, as cash committed to inventory is unavailable for reserves.

$\beta_5 \cdot Debt\ maturity_{i,t}$: this term quantifies the average maturity of a firm's debt obligations. A longer maturity profile means less immediate pressure for debt repayment, which would imply

a negative coefficient. Conversely, for a risky firm, a longer maturity could motivate cash accumulation as a long-term buffer, which would imply a positive coefficient.

$\beta_6 \cdot \Delta Net\ assets_{i,t}$: this term measures the variations in net fixed assets, such as property, plant, and equipment, scaled by total assets. It is a direct proxy for capital expenditures (CAPEX). A firm's acquisition of fixed assets constitutes a primary use of cash. The analysis anticipates a negative coefficient.

Firm-fixed effects account for stable, unobserved attributes of each firm, such as its operational efficiency. The term t represents time-fixed effects, which account for macroeconomic conditions affecting all firms in a given year, such as changes in the business cycle. The idiosyncratic error is included and comprises all other unobserved factors that affect a firm's cash holdings.

3.   Results

Table 2 provides a comparative financial analysis of zombie and non-zombie across multiple metrics. Non zombie firms report a more favorable asset turnover relative to their non-viable counterparts. Capital expenditure allocation remains commensurate between the two categories.

The financial architecture of underperforming diverges from that of viable enterprises, with evident differences in operational efficiency, capital composition, and liquidity management. The asset turnover ratio is demonstrably low for zombie firms, which denotes an inefficient utilization of assets to generate revenue. Leverage dominates their capital structure, with debt obligations that outweigh equity by a considerable margin.

Capital allocation for investment purposes, as a proportion of total assets, is equivalent between the two groups. However, the asset composition of viable corporation's weights tangible fixed assets more heavily, a condition that fortifies their collateral capacity and facilitates access to a broader set of financing instruments. Operating cash flow generation is more robust within the viable cohort, while non-viable corporations' function under binding financial constraints and with restricted flexibility in managing their obligations.

Indebtedness levels diverge markedly between the two cohorts, with non-viable corporations depending more acutely on external financing. This disparity is quantified by the interest coverage ratio; viable corporations generate operating income that more than covers their interest expense, whereas the ratio for non-viable corporations is below one, a testament of their inability to service interest payments from operating income alone. In contrast, short-term liquidity metrics, including the current and acid-test ratios, are identical across both classifications.

Table 2

Descriptive Analysis of Financial Characteristics in Zombie and Non-Zombie Firms

Zombie firms				
Variable	**Mean**	**Median**	**SD**	**Range**
Asset Turnover	0.314	0.390	0.104	0.513
CAPEX to Assets	0.032	0.031	0.018	0.047
Asset Tangibility	0.228	0.167	0.142	0.461
Cash Flow Operating Ratio	0.294	0.285	0.113	0.382
Debt to Equity Ratio	2.323	2.689	0.523	0.774
Operating Income to Interest Expense Ratio	0.986	1.011	0.711	0.942
Current Ratio	1.013	1.411	0.198	0.576
Acid Test Ratio	0.821	0.810	0.159	0.408
Non-Zombie firms				
Variable	**Mean**	**Median**	**SD**	**Range**
Asset Turnover	0.593	0.690	0.104	0.513
CAPEX to Assets	0.032	0.031	0.018	0.047
Asset Tangibility	0.528	0.532	0.142	0.461
Cash Flow Operating Ratio	0.495	0.485	0.113	0.382
Debt to Equity Ratio	1.323	1.489	0.523	0.774
Operating Income to Interest Expense Ratio	1.286	1.407	0.711	0.942
Current Ratio	1.211	1.411	0.198	0.576
Acid Test Ratio	0.821	0.810	0.159	0.408

The probit regression estimations from the PPA model, detailed in Table 3, quantify the determinants of a corporation's classification as zombie, a binary outcome formally specified by the model in Equation 2.

The coefficients for *Asset Tangibility* (-0.628) and the *Cash Flow Operating Ratio* (-0.745) are both negative and significant. The negative coefficient for asset tangibility confirms that a greater proportion of physical assets in a corporation's asset base attenuates the probability of financial non-viability. This relationship is a direct function of collateral capacity; tangible assets provide lenders with superior security, which facilitates access to credit markets and lowers the cost of capital, thereby insulating the corporation from the funding constraints that define underperforming entities. Similarly, the negative coefficient for the operating cash flow ratio quantifies the inverse relationship between operational self-sufficiency and financial distress. A robust ratio denotes a corporation's capacity to generate adequate internal capital to service its obligations, a condition that obviates the need for continuous costly external financing, which is the hallmark of an underperforming firm.

Conversely, the Debt-to-Equity Ratio yields a positive coefficient of 1.957 with robust statistical power ($p < 0.001$). This confirms that amplified financial leverage is a primary driver of non-viability classification. A capital structure heavily weighted toward debt imposes a prohibitive

fixed-cost burden, magnifies cash flow volatility, and elevates solvency risk, directly corresponding to the defining characteristics of a zombie firm. In contrast, several other financial metrics lack statistical power within this specification. The coefficients for *Asset Turnover*, *CAPEX to Assets*, *Interest Expense Ratio*, *Current Ratio*, and *Acid Test Ratio* are all statistically indistinguishable from zero at 95 % confidence. The absence of explanatory power for short-term liquidity metrics confirms that non-viability is a structural condition of chronic insolvency, a state not adequately quantified by a corporation's immediate capacity to service current liabilities.

The model as a whole is statistically valid, as confirmed by a chi-square statistic whose associated p-value is below 0.001. This test rejects the null hypothesis that all regressor coefficients are jointly equal to zero, confirming that the model has explanatory power.

Table 3

PPA Probit regression model

Dependent	Coefficient	Std. Error	t-value	p-value	[95 % Conf. Interval]	Sig
Asset Turnover	-1.271	0.721	-1.762	0.078	-2.684 , -0.142	*
CAPEX to Assets	-0.873	0.578	-1.511	0.137	-2.020 , 0.274	
Asset Tangibility	-0.628	0.182	-3.460	0.001	-0.984 , -0.272	***
Cash Flow Operating Ratio	-0.745	0.225	-3.310	<0.001	-1.185 , -0.304	***
Debt to Equity Ratio	1.957	0.319	6.137	<0.001	1.331 , 2.583	***
Interest Coverage Ratio	0.366	0.251	1.459	0.145	-0.070 , 0.190	
Current Ratio	-0.023	0.055	-0.207	0.789	-0.189 , 0.144	
Acid Test Ratio	-0.077	0.092	-0.840	0.404	-0.257 , 0.104	
Constant	16.663	3.246	5.130	<0.001	10.301 , 23.025	***
Chi-square	37.400					
Prob >chi2		<0.001	Akaike crit. (AIC)		188.535	

Note: *p<0.1; **p<0.05; ***p<0.01

This empirical study employs a pooled logit model to estimate the financial constraint indices specified in Equations 4, 5, and 6. The analysis evaluates the Kaplan-Zingales (KZ), Size-Age (SA), and Whited-Wu (WW) indices, with model results compiled in Table 4.

The estimation of the KZ index model produces a robust negative coefficient for cash flow (-3.927), which corresponds to a diminished probability of a corporation's classification as zombie. Conversely, the debt variable is a meaningful predictor. The coefficients for dividends, cash holdings, and total assets lack statistical power to influence the outcome in this model specification. The SA index model reports a robust negative coefficient for corporate size (-2.116), a finding consistent with corporate finance theory where scale acts as a buffer against financial distress. The coefficient for corporate age, while negative, is statistically indistinguishable from zero.

The WW index estimation yields a statistically significant negative coefficient for cash flow (-4.314) and a robust positive coefficient for leverage (0.766). This latter value quantifies the direct association between the corporate debt burden and the probability of financial non-viability. The coefficients for size (1.404), dividend payment status (DIVPOS), and industry sales growth (ISG) do not possess statistical importance. This pattern corroborates the premise that capital structure and operating cash flows supersede dividend policy and market growth metrics as predictors of

corporate distress within this model. A comparison of model fit statistics, using deviance, AIC, and BIC values, identifies the WW index as having the most favorable specification. The KZ index follows, while the SA index reports the least effective model fit.

Table 4

Pooled Logit Model Estimates of Financial Constraint Indices and Zombie Firm Classification

Term	KZ	SA	WW
Cash flow	-3.927* (0.500)		-4.314* (0.550)
Total assets	0.461 (0.283)		
Debt	2.492* (0.428)		
Dividends	-0.423 (0.274)		
Cash holdings	-0.871 (0.178)		
Size		-2.116* (0.337)	1.404 (0.953)
Age		-0.030 (0.032)	
Leverage			0.766* (0.189)
DIVPOS			0.156 (0.351)
ISC			-0.099 (0.345)
Deviance	390.24	391.62	385.84
AIC	404.24	405.62	399.84
BIC	443.45	444.83	439.05

*Significant at the 95 % level.

The standard errors are in parentheses next to the coefficients.

Figure 1 contains three images that present Receiver Operating Characteristic (ROC) curves for three different indices used to classify zombie firms: KZ, WW, and SA. Each graph shows the ROC curve for one index, plotting the True Positive Rate against the False Positive Rate. The Area Under the Curve (AUC) is provided for each index, which is a measure of the model's performance.

The WW index reports the highest performance among the three indices with an AUC of 0.64 and shows an initial ascent that reflects robust performance at lower thresholds, and it maintains a consistent slope thereafter. A relatively stable discriminatory capacity across various threshold settings positions the WW index as the most reliable measure among the three for identifying financially constrained firms.

In contrast, the KZ index displays notably weaker performance, with an AUC of 0.48. This value, approximating 0.5, implies that the KZ index performs only marginally better than random chance in differentiating between constrained and unconstrained firms. The near-linear trajectory of its ROC curve signals its limited discriminatory capability across all thresholds and raises substantive concerns about its efficacy as a proper measure of financial constraints.

With an AUC of 0.54, the SA index holds an intermediate position; the subtle convexity of its ROC curve denotes modest classificatory power, albeit a performance subordinate to that of the WW index.

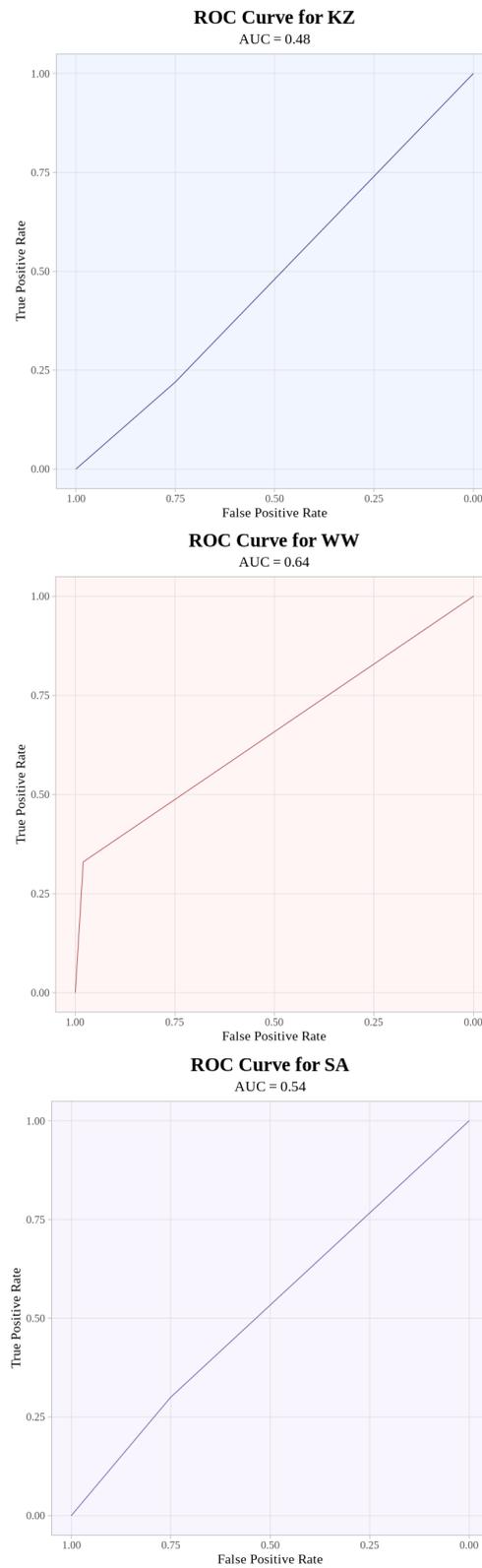**Figure 1.** ROC Curves for Financial Constraints Indices (KZ, WW, SA)

Table 5 estimates the model specified in Equation 7 and presents the relationship between cash flows, zombie status, and investment decisions for firms with negative (CF $<$0) and positive

(CF >0) cash flows. Zombie firms with negative cash flows, the -0.253 coefficient (p <0.10) report a direct relationship between cash flow deterioration and investment reduction. It is observed a dependence of distressed firms on internal capital resources. When such resources are scarce, their capacity to invest is severely curtailed because financially constrained firms are unable to offset internal cash flow deficits with external financing.

For corporations with operating cash flow deficits, the primary cash flow variable itself is not determinant. Instead, the corporation's classification as non-viable and the corresponding interaction term operate as the principal drivers of investment policy. This outcome confirms that for these financially distressed entities, marginal deteriorations in their already-negative cash flow do not systematically affect capital allocation. The corporation's classification as non-viable and the corresponding interaction term operate as the principal determinants of investment policy. The coefficient for non-viable corporate status (Finzomb) is statistically significant at the 10 % level. This result means that the non-viable classification is associated with a contraction in capital expenditures. Even when government subsidies or creditor forbearance sustain their operations, their distressed status directly curtails investment.

The investment opportunity coefficient is statistically null for the same cohort. This outcome confirms that non-viable firms with deficient cash flows do not adjust their capital budgeting to capitalize on favorable market developments, such as industry-wide sales growth. This static investment posture affirms the thesis that these firms function with capital impediments; their inability to tap market expansion is explained by inadequate internal capital generation and the reluctance of capital providers to extend credit. The interaction between cash flow and non-viable status is significant at the 5 % level. This finding measures the amplified negative impact of cash flow shortfalls on the capital investment of non-viable firms. For every unit of negative cash flow from operations (CFO), these firms steeply contract their capital investment.

For solvent corporations reporting positive cash flow, the cash flow coefficient is significant at the 5 % level. These corporations direct more funds to capital projects for each marginal unit of positive operating cash flow. This outcome is characteristic of financially sound corporations that prioritize internal capital and deploy these resources to exploit sectoral expansion. The positive statistical relationship confirms that solvent corporations readily recalibrate their investment budgets following improvements in their liquidity position. The designation as zombie or non-zombie does not directly alter capital allocation for corporations with positive cash flow, as they do not operate under the financial duress that would otherwise constrain capital deployment.

The investment opportunity is also statistically valid for solvent corporations. This finding conveys that these entities expand their capital outlays in reaction to attractive external conditions, such as industry revenue growth. Their responsiveness to positive market dynamics is a direct function of their financial flexibility to underwrite growth initiatives. Finally, the interaction term is inconsequential for this group. For solvent firms with positive cash flows, the interaction of cash flow and the non-viable classification does not meaningfully sway their investment choices. As financially robust entities, this interaction is not a binding constraint, as their overall financial health provides them access to multiple capital sources.

The model's diagnostic statistics reveal an important asymmetry in explanatory power. The

F-statistic for the CF<0 group confirms the model's overall statistical validity in explaining investment for non-viable corporations. Conversely, the F-statistic for the CF>0 group (1.160) fails to establish the model's overall statistical explanatory power. This outcome conveys that while certain variables like cash flow are individually important, the model as a whole is an incomplete specification for solvent corporations. Their investment decisions likely depend on a wider set of strategic factors not captured by this distress-focused model.

Table 5

Impact of Cash Flows and Zombie Status on Investment Decisions

Term	CF <0	CF >0
Cash Flows	-0.253 (0.059)	0.308** (0.072)
Finzomb	-0.249* (0.127)	0.007 (0.015)
Invest opport-1	-0.016 (0.013)	0.258** (0.047)
Cash Flows * Finzomb	-0.351** (0.111)	-0.172 (0.133)
Adjusted R2	0.321	0.298
F Statistic	2.426** (df=4)	1.160 (df=4)

Note: $p < 0.1$; $p < 0.05$; $p < 0.01$. The standard errors are in parentheses next to the coefficients.

Table 6 contains the regression results for the flow of funds analysis of financially sound, non-zombie firms specified in Equation 9. Both Table 6 and Table 7 are used to estimate the same model, but they apply it to different groups of firms for comparison.

In healthy, non-zombie companies, dividend policy is often stable and predictable, driven by long-term payout ratios and shareholder expectations rather than short-term fluctuations. While dividend disbursements constitute a capital outflow and contribute to the deficit definitionally, the statistical model fails to demonstrate statistical relationship with independent variables in the examination of financially sound enterprises. Hence, is observed statistical insignificance.

The capital expenditure determinations of non-zombie firms rest upon a constellation of market factors, including but not limited to: expansion prospects, prevailing market conditions, tactical corporate directives, long-term capital budgeting. Though net investment stands as a primary component in deficit computations, the regression analysis fails to establish robust correlations with auxiliary variables across a broad sample of financially sound corporations.

Variations in working capital among solvent enterprises reflect generally well-managed operations and foreseeable commercial cycles. The fluctuations in working capital, though intrinsic to deficit calculations, is relatively stable and driven by routine operational adjustments among non-distressed firms. The methodical administration of working capital within sound enterprises renders these variations peripheral to the financial deficit in this elementary analytical framework.

The current portion of long-term obligations among solvent firms constitutes a predetermined and manageable financial commitment. Debt repayment is a routine part of their financial planning. The variation in debt service among sound enterprises is stable and predictable, governed by predetermined amortization schedules rather than transient market phenomena captured by the present model. Sound enterprises exercise proactive debt administration protocols.

While theoretically cash flow and deficit are inversely related, for healthy, non-zombie firms, cash flow after interest and taxes is usually robust and positive. Cash flow variations among such firms fall within acceptable parameters, addressed through conventional financing mechanisms. In this case, negative cash flow might not be a dominant or statistically significant predictor of the deficit, because healthy firms have adequate internal capital generation capacity.

Table 6

Corporate Flow of Funds Model for non-zombie firms

Variable	Estimate	Std. Error	Lower CI (95%)	Upper CI (95%)	T-value	P-value
Dividends	-0.102	0.329	-0.747	0.543	-0.310	0.757
Net Investment	0.503	0.310	-0.104	1.11	1.62	0.104
Change in Working Capital	-0.021	0.313	-0.635	0.593	-0.0671	0.947
Current Portion of Long-Term Debt	0.126	0.320	-0.501	0.753	0.394	0.694
Negative Cash Flow	0.022	0.297	-0.560	0.604	0.0741	0.941

Table 7 presents regression estimates and assesses the relationship between financial variables and zombie firms.

Zombie companies allocate available capital toward debt service obligations and basic operational continuity and render dividend disbursements superfluous to their financial strategy. The statistical irrelevance of dividends for Zombie firms derives from a fundamental premise. It is possible that these enterprises suspend dividend payments as a matter of necessity. The preservation of cash reserves takes precedence over shareholder distributions.

Structural imperfections within capital markets dictate the cash accumulation policies of non-viable corporations. The rationale for such behavior derives from market frictions and incompleteness. These firms operate under severe constraints in their access to external financing under normal conditions, which compels them to accumulate and retain cash from operational activities.

These entities undertake dramatic reductions in capital expenditure, with investment decisions governed predominantly by immediate survival considerations rather than strategic expansion objectives. The conventional relationship between investment activity and fiscal deficit becomes notably unstable in this context of financial distress.

Such firms pursue tactical rather than strategic investment policies, with decisions predicated upon immediate survival imperatives rather than long-term expansion objectives. Net investment loses its power to systematically explain the deficit in this context.

For zombie firms, volatility in net working capital (NWC) operates as a primary determinant of their financing shortfall. These entities often operate with operational inefficiencies and confront acute liquidity constraints. Unforeseen shifts in inventory levels, protracted collection cycles for receivables, or impediments in accounts payable management directly impair their constrained liquidity profiles and exacerbate the financing gap.

Although debt service obligations represent a fundamental component of their capital structure, the variable lacks statistical predictive power in forecasting the deficit. The chronic character

of these fixed obligations for zombie firms produces this anomalous outcome. The absolute value of this liability remains consistently material, but its period-over-period volatility does not principally explain movements in the financing deficit.

As hypothesized, negative cash flow from operations (CFO) possesses strong, positive explanatory power for the financing deficit of non-viable corporations. A structural inability to generate sufficient operating cash flow defines these corporations. Their failure to produce adequate internal capital forms the basis of their financial non-viability and any deterioration in cash flow from operations corresponds directly to a widening financing gap. This metric quantifies the central financial fragility of these corporations.

Table 7

Corporate Flow of Funds Model for zombie firms

Variable	Estimate	Std. Error	Lower CI (95 %)	Upper CI (95 %)	T-value	P-value
Dividends	0.157	0.307	-0.445	0.759	0.511	0.609
Net Investment	-0.203	0.335	-0.859	0.453	-0.606	0.545
Change in Working Capital	0.701	0.0306	0.641	0.761	22.9	0.000
Current Portion of Long-Term Debt	0.258	0.302	-0.334	0.850	0.854	0.393
Negative Cash Flow	-0.853	0.0153	-0.883	-0.823	-55.8	0.000

The cash flow sensitivity of cash model, specified in Equation 10, is estimated for zombie firms in Table 8. The statistically significant and positive coefficient for the "Cash Flow Proxy" is the linchpin of the model's interpretation. From an econometric standpoint, this result rejects the null hypothesis of no relationship between cash flow and cash holdings for these firms. Financially, this outcome corroborates the cash flow sensitivity hypothesis as a measure of financial constraints. The determinant positive coefficient establishes that internal cash flow operates not merely as a source of funds but as a binding constraint on liquidity policy, consistent with a precautionary motive for holding cash driven by financial distress.

The negative coefficient for the variation in net fixed assets is also a meaningful predictor, confirming the model effectively controls for investment as a competing use of cash. This inverse relationship between capital expenditures and cash reserves aligns with neoclassical investment theory and the trade-off theory of liquidity. Non-zombie firms appear to utilize their cash balances to underwrite capital investments and an economically meaningful substitution effect between liquid assets and capital formation is observed.

The debt maturity coefficient is positive. This counterintuitive finding points to a long-term precautionary motive specific to underperforming firms. From a financial risk management perspective, these entities, defined by persistent low profitability, adopt conservative liquidity management. The positive coefficient means firms with longer-dated debt paradoxically accumulate more cash, operating this as a strategic buffer against future economic shocks that would jeopardize their solvency. Corporate size is not a statistically discernible determinant of cash holdings for this cohort of non-zombie firms. Within this sample, any benefits from economies of scale in cash management do not manifest as a dominant factor. The operational inefficiencies and

financial vulnerabilities endemic to these corporations apparently overshadow any scale-based advantages in treasury management.

The lack of relevance for the sales growth variable is also informative. The data show that for non-viable corporations, past revenue expansion is not a reliable proxy for future investment opportunities that would command cash accumulation. Their investment decisions are governed more by immediate survival needs than by growth prospects. Likewise, variations in inventory levels do not systematically correspond to changes in cash holdings for non-viable corporations. Other working capital components or operational factors are more central to their short-term liquidity fluctuations.

Table 8

Cash Flow Sensitivity of Cash for zombie firms

Variable	Estimate	Std. Error	Inferior 95%	Superior 95%	T-value	P-value
Size	0.003	0.022	-0.040	0.046	0.136	0.8920
Sales growth	-0.078	1.800	-3.606	3.450	-0.043	0.9657
Cash flow	0.797	0.037	0.724	0.870	21.541	< 0.001
Alav.	-0.595	0.389	-1.357	0.167	-1.530	0.1260
Debt maturity	0.245	0.077	0.094	0.396	3.182	0.0015
Net assets	-1.560	0.553	-2.644	-0.476	-2.821	0.0048

According to Table 9, corporate scale is the dominant determinant of cash reserves in non-zombie firms, confirming a statistically robust inverse relationship between firm size and the cash-to-assets ratio. The primary rationale emanates from economies of scale in liquidity management. Larger corporations, by virtue of their operational breadth and diversification across products, markets, and cash flow streams, exhibit lower cash flow volatility relative to their smaller counterparts. This intrinsic stability diminishes their exposure to unexpected liquidity shortfalls, which reduces the marginal benefit of holding precautionary cash reserves. Their superior access to external capital, including committed lines of credit, functions as a direct substitute for holding large internal cash balances. Instead of maintaining costly, low-yielding cash reserves, these corporations can rely on their capacity to raise funds on demand to meet financing needs or capitalize on investment opportunities.

In contrast, the coefficient for operating cash flow is statistically indistinguishable from zero. This result contradicts the pecking order theory's premise that corporations use internal capital generation to build liquidity buffers. Most other control variables, including sales growth, debt maturity, and net asset changes, lack explanatory power. An exception is the change in inventory, which has a negative coefficient statistically significant at the 10% level. This body of evidence confirms that for viable corporations, cash management policy is predominantly a function of corporate scale, while other structural variables, including operating cash flow, do not systematically govern liquidity levels. The remaining controls, including sales growth, inventory fluctuations, debt maturity, and net asset changes, yield inconclusive outcomes aside from an inventory coefficient that reflects a marginal negative association. Findings convey that, among non-zombie firms, other structural determinants than firm size do not exercise primary influence over cash management policies, whereas the direct association between operating cash flow and

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liquidity reserves remains unmaterialized.

Table 9

Cash Flow Sensitivity of Cash for non-zombie firms

Variable	Estimate	Std. Error	Inferior 95 %	Superior 95 %	T-value	P-value
Size	-0.964	0.076	-1.110	-0.815	-12.684	< 0.001
Sales growth	0.466	0.954	-1.404	2.336	0.488	0.6258
Cash flow	0.107	0.072	-0.034	0.248	1.486	0.1374
Alav.	-0.073	0.044	-0.159	0.013	-1.659	0.0971
Debt maturity	-0.011	0.009	-0.029	0.007	-1.222	0.2218
Net assets	0.489	0.973	-1.418	2.396	0.503	0.6149

DISCUSSION

The paramount identifier of zombie firms is in their inability to service their outstanding debts, most notably in the matter of coupon payments (Binh et al., 2020). In virtue of the deficiency of comprehensive empirical data, various scholars have advanced methodologies, such as a firm's inability to honor current liabilities, for the identification of such enterprises by examining their capacity to honor immediate financial commitments, found in financial statements or balance sheets.

The impediments to proper capitalization in these circumstances emanate from friction in the mechanisms of capital allocation, wherein the information asymmetries between the providers of capital and the commercial entities constitutes the primary wellspring of dysfunction. These frictions in the supply of capital diminish the elasticity of external capital provision and amplify the disparity between internal and external costs of procurement of funds.

In imperfect financial markets, instantaneous cash flow of an enterprise at any given moment comprises three distinct elements: the function of short-run profit realization, the function of adjustment expenditure, and the net balance of financial decisions. The fixed cost of adjustment establishes a critical threshold for increment in marginal profitability, beneath which adjustment is suboptimal. Due to the convexity of the variable expenditure function, any negative investment causes that total costs surpass the baseline cost. Given the positive marginal product of capital, the firm shall not undertake negative investment, thus establishing a domain of stasis in investment policy (Farre-Mensa and Ljungqvist, 2016).

Constrained firms have inelastic capital supply and limited credit market access. A firm's capital supply curve shows the price for an incremental capital unit. The elasticity of this curve determines financial constraints. An economic entity is financially constrained when facing an inelastic capital supply function, where cost of capital variations causes disproportionate capital demand fluctuations. This is compatible with Kaplan and Zingales (1997)'s postulation that firms, except those excluded from the capital market, face binding financial constraints. However, the latent nature of a firm's capital supply function obstructs direct empirical quantification of financial constraints. Literature attempts to infer capital supply curve elasticity indirectly as direct measurement is impracticable. Surrogate measures like multifactor indices (e.g., KZ index, HP index) or discrete corporate actions (e.g., dividend policies, credit ratings) are used. These

proxies assume managers' actions reflect their perception of the firm's capital supply curve (Farre-Mensa and Ljungqvist, 2016).

The first category comprises quantitative indices, exemplified by the Kaplan-Zingales (KZ) index and the Hadlock-Pierce (HP) index. These instruments combine multiple financial metrics to produce a composite measure of constraint. The KZ index incorporates variables such as cash flow, market value, and leverage ratios. The HP index focuses on firm size and age as fundamental determinants of financial constraint. The second category examines specific corporate decisions as indicators of constraint. This approach scrutinizes dividend distribution policies and credit ratings (Farre-Mensa and Ljungqvist, 2016).

The empirical evidence, when these measures prove valid, shows that firms under financial constraint conduct their affairs in a manner consonant with an inelastic capital supply. The investment–cash flow sensitivity bears testament to their reliance upon internally generated resources. In contrast, unconstrained firms adhere to the principles set forth in the Modigliani–Miller theorem, wherein investment decisions flow from opportunities that present positive net present value, irrespective of internal capital reserves.

The most telling distinction between no-zombie and zombie firms, however, surfaces in the role of operating cash flow. An analysis of the financing deficit for zombie firms confirms that negative cash flow from operations possesses strong, positive explanatory power for their financing gap. A structural inability to generate sufficient operating cash flow defines these corporations. Any deterioration in their operational cash generation corresponds directly to a wider financing deficit. This metric quantifies the central financial fragility of these corporations. For healthy, non-zombie firms, the same analysis finds that negative cash flow is not a dominant or statistically determinant predictor of their financing deficit. This is because sound enterprises maintain adequate internal capital generation capacity, allowing them to absorb routine cash flow variations through conventional financing mechanisms. This asymmetry confirms that while both types of firms face financial obligations, only for zombies does a deficit in operational cash flow constitute the very foundation of their financial non-viability.

Non-zombie firms are endowed with a more substantial reservoir of internal resources. This stands in stark contrast to the behavior of their less-endowed counterparts, for whom the revenue effect assumes primacy. Firms burdened with an onerous debt-to-equity ratio find themselves in a precarious position, with their financial stability teetering on the unpredictable fluctuations of cash flow. As the influx from sales diminishes, so does their capacity to service financial obligations, compelling them to rely disproportionately on internal funds to sustain operations and pursue investments. (Yilmaz, 2022).

Commercial entities that benefit from subsidized financing yield performance inferior to the standard, even when measured against other enterprises of modest quality. The empirical record demonstrates that these "defunct enterprises" report inferior profitability, reduced capacity for interest payment coverage, and depressed capital expenditure. Furthermore, such firms possess a lesser proportion of tangible assets and maintain a minimal portfolio of assets suitable for collateralization Further analysis of corporate financing deficits offers a granular view of this dysfunction. For viable corporations, volatility in net working capital operates as a primary

driver of their financing gap. This outcome originates from operational inefficiencies and acute liquidity constraints, where unforeseen movements in inventory or protracted receivable cycles directly impair constrained liquidity profiles and widen the financing shortfall. In stark contrast, an examination of the financing deficit for non-zombie firms shows no such relationship. For these solvent enterprises, methodical administration of working capital renders such fluctuations peripheral to their overall financing needs (Acharya et al., 2022).

Kaplan and Zingales (1997) argue that investment–cash flow sensitivities do not unequivocally indicate more severe financial constraints, contradicting Fazzari et al. (1988). This difference has sparked debate. These findings align with Kaplan and Zingales (1997), who oppose the notion that U.S. firms with low dividend payout ratios necessarily face external financial constraints. By extending Fazzari et al. (1988) and incorporating qualitative data on capital needs and accessibility, they created a five-tier classification system from "not financially constrained" to "undoubtedly financially constrained."

The apparent superiority of the Whited and Wu (WW) index in identifying "zombie firms" is attributed to its incorporation of dynamic elements and industry-specific factors. These features allow for distinguishing between temporary illiquidity and fundamental insolvency.

Due to adverse selection, unprofitable projects may still be financed, allowing zombie firms to survive in unfavorable market conditions. Indeed, they may continue to receive funding even when shown to be low-quality if sunk costs have already been incurred (Dewatripont and Maskin, 1995). When pledgeability of cash flows is sufficiently low, the credit market breaks down—that is, no firm receives financing, regardless of its quality. High-quality firms borrow and invest because pledgeable funds are sufficient in expectation to cover the investment costs of lenders, while low-quality firms prefer to stay out of the market, anticipating no future reinvestment once their quality is revealed. These beleaguered enterprises often find themselves in the unenviable position of maintaining an interest coverage ratio (ICR) that falls below unity. Such a precarious state implies insufficient earnings to meet their debt service obligations and heightened sensitivity of liquidity to operational performance, where even a modest contraction in revenue causes an immediate liquidity crisis (Bernhardt et al., 2021).

The persistence of the financing deficit in non-viable corporations also stems from their lower propensity to execute asset divestitures relative to their viable counterparts. Zombie firms, when confronting a financing gap, do not resort to asset sales to ameliorate financial pressure. This operational behavior diverges from the conduct of viable corporations, which actively divest non-core or underperforming assets to generate liquidity and fortify their financial standing. Several rationales explain the aversion of non-viable corporations to asset sales, including managerial objectives to preserve corporate scale, expectations of a future operational recovery, or constraints imposed by creditors holding claims against those assets. Non-viable corporations with superior investment prospects accumulate larger cash reserves. This observation is anomalous, as it deviates from established corporate finance principles which postulate that corporations with an abundance of positive net present value projects will favor capital expenditures over liquidity preservation. The financing frictions these corporations confront explain this behavior. Restricted access to external capital markets dictates that non-viable corporations conserve cash

to underwrite future projects, a policy that subordinates current investment outlays.

A central finding of this research is the empirical identification of a distinct financial profile that characterizes zombified corporations. The probit regression analysis provides the primary evidence, isolating three variables that operate as robust determinants of a firm's classification as a zombie. The model returns a determinant positive coefficient for the Debt-to-Equity Ratio, confirming that an overleveraged capital structure is a cardinal attribute. Conversely, the analysis computes determinant negative coefficients for both Asset Tangibility and the Cash Flow Operating Ratio. This outcome establishes that corporations with a larger base of collateralizable assets and superior operating cash flow generation capacity are statistically less prone to zombification. These regression outputs find direct corroboration in the descriptive financial statistics which document a stark divergence between the two cohorts. A comparison shows that zombie firms, on average, operate with more precarious leverage ratios, inferior asset tangibility, and deficient cash generation relative to their non-zombie counterparts. These results furnish a precise, evidence-based taxonomy of the zombified firm, specified by the confluence of excessive debt, inadequate operational profitability, and a deficient base of tangible assets. This distinct financial structure gives rise to anomalous corporate policies, particularly in capital allocation and treasury management, that deviate from neoclassical corporate finance tenets. Unstable firms with high information asymmetry and low growth face acute financial constraints and show a negative relationship between financial leverage and investment. Short-term debt worsens this relationship and the impact of nominal interest rate fluctuations on the optimal debt–equity ratio depends on the tax deductibility of interest and the weighted average cost of capital. Modifications to the debt–equity proportion generate additional risk exposure for equity investors, and riskier debt elevates the variance of returns on debt (Chang, 2016).

The cash flow sensitivity of cash specification confirms a parallel anomaly: a precautionary motive governs the cash accumulation policies of non-viable corporations. The analysis employs operating cash flow (OCF) because the metric precisely quantifies internal capital generation. Cash-flow-based metrics circumvent the distortions possible in accrual-based accounting, which financially distressed corporations often manipulate (Rujoub et al., 1995). For the cohort of corporations with operating cash flow deficits, investment opportunities do not alter capital expenditures. This unresponsiveness quantifies their static capital allocation policy, as these entities do not adjust capital outlays to fund sectoral expansion. Their capital budgeting, however, reacts acutely to internal liquidity contractions, where any shortfall in operating cash flow directly curtails capital expenditure.

A direct positive statistical relationship between operating cash flow and cash reserves confirms that these entities systematically allocate a portion of internally generated funds to their reserves. This behavior directly opposes the practices of unconstrained corporations that treat internal and external capital as fungible (Huang et al., 2022). The absence of a statistical relationship with sales growth corroborates this diagnosis; future growth prospects do not govern the cash retention policies of these survival-focused entities. This dual conduct—investment paralysis and precautionary cash hoarding—diagnoses a disconnection from external capital markets. An inability to source financing on conventional terms compels these non-viable corporations to su-

bordinate value-creating investment to the preservation of internal liquidity buffers. This resource misallocation offers a micro-foundational explanation for the sectoral stagnation associated with zombification.

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