Survival of the Weakest: Listed Zombie Firms in Malaysia's Industrial Products and Services Sector

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Abstract: This study investigates the prevalence and determinants of zombie firms in the industrial goods and services sector listed on Bursa Malaysia from 2011 to 2022. Using the Altman Z-score, Ohlson O-score, and selected financial indicators, we find that 22% of firms with adequate financial disclosures can be classified as "walking dead." Panel logistic regression analysis reveals that the asset turnover ratio is the most significant predictor of zombification, though its marginal effect diminishes at higher levels. Leverage follows a non-linear relationship, where moderate debt increases the probability of zombification, but excessive debt appears to reduce it – possibly reflecting creditor intervention. Interestingly, firms were less likely to be classified as zombies during the COVID-19 period, potentially due to government relief measures and regulatory forbearance. Despite clear signs of financial distress, most zombie firms are not designated as PN17 or GN3, suggesting limitations in current distress recognition frameworks. These findings offer important implications for policymakers seeking to strengthen regulatory mechanisms and ensure efficient capital allocation. Retail investors may also benefit from improved tools to identify and avoid zombie firms.

Keywords: Industrial goods and services sector, Malaysia, zombie companies
JEL classification: D22, G33, L6

1. Introduction

The discussion of zombies in this paper deviates from the typical horror film where tropes of "walking dead" attempt to quench their temptation of human flesh. Instead, it is a much-watched phenomenon in the corporate world where financially struggling companies are still allowed to operate in the market because of subsidised credits or affiliations. These zombie companies feed on market forces, distort competition and crowd out healthy non-zombie firms. Although there is no commonly accepted definition of what constitutes a zombie firm, it can be generally defined as an insolvent

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business with little hope of recovery that has been prevented from going bankrupt with the assistance of banks, affiliations and connections (Hoshi, 2006). These zombie firms are more leveraged, less productive, smaller, invest less in intangible and tangible capital, and have decreasing employees and assets. The International Monetary Fund (IMF) found that the number of zombie enterprises has been rising globally, especially since the global financial crisis (GFC) (Albuquerque & Iyer, 2023). Banerjee and Hofmann (2018, 2022) noted that the proportion of zombie firms has increased significantly over the past 30 years, from 2% in early 1990 to 12% in 2018. According to the Nikkei Report, there are zombie businesses in Asia, and they are concentrated in countries like South Korea (18%, +4% over the past ten years), Indonesia (24%, +11%), and India (26%, +13%) (Noguchi, 2019).

Corporation zombies can be traced back to Japan's Lost Decades, when Japanese banks, motivated by perverse incentives, continued to lend credit to impaired firms to conceal losses on their balance sheets (Peek & Rosengren, 2005). The effects of zombie companies disrupting the typically competitive nature of the market were first examined by Caballero et al. (2008) and Hoshi (2006). They found that industries with high concentration of zombies have lower levels of investment, employment creation and productivity. There are several ways in which zombie firm distortions manifest themselves, such as significant negative spillovers or congestion effects on healthy companies that lower growth and productivity (Acharya et al., 2019; McGowan et al., 2018). Economic inefficiencies and the misallocation of resources are the typical outcomes of such negative externalities.

Extensive research has been done globally to identify the walking dead. Economists claimed that a decade of low interest rates following the 2008–2009 GFC was a significant factor that contributed to the rise of zombie companies (Taylor, 2019). Low interest rates reduce the expense of debt payment; therefore, lenders and banks might be more inclined to give long-term credit to non-viable firms overall (Altman et al., 2023). Further worries emerged during the COVID-19 pandemic when governments worldwide implemented significant fiscal stimulus measures to mitigate the economic downturn. These measures raise concerns that the emergence of several indebted zombie enterprises would impede the economic recovery.

However, empirical studies on listed zombie companies in Malaysia are scarce, and these studies were primarily focused on distinguishing and predicting financially distressed companies through running discrimination or regression analysis on samples of non-Practice Note 17 (PN17) and PN17 companies. Consequently, this research justifies its significance in adopting contemporary and widely applied techniques to identify potential zombies that may crowd out productive investments in the Malaysian bourse and fall under the Type I error of PN17 and Guidance Note 3 (GN3) classification by Bursa Malaysia. From another perspective, the relief of Bursa Malaysia's regulations about PN17 and GN3 amid the COVID-19 pandemic has allowed many zombie firms to continue listing in the stock market, misallocating investors' capital and undermining the general climate for equities. It is common knowledge that our benchmark index, the Kuala Lumpur Composite Index (KLCI) has stagnated for decades due to the prevailing negative perceptions of diminishing competitive edge, bureaucracy and political uncertainty. Furthermore, back in 2016, penny stocks that were priced below

RM1, were already constituting more than half of the listed companies on Bursa (Liew, 2016). These penny stocks are often characterised as manipulative by smart money and speculative in nature, high assets with poor performance, and often with frequent actions to dilute the rights of minority shareholders. Given that such low-quality companies eventually undermine the confidence of retail investors and shun foreign capital, the study provides an interesting case study to provide some clarity on the existence of such zombies and spark further discussions of such an investment climate.

To that purpose, this paper examines the listed firms under the industrial products and services sector to determine how many of these companies exhibit the features of zombie firms. Being one of the major classifications on the stock exchange, this sector provides a sufficient basis for a preliminary study. In addition, the manufacturing nature of this sector fits squarely into the field of industrial economics, and company performance can be readily evaluated through conventional indicators that are easy to compute and accessible publicly or via subscription platforms.

The primary contribution of this study is the revealing of the evolving existence and dynamics of listed zombie companies in the Malaysian context, boosting understanding of their prevalence and highlighting potential pathways for further research. By adopting various contemporary approaches, zombies can be identified in a multifaceted way by using indicators and data that are widely accessible. The logistic regression technique is applied to delve into the determinants of such zombification.

This paper consists of five sections and the remainder of this write-up is structured as follows. The second section reviews the extensive literature regarding the zombie company phenomenon. The third section presents the methodologies used to detect zombie companies in the Malaysian context whilst illustrating the econometric technique used. The main findings, along with discussions are presented afterwards. The last section concludes.

2. Literature Review

2.1 Emergence of Research on Zombie Companies and Evolving Methods

The exploration of zombie companies was initiated following the postulation of credit misallocation as the decisive factor in the prolonged Japanese economic catastrophe in the 1990s. This was done considering the institutional context of the existence of *keiretsu*, a conglomerate comprised of interdependent corporates often associated with their own banking and financial providers. The pioneering study by Peek and Rosengren (2005) empirically establish that Japanese banks possess preserved incentives to continuously supply credit to affiliated impaired firms within the *keiretsu*. The action reflects both internal incentives to maintain the intertwined corporate ties and external incentives imposed by relevant authorities. Building on such premise, Caballero et al. (2008) carried out the first extensive empirical study to classify those struggling zombie companies and found that in the wake of the Japanese crisis in the 1990s, up to 30% of publicly traded companies obtained funding at subsidised rates. Firm-level regressions show that the expansion of zombie firms widens the productivity gap between zombie and non-zombie firms while slowing investment and employment growth in non-zombie firms.

The method used by Caballero et al. (2008) (hereafter the CHK method) primarily involves comparing actual total interest payments of a company to a theoretical lower bound on interest payments deriving from interest on issued bonds, short-term bank loans and long-term bank loans. If the actual total interest payment is less than the theoretical lower bound, it shows the company may be receiving subsidised lending by the banks, and is considered a zombie. Nevertheless, Fukuda and Nakamura (2011) pointed out that the CHK method is prone to type I and II errors. Specifically, it may incorrectly identify healthy firms as zombies, as financially robust firms are expected to receive lower interest rates. Conversely, it may fail to classify unhealthy firms as zombies, owning that banks may extend evergreen lending to financially stressed firms, allowing them to pay the prevailing interest rates without discount. Evergreen lending typically refers to banks extending extra credit to keep borrowers afloat as a strategy to prevent the loan from being written off as bad. Hence, they suggest incorporating additional criteria: 'profitability' and 'evergreen lending' (hereafter the FN method).

Under this approach, a company is disregarded as a zombie if its earnings before interest and taxes (EBIT) exceeds the theoretical interest payments to mitigate the type I error of the CHK method. On the other hand, a company is counted as a zombie if, within a given timeframe, it increases its borrowings while its EBIT is less than the theoretical interest payments and with external debt over half of its total assets to address the type II error. Nakamura (2023) further modified the FN method in three aspects. First, the author proposed the change from EBIT to earnings before interest, taxes, depreciation and amortisation (EBITDA) as a measure of profitability condition given that depreciation and amortisation are non-cash outflow expenses. Second, real borrowing amounts, adjusted by the core consumer price index (CPI) should be used instead of nominal to reveal the true cost. Lastly, Nakamura (2023) also proposed the removal of temporary earnings changes that may distort the long-term performance.

With that being said, however, the implicit subsidised interest rate required in the abovementioned methods is computationally complicated and cumbersome as the data of exact interest payments on every single borrowing by companies is mostly unavailable to the public (Albuquerque & Iyer, 2023). Consequently, this study focuses on the use and calculation of financial ratios commonly disclosed in companies' financial reports. Following Banerjee and Hofmann (2022), zombie companies are defined as those with Tobin's Q ratio below the industry Q ratio median for two consecutive years and an interest coverage ratio (ICR) of less than one. Similarly, Albuquerque and Iyer (2023) classified a corporation as a zombie based on: (a) a leverage ratio more than the industry median, (b) an ICR of less than one, and (c) negative real sales growth. All of the indicators are of a two-year horizon to avoid cyclical fluctuations. The use of financial and accounting ratios to identify distressed companies is not new. Altman (1968) and Ohlson (1980) developed linear combinations of financial ratios to predict corporation bankruptcy through discrimination analysis and logistic regression, respectively. They are later known as the Altman Z-score and Ohlson-O score and remain widely used in the fields of business and finance.

2.2 Findings on the Prevalence of Zombie Companies

Imai (2016) examined the frequency of zombie small and medium enterprises (SMEs) in Japan and their investment and borrowing patterns using the FN and CHK methods. The author concluded that there were between 7% and 20% zombie companies among small enterprises with less than 10 million yen in capital between 2002 and 2008. A plethora of studies reveal that the incentives of banks to cover bad debt losses and preserve their capital buffers play a crucial role in the emergence of zombie companies (Hoshi & Kashyap, 2010; Peek & Rosengren, 2005; Ueda, 2012; Watanabe, 2011). Okamura (2011) argued that insufficient bank capital was the primary driver behind the rise of zombie corporations in Japan. Additionally, lax regulatory supervision and slow policy responses in the 1990s further enabled the prevalence of zombie firms instead of allowing market-driven exits (Chernobai & Yasuda, 2013; Hoshi & Kashyap, 2011).

Jeong (2018) reported similar findings regarding continued lending by public banks to distressed firms in South Korea given the similar contexts of both countries. The proportion of zombies in South Korea has risen since 2010, following a declining exit rate, funded mostly via maturity extensions by banks that constituted over 90% of the zombie assets (Jeong, 2018). Hoshi and Kim (2012) reinforced the finding by using a more robust method to examine zombie businesses in South Korea between 2000 and 2010. They included two additional metrics – the bank help ratio and the financial expenditure to sales ratio – to complement the FN method. Like their Japanese counterparts, South Korea's zombie companies prevent healthy businesses from growing, and as the proportion of zombies in the industry rises, so does the productivity gap between zombies and non-zombies. On the contrary, zombies do not constitute a significant portion of the US economy as shown by Favara et al. (2022). Unlike the experience of Japan and South Korea, US banks face less political and social pressure to sustain lending to the export sector, allowing distressed firms to exit the market through restructuring and liquidation procedures.

Shiraishi and Yano (2021) investigated the emergence of zombies within Chinese private enterprises by analysing data from companies' annual financial statements across 41 industries from 2002 to 2010. The study suggested unsound trade credit financing allows underperforming private Chinese enterprises to survive in the market, particularly in large private firms that are seen as pivotal to the Chinese community. It can be described as a principal-agent problem arising from taxation reform between the central and local along with fiscal decentralisation, leading municipals to focus on political goals rather than the reliability of the businesses (He et al., 2020). For instance, the mining sector in China expanded by 100% between 2016 and 2017, led by government-affiliated funding at the cost of other healthy corporations, resulting in overcapacity (Dai et al., 2019). Additionally, Shen et al. (2023) found that increased competition among banks promoted the proliferation of zombie firms. The proportion of zombie firms rises followed by increased bank rivalry as subpar lending standards and business information evaluation practices make it easier for these firms to survive. Thus, government involvement and excessive bank competition appear central to the formation of zombie enterprises in China.

McGowan et al. (2018) presented a comprehensive analysis of zombie firms utilising firm-level data collected among the Organisation for Economic Co-operation

and Development (OECD) nations. Their study demonstrated that the creation of congestion effects by zombies depress productivity and artificially enact higher entry barriers for productive firms, particularly as the size of zombie firms increased since the mid-2000s. Acharya et al. (2024) examined the inflationary effects of providing excessive credit to impaired firms. Their study, which utilises firm-level data and product inflation statistics in 12 European countries from 2012 to 2017, concluded that low-interest loans to struggling businesses cause disinflation. If credit had not been extended to zombie credit firms after 2012, annual inflation in Europe would have increased by 0.45% between 2012 and 2016.

Studies at a global level, such as Banerjee and Hofmann (2022), analysed data on listed firms across 14 OECD nations from 1980 to 2017. They discovered that the percentage of zombie companies rose from 4% in the late 1980s to 15% in 2017. In the long run, an increase of 1% in the percentage of zombies inside an economy reduces the overall growth in productivity by approximately 0.1%. Likewise, Albuquerque and Iyer (2023) investigated zombie businesses in 63 countries, comprising 32 emerging markets and 31 advanced nations. Using company balance sheet data from 2000 to 2021, they found that industries with a high concentration of zombie firms exhibit lower total factor productivity, investment and employment growth. Both Albuquerque and Iyer (2023) and Banerjee and Hofmann (2022) highlighted that zombies reduce credit availability for healthier businesses, echoing the findings on Japan's 'lost decade'.

Healthy firms, in this case, tend to underinvest amid facing restricted credit access, which ultimately drives up their savings rate and depresses broader industrial productivity (Caballero et al., 2008; Feng et al., 2022; Hoshi & Kim, 2012). Geng et al. (2021) recognised the consequences of inappropriate resource allocation and innovation inhibition following the increasing proportion of zombie firms. They further quantified that every 1% increase in such proportion hinders the industrial upgrading status by 0.22%. Zombies also contribute adversely to the environment and sustainable objectives, particularly in the context of excessive state support and shielding from regulations (Han et al., 2019). Thus, the adverse effects of zombies extend beyond economic stagnation, influencing broader industrial development and sustainability goals.

Altman et al. (2023) collected data on all listed non-financial enterprises (1990–2021) in the World Bank's top 20 economies by gross domestic product (GDP) in 2020 and discovered that the average share of listed zombie enterprises has increased dramatically, from 1.5% in 1990 to more than 7% in 2020. The study indicated that countries with a high proportion of small businesses, a large public utility sector, and low manufacturing activity have a higher proportion of zombie firms. In contrast, countries with better equity returns, GDP growth rates, and investment-grade sovereign credit ratings have fewer zombie enterprises (Altman et al., 2023).

2.3 Relevant Studies and Research Gaps in Malaysia

Although there are no specific and systemic studies on corporations' zombification in Malaysia, several studies have examined the predictability of financially distressed com-

panies. Thai et al. (2014) analysed a sample of 15 non-PN17 and 15 PN17 companies from 2009 to 2013. Through discriminant analysis, they applied the financial ratios from the Altman Z-Score model to classify financial distress among Malaysian enterprises. The resulting model showcases a 76.7% prediction accuracy while pointing out that the most pivotal distinction between healthy and troubled firms is the working capital to total assets ratio. Azhar et al. (2021) took a different approach by running qualitative response regression models. They examined financial ratios across five dimensions: solvency, leverage, liquidity, profitability and efficiency. Based on data from 28 companies, they found that the leverage ratio provides the soundest early signals of the financial difficulty of a firm. Conclusions from Azhar et al. (2021) and Thai et al. (2014) signified the importance of debt management and the efficient use of assets in generating turnover to withstand ongoing obligations.

To conclude, a defined and systematic methodology to categorise zombie companies is lacking in the Malaysian context. Given this significant gap, this study provides a preliminary analysis focusing on the industrial products and services sector to explore how zombie firms manifest within it. The rationale of selecting this sector is that it is one of the largest on Bursa Malaysia, representing a substantial portion of firms and market activity.

3. Methodology

This study analyses company-level data, focusing on quantitative financial ratios extracted from the financial statements of 283 listed corporations in the industrial products and services sector on Bursa Malaysia, covering the period from 2011 to 2022. In line with the recommendations of Albuquerque and Iyer (2023) and Banerjee and Hofmann (2022), data for 2010 are also included to compute two-year moving averages, thereby mitigating the effects of cyclical fluctuations.

Annual standardised financial statement data are collected from the Bloomberg Terminal. According to Bursa Malaysia, the 283 firms in the industrial products and services sector can be further classified into sub-sectors: industrial materials, components & equipment (62 firms), industrial services (47 firms), metals (42 firms), building materials (31 firms), packaging materials (25 firms), chemicals (19 firms), wood & wood products (19 firms), industrial engineering (16 firms), auto parts (13 firms) and diversified industrials (9 firms).

To comprehensively identify zombie firms, this study employs the Altman Z-Score, the Ohlson O-Score, and three financial ratios: the interest coverage ratio (ICR), leverage ratio and Tobin's Q. A panel logistic regression model is subsequently estimated to examine the characteristics of the identified zombie firms.

3.1 Altman Z-Score

The Altman Z-Score model is derived from a multivariate discriminant analysis developed to predict a company's likelihood of bankruptcy within a two-year horizon. It evaluates a firm's financial health by analysing a set of financial ratios computed from publicly available financial statements (Altman et al., 2014). This study applies the

classic Z-Score specification, as presented in Altman (1983, p. 108), which is detailed below:

$$\text{Z-Score} = 1.2X_1 + 1.4X_2 + 3.3X_3 + 0.6X_4 + 1.0X_5 \quad (1)$$

where:

X_1 = Working Capital/Total Assets. This ratio serves as a measure of short-term liquidity, where working capital is defined as the difference between a firm's current assets and current liabilities, scaled by total assets. Negative working capital indicates the firm's inability to meet short-term financial obligations due to insufficient liquid assets, while positive working capital reflects stronger liquidity. According to Altman (1968), this ratio outperforms traditional liquidity measures such as the current and quick ratios.

X_2 = Retained Earnings/Total Assets. This ratio reflects the extent to which a company relies on accumulated profits to finance its assets. A lower ratio may suggest that the firm depends more heavily on external financing, such as borrowed funds or debt, thereby increasing its risk of default.

X_3 = EBIT/Total Assets. This ratio is inversely related to the likelihood of corporate bankruptcy and is used to measure a company's operational profitability relative to its asset base. EBIT reflects a firm's profitability from core operations, excluding financing costs and taxes. A higher EBIT-to-total-assets ratio indicates that a company is generating strong returns from its assets, which enhances its ability to finance operations, service debt and sustain profitability. Therefore, firms with higher profitability relative to their assets generally face a lower risk of default.

X_4 = Market Value of Equity/Book Value of Liabilities. This ratio reflects the market's perception of a firm's financial health. The market value of equity captures investor confidence in the firm's future prospects, while the book value of liabilities represents its outstanding obligations. According to Altman (1968), this ratio can detect a decline in market confidence and asset values before a firm becomes insolvent. A higher ratio indicates that investors place greater confidence in the firm's financial stability, whereas a lower ratio suggests declining investor trust and increased financial vulnerability.

X_5 = Sales/Total Assets. This ratio measures a company's asset turnover, indicating how efficiently management is using its assets to generate revenue. A higher ratio suggests effective utilisation of resources to drive sales, while a low or declining ratio may signal inefficiency in asset use or underutilisation of resources.

Altman (1983, pp. 119–120) classified firms with a Z-Score below 1.81 as financially distressed, with a high probability of default. Scores between 1.81 and 2.99 fall into the grey area, indicating financial uncertainty, while scores above 2.99 are considered safe. In this study, firms with a two-year average Z-Score below 1.81 are defined as zombie companies.

3.2 Ohlson O-Score

Apart from the Altman Z-Score, the Ohlson O-Score (Ohlson, 1980) is another widely recognised approach for assessing the probability of corporate financial distress. It is

based on a logistic regression model that combines nine financial ratios, estimated from over 2,000 US industrial firms. The equation below presents the weighted linear combination used to calculate the O-Score:

$$\text{O-score} = -1.32 - 0.407\ln(TA_t / GNP) + 6.03\frac{TL_t}{TA_t} - 1.43\frac{WC_t}{TA_t} + 0.0757\frac{CL_t}{CA_t}$$

$$-1.72X - 2.37\frac{NI_t}{TA_t} - 1.83\frac{FFO_t}{TL_t} + 0.285\Upsilon - 0.521\frac{NI_t - NI_{t-1}}{|NI_t| + |NI_{t-1}|} \quad (2)$$

where:

$\ln(TA_t/GNP)$ is the natural logarithm of total assets (TA) scaled by gross national product (GNP), where GNP is expressed in index form with 2010 as the base year.

$\frac{TL_t}{TA_t}$ is the ratio of total liabilities (TL) to total assets (TA).

$\frac{WC_t}{TA_t}$ is defined as working capital (WC) over total assets.

$\frac{CL_t}{CA_t}$ is defined as current liabilities (CL) over current assets (CA).

X is a dummy variable that takes the value 1 if total liabilities exceed total assets, and 0 otherwise at a given point of time.

$\frac{NI_t}{TA_t}$ is the ratio of net income (NI) to TA.

$\frac{FFO_t}{TL_t}$ is the ratio of funds from operations to total liabilities. This study uses cash flows from operations due to its standardised reporting in the cash flow statements, as applied in Lawrence et al. (2015).

Υ is a dummy variable that takes the value 1 if the company experiences net losses for two consecutive years, and 0 otherwise.

$\frac{NI_t - NI_{t-1}}{|NI_t| + |NI_{t-1}|}$ is defined as the change in net income (NI) divided by the sum of its absolute values in the current and previous periods.

The Ohlson O-score is a numerical measure of a company's latent distress risk and overall financial health. A higher O-score indicates a greater risk of bankruptcy or financial distress. According to Ohlson's logistic regression model, a score greater than the threshold value of 0.38 implies a probability of bankruptcy within two years calculated as: $\frac{e^{0.38}}{1+e^{0.38}}$ = 59.38% (Imelda & Alodia, 2017). Thus, this study classifies a company as financially distressed if its O-score exceeds 0.38. Companies scoring below this threshold are not expected to experience significant financial difficulties.

3.3 Financial Ratio Metrics

This paper complements the Altman Z-Score and Ohlson O-Score models by incorporating additional financial ratio-based criteria to improve the identification

of zombie firms. Specifically, the following three conditions must be met for two consecutive years: (i) Tobin's Q is below the industry median, reflecting low market value relative to book value and signalling weak future growth potential; (ii) leverage ratios are above the industry median, indicating higher financial risk; and (iii) the interest coverage ratio (ICR) is less than one, suggesting an inability to meet interest obligations from operating income.

These criteria are grounded in the literature of Albuquerque and Iyer (2023) and Banerjee and Hofmann (2022), who highlighted that zombie firms are characterised by persistently low profitability and high leverage, leading to prolonged financial underperformance. By requiring all three conditions to hold for two consecutive years, this study aims to reduce the influence of temporary shocks and more reliably identify firms with sustained signs of distress.

3.4 Identification of Zombie Firms

Figure 1 summarises the identification process for classifying zombie companies in this study. A firm is categorised as a zombie if it meets at least two out of the three criteria outlined in Sections 3.1 to 3.3. These include the Altman Z-Score, the Ohlson O-Score, and financial ratio metrics. Incorporating all three criteria allows for triangulation and enhances robustness, as each captures different dimensions – bankruptcy risk, financial distress, future prospects and leverage. This approach ensures a more comprehensive assessment by balancing the strengths and limitations of each metric. The two-thirds

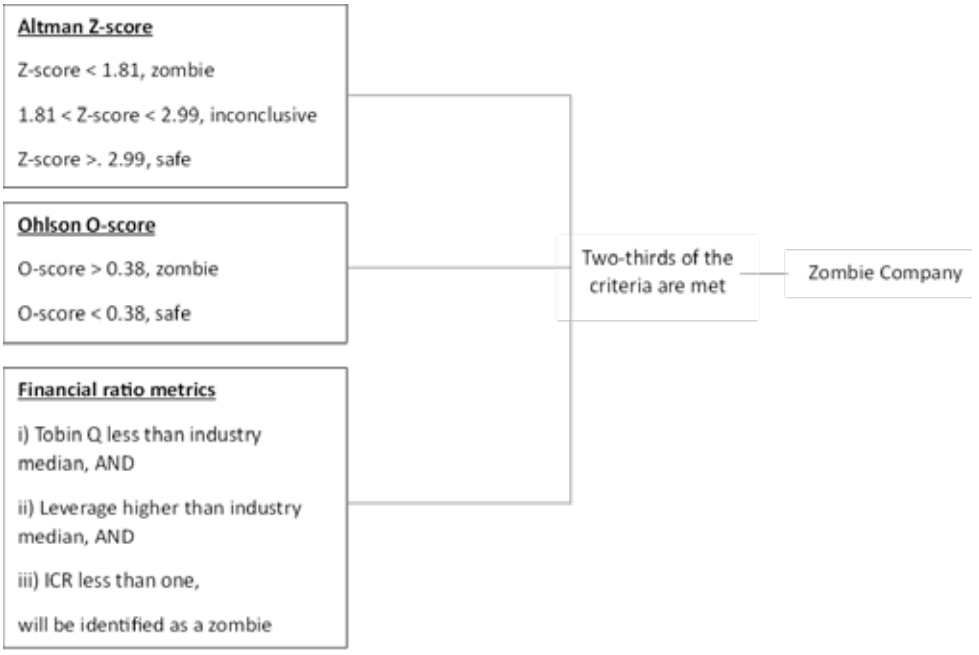

Figure 1. Criteria for identifying zombie firms

rule mitigates the effects of data sensitivity and reduces the likelihood of both false positives and false negatives in zombie classification.

3.5 Logistic Regression

Logistic regression analysis is employed to assess the predictability of various accounting and financial variables on the likelihood of firm zombification. This approach follows seminal works such as Ohlson (1980) and Zavgren (1985), among others. Logistic regression has gained widespread use in applied econometric studies due to its relative robustness and interpretability when compared with alternative models (Horowitz & Savin, 2001).

In the context of this study, logistic regression is appropriate given the binary nature of the dependent variable, which classifies firms into one of two categories: zombie or healthy. The model estimates the probability of a firm being a zombie based on selected explanatory variables. The analysis is conducted using panel data, comprising observations of individual listed firms over the period from 2011 to 2022.

The logit model is estimated using the maximum likelihood (ML) procedure. Following Gujarati and Porter (2009, pp. 553–555), the standard specification of the model is expressed as:

$$P_{it} = \frac{1}{1+\exp(-(\beta_0 + \beta_1 X_{1it} + \cdots + \beta_n X_{nit} + \varepsilon_{it}))} \tag{3}$$

where exp( ) is the natural exponential function, $X_{1it} \ldots X_{nit}$ are the independent variables, ε_{it} represents the idiosyncratic error term, and $P_{it} = E(Y_{it} = 1 | X_{it})$ represents the probability that firm *i* at time *t* is identified as a zombie firm. The subscripts *i* and *t* indicate the panel nature of the dataset, comprising cross-sectional observations over time. To facilitate estimation, the model can be transformed into its linear form using the log-odds transformation:

$$L_{it} = \ln\left(\frac{P_{it}}{1-P_{it}}\right) = \beta_0 + \beta_1 X_{1it} + \cdots + \beta_n X_{nit} \tag{4}$$

where $P_{it}/(1–P_{it})$ represents the odds ratio in favour of a company being classified as a zombie.

Building on the model specification of Binh et al. (2020), with several amendments to suit the present study, the following equation is estimated using firms with complete data for all independent variables over the 2011–2022 period.

$$L_{it} = \beta_0 + \beta_1 atr_{it} + \beta_2 current_{it} + \beta_3 leverage_{it} + \beta_4 size_{it} + \beta_5 covid_{it} + \varepsilon_{it} \tag{5}$$

The independent variables include the asset turnover ratio (*atr*), defined as net income divided by the average of total assets, which reflects how efficiently a firm generates profits from its assets. Short-term solvency is proxied by the current ratio (*current*), while the leverage ratio (*leverage*) captures the firm's debt burden relative to its equity. Firm size (*size*) is measured using the natural logarithm of total assets. The variable $covid_t$, unlike the other firm-level variables, is treated as cross-sectionally invariant and therefore does not carry the subscript *i*. It is introduced to capture the

potential impact of the COVID-19 pandemic on firm operations. The error term is denoted as ε_{it}.

Considering the nature of panel data, this study evaluates two standard estimation techniques: the fixed effects and random effects models. The key distinction between the two lies in the assumed correlation between the idiosyncratic error term and the explanatory variables. To determine the appropriate model, the Hausman test (Hausman, 1978) is employed. This test assesses whether the unique errors are correlated with the regressors – if they are, the fixed effects model is preferred; if not, the random effects model is more efficient and thus preferred.

4. Results and Discussions

4.1 Descriptive Statistics

The central tendency statistics presented in Table 1 (full sample, 2011–2022) suggest that a considerable portion of firms are likely non-distressed, with many exhibiting values well above or below the respective zombie thresholds. However, the wide dispersion – as shown by the large standard deviations and broad range – indicates a substantial spread in financial performance across the sample, implying the possible existence of zombie firms.

To gain further insight, Table 2 segregates the statistics into pre-COVID (2011–2019) and post-COVID (2020–2022) periods. This comparison reveals a marked deterioration

Table 1. Descriptive statistics for full sample (2011–2022)

Variables	Mean	Median	Std. dev.	Min	Max
Altman Z-score	4.35	2.56	9.01	-9.62	207.62
Ohlson O-score	-0.22	-0.037	2.86	-37.89	50.55
Interest coverage ratio	281.87	3.24	4626.29	-42048.71	156847.19
Leverage ratio	17.93	13.67	28.80	0	680
Tobin's Q	1.04	0.85	0.71	-0.20	7.81

Table 2. Descriptive statistics segregated by pre- and post-COVID periods

Variables		Mean	Median	Std. dev.	Min	Max
Altman Z-score	2011–2019	4.20	2.53	8.53	-6.93	207.62
	2020–2022	4.79	2.67	10.23	-9.62	157.01
Ohlson O-score	2011–2019	-0.26	-0.02	2.84	-37.89	50.55
	2020–2022	-0.14	-0.07	2.93	-17.14	32.14
Interest coverage ratio	2011–2019	351.82	3.17	5371.38	-42048.71	156847.19
	2020–2022	88.24	3.41	838.43	-8919.46	12652.20
Leverage ratio	2011–2019	17.85	14.30	25.47	0	680
	2020–2022	18.14	12.26	36.56	0	580.46
Tobin's Q	2011–2019	1.01	0.84	0.65	-0.20	7.81
	2020–2022	1.14	0.87	0.85	-0.09	6.45

in debt servicing capacity post-pandemic, reflected in the sharp decline in the mean interest coverage ratio (from 351.82 to 88.24) and a slight increase in leverage volatility. Although the mean and median values of other variables such as Tobin's Q have shown marginal improvements post-COVID, the standard deviations have generally increased, suggesting rising variability in performance. This points to uneven recovery trajectories and a widening gap in firm-level financial health, consistent with fragmented outcomes across the sector.

4.2 Identification of Zombie Firms

Based on the methodology for identifying zombie firms, Table 3 presents the yearly distribution of zombie companies among listed firms in Malaysia's industrial products and services sector from 2011 to 2022. It is important to note that the number of valid companies varies each year due to several factors. These include changes in fiscal year-end reporting by companies (which may result in missing data), delistings from Bursa Malaysia (either due to privatisation or mergers and acquisitions), and the exclusion of newly listed companies until at least two full financial years of data are available.

The table shows that the proportion of zombie enterprises fluctuated over the study period, with the lowest share recorded in 2017 at 17.89%. The trend from 2012 to 2017 reflects a general decline in zombie prevalence, likely supported by favourable financing conditions and stable economic growth in Malaysia. However, the proportion of zombie firms began rising again from 2018, peaking at 26.46% in 2020. This spike may reflect heightened policy uncertainty and economic disruption following the change of government in Malaysia. Notably, the new Malaysian government cancelled or postponed several large-scale infrastructure projects after taking office, adversely affecting the revenue and profitability of many companies and contributing to a decline in their ICR.

Table 3. Yearly identification of zombie firms in Malaysia's industrial products and services sector (2011–2022)

Year	Number of valid companies	Number of zombies	Proportion (%)
2011	196	43	21.94
2012	198	52	26.26
2013	207	45	21.74
2014	216	47	21.76
2015	216	47	21.76
2016	214	43	20.09
2017	218	39	17.89
2018	227	50	22.03
2019	222	57	25.68
2020	223	59	26.46
2021	230	50	21.74
2022	237	44	18.57

In addition, the COVID-19 pandemic and its impact on the Malaysian economy make it challenging to assess the impact of the recession on the proportion of zombie companies. In 2020, cash flow and profits for most Malaysian companies declined significantly, resulting in a decline in the ICR. However, the Malaysian government's fiscal stimulus measures and the accommodative monetary policy adopted by Bank Negara Malaysia (BNM) directly improved the corporate Z-Score. Government support for SMEs – such as loan moratoriums – also helped to raise companies' interest coverage ratios. Therefore, zombie companies that might otherwise have failed continue to survive. All these dynamics could lead to an increase in the number of zombies in industrial products and services in Malaysia during the pandemic. Following the COVID-19 pandemic, the zombification trend declined, with the proportion of zombie enterprises falling to 18.57% in 2022. This decrease likely reflects a sustained economic recovery and improvements in corporate profitability.

Retrieving the last trading prices in 2024 of companies identified as zombies in 2022 reveals that 90.91% of them are penny stocks, with share prices below RM1. In contrast, only 69.43% of non-zombie firms fall into the penny stock category. Zombie companies typically exhibit weak financial fundamentals, such as poor profitability, high debt levels and negative cash flows. In addition, operational inefficiencies and limited growth prospects erode investor confidence, resulting in depressed stock prices and making these firms more likely to attract speculative rather than long-term investment.

Interestingly, 97.73% of zombie companies identified in 2022 were not classified as PN17 or GN3 companies. In other words, less than 5% of zombie firms were formally recognised as financially distressed under Bursa Malaysia's PN17 or GN3 classification. These frameworks are designed to serve as early warning mechanisms, alerting investors when a listed company faces significant financial difficulties. While these classifications provide helpful signals to the market, the data suggest that the majority of zombie firms are not flagged under these systems – highlighting a gap in investor awareness and the limitations of existing warning mechanisms.

4.3 Determinants of Zombie Firms

Table 4 presents the estimation results for Equation (5), which models the likelihood of a firm being classified as a zombie based on five independent variables: asset turnover ratio, current ratio, leverage ratio, firm size and a COVID-19 dummy. These results are obtained using both fixed effects and random effects logistic regression models. The choice between the two is guided by the Hausman specification test, which strongly rejects the null hypothesis that random effects are more efficient and consistent. With a p-value significantly below the 5% threshold, the fixed effects model is preferred for interpretation. Furthermore, both models demonstrate good overall fit based on the likelihood ratio (LR) and Wald chi-square statistics, with p-values less than 0.01. Accordingly, the discussion will focus on the signs and magnitude of the coefficients from the fixed effects model.

To assess the economic significance of the examined variables, Table 5 reports standardised coefficients and odds ratios based on the fixed effects model in Table 4. The coefficients are standardised by rescaling the variables, typically using their standard

Table 4. Logistic regression on the determinants of zombie firms

Model	Fixed effects	Random effects
Estimated coefficients		
atr	-13.8758***	-20.3530***
	(2.6298)	(2.5166)
current	-2.2335***	-2.2407***
	(0.3671)	(0.2947)
leverage	0.1396***	0.1193***
	(0.0202)	(0.0168)
size	-1.3141***	-1.0049***
	(0.3734)	(0.1958)
covid	1.1331***	0.9369***
	(0.3250)	(0.3017)
constant		5.0446***
		(1.2356)
$LR\chi^2$ (5)	284.69	
Probability	0.000	
Wald χ^2 (5)		152.2
Probability		0.000
Hausman test	76.28	
Probability	0.000	

Notes: Estimated coefficients are reported with standard errors in parentheses. ***, ** and * denote 1%, 5% and 10% significance levels.

Table 5. Standardised coefficients and odds ratio

Variables	Standardised coefficients	Odds ratio
atr	-36.491	0.000
current	-0.820	0.440
leverage	0.003	1.003
size	-0.491	0.612
covid	0.368	1.445

deviations, to facilitate comparability across regressors. Given that the coefficients in a logistic regression model represent changes in the log odds of the dependent variable, it is more intuitive to interpret them in terms of odds ratios. These are presented in the last column of Table 5, calculated by exponentiating the coefficients. For interpretive clarity, odds ratios can be translated into percentage changes using the formula:

$$\%\Delta = (e^{\beta} - 1) \times 100 \quad (6)$$

For instance, a one-unit increase in the current ratio reduces the odds of a firm being classified as a zombie by 56% (odds ratio of 0.44), while a one-standard-deviation increase in leverage raises the odds by approximately 0.3% (odds ratio of 1.003), *ceteris*

paribus. Nevertheless, interpreting the magnitude of one-unit changes in variables like asset turnover ratio or current ratio may be less practical, as such changes could represent extreme shifts. Smaller, more realistic increments – such as 0.1 – may better reflect the financial behaviour of typical firms.

The results show that the *atr* is the most significant determinant of corporate zombification. This finding is intuitive, as the ratio reflects a company's ability to utilise its resources efficiently and effectively to gain a competitive edge – an idea that aligns with the Resource-Based Theory of strategic management (Alarussi, 2020). It also supports the observation that a large proportion of identified zombie firms are penny stocks, as reported by Patin et al. (2020), who found that stock returns and *atr* exhibit contemporaneous positive effects. This highlights the importance of improving operational efficiency to reward shareholders. Nam and Tuyen (2024) revealed that financial performance can be enhanced through effective liquidity management and capital structure mediation, which in turn creates additional investment opportunities.

In line with these insights, the considerable magnitude and economic significance of the *current* ratio are consistent with expectations and support prior findings by Md. Zeni and Ameer (2010), Thai et al. (2014) and Yap et al. (2010). These authors conclude that a firm's ability to service short-term obligations serves as a strong predictor of corporate failure. Nonetheless, Waqas and Md-Rus (2018) refuted this conclusion and found that both *atr* and the *current* ratio are positively associated with financial distress. Similarly, Brigham and Ehrhardt (2014) suggested that a company's inability to meet its short-term obligations does not necessarily indicate that the firm will go bankrupt.

Although the effect size of *leverage* is relatively small, its statistical significance suggests that increasing leverage indicates enterprises are overly reliant on creditors for financing. Borrowing beyond certain thresholds leads to higher interest expenses and, consequently, a lower ICR, which ultimately raises the risk of bankruptcy. The negative relationship between firm *size* and the probability of zombification can be explained through two channels. First, larger firms tend to benefit from economies of scale and scope, allowing them to accumulate sizable retained earnings and capital to weather economic downturns. Second, large corporations are often considered 'too big to fail', prompting authorities to extend support to prevent systemic disruptions. This interpretation is supported by Binh et al. (2020) and Hoshi (2006), who found that firm size helps mitigate the risk of zombification. Similarly, Altman et al. (2023) demonstrated that countries with a high concentration of listed small-scale firms tend to exhibit a higher zombie ratio. However, Almajali et al. (2012) found the relationship between size and performance remains ambiguous and argued that large firms may also become vulnerable due to inefficient management.

Lastly, the statistical significance of the cross-sectional invariant dummy variable, *covid*, implies that the COVID-19 pandemic increases the odds of zombification compared to the years without the disease. As noted by Albuquerque and Iyer (2023), the global rise in zombie firms is largely attributed to the abrupt halt in economic activity caused by strict containment measures during the pandemic. From another perspective, Altman et al. (2023) argued that unprecedented interventions by central banks and government support have played a crucial role in keeping financially distressed companies afloat. In the Malaysian context, this includes regulatory relief

by Bursa Malaysia concerning PN17 and GN3 classifications, fiscal stimulus packages and loan moratoriums under schemes such as PRIHATIN and PENJANA, aggressive monetary easing through reductions in the overnight policy rate and statutory reserve requirements, and the provision of special relief funds by BNM, among others.

Another motivation for running a logistic regression is to estimate marginal effects – that is, how the probability of a firm being identified as a zombie changes with a one-unit increase in an explanatory variable. These effects are computed by taking the partial derivative of the predicted probability function in equation (3) with respect to each regressor, as shown below:

$$\frac{\partial P}{\partial X_k} = \beta_k \bullet P \bullet (1 - P) \tag{7}$$

Because the marginal effect of a variable depends on the values of all covariates, researchers must decide which values to assign to the other variables when computing these effects. Three common approaches are typically used: (i) evaluating the marginal effect at the mean of the covariates, (ii) holding covariates at representative values, and (iii) computing average marginal effects (AME), as suggested by Breen et al. (2018). In this study, the second approach is adopted: each covariate is fixed at its median value, accounting for potential skewness in the data, while the variable of interest is varied across its observed range. This method is selected for its intuitive interpretation and computational efficiency. Additionally, a separate line is included in the plots to illustrate and compare the effect of the categorical variable.

It is evident from Figure 2 that all variables – except leverage – exhibit decreasing marginal effects. Specifically, initial improvements in low levels of asset turnover ratio (atr), current ratio, and firm size substantially reduce the probability of being classified as a zombie firm, but the effect diminishes at higher levels of these variables. Consistent with the odds ratio interpretation, the asset turnover ratio exerts the most substantial marginal effect, reinforcing its importance as a determinant of corporate zombification.

A notable observation is the distinct difference in marginal effects between pandemic and non-pandemic periods. The inclusion of the dummy variable for the COVID-19 period shifts the curves downward, indicating that during the pandemic, companies are less likely to be classified as zombies at any given level of the explanatory variables. This likely reflects the effectiveness of government fiscal support, accommodative monetary policy, and regulatory relief – such as relaxed listing requirements and loan moratoriums – in mitigating financial distress during COVID-19.

The marginal effect plot for leverage is the only one that exhibits a non-linear relationship. Initially, the association is positive – an increase in debt obligations relative to a firm's capital clearly raises the probability of being identified as a zombie firm. However, beyond a certain threshold, the relationship reverses. This suggests that creditors may continue to support highly leveraged firms, thereby reducing their likelihood of zombification despite elevated debt levels. Bliss and Gul (2012) found that political connections are positively associated with leverage among Malaysian listed firms, potentially indicating a channel through which such connections help firms remain afloat, even in the face of deteriorating leverage positions.

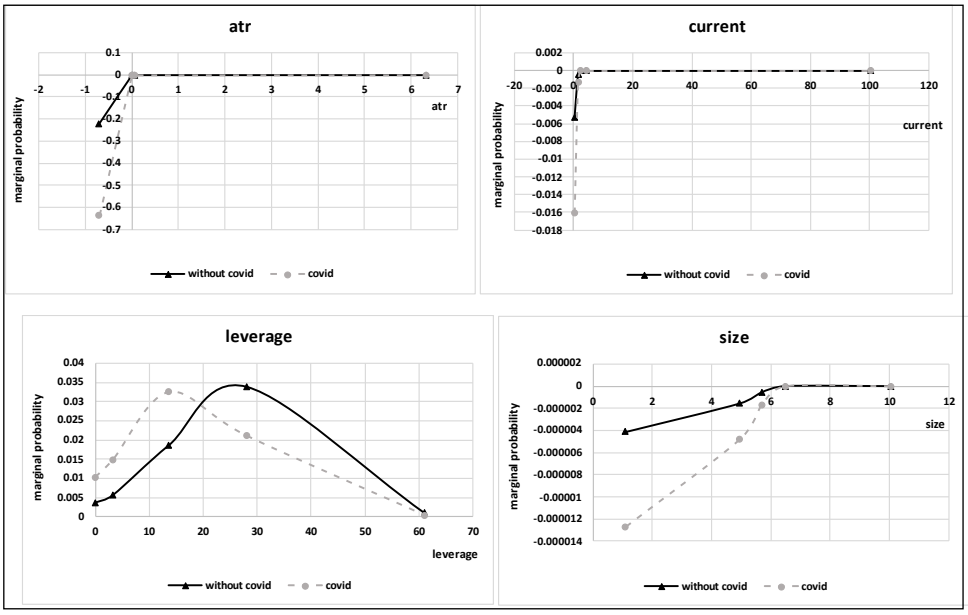

Figure 2. Marginal effects of key variables on the probability of being classified as a zombie firm

Note: The plots depict the marginal effects of each variable on the probability of zombification, across their observed ranges, under both pandemic (covid = 1) and non-pandemic (covid = 0) conditions. Other variables are held at their median values to mitigate skewness in the data.

5. Conclusion

This paper contributes to the study of zombie firms, particularly in the Malaysian context, and lays the foundation for future research. The findings reveal that the proportion of zombie companies in the Malaysian industrial products and services sector ranges between 17% and 27% over the period 2011 to 2022. However, fewer than 5% of these firms are classified under PN17 or GN3, indicating a potential gap in official distress recognition mechanisms. The logistic regression analysis identifies financially significant metrics that could serve as early warning indicators for regulators, helping to assess the likelihood of zombification. The persistent presence of zombie firms may signal deficiencies in the delisting framework and standards imposed by the Securities Commission (SC) and Bursa Malaysia. These shortcomings could undermine investor confidence and contribute to capital misallocation toward speculative activities. In contrast, studies from the United States report that between 3% and 6% of firms were classified as zombies between 2014 and 2019, while 15.3% of zombie firms filed for bankruptcy and 42.3% were delisted (Altman et al., 2023; Favara et al., 2022). On average, it takes 3.7 years for a zombie firm to be delisted, and 4.7 years to go bankrupt (Altman et al., 2023).

To address these challenges, a more coordinated and holistic policy response is warranted. BNM, in collaboration with the SC and Bursa Malaysia, could strengthen

financial transparency and corporate governance frameworks. BNM could also play a pivotal role in shaping loan restructuring and exit strategies, alongside enhanced credit risk assessments for commercial banks. At the same time, macroprudential and microprudential measures could be implemented to curb the effects of an ultra-accommodative financial environment that encourages excessive lending and weakens capital discipline. These reforms would help ensure that credit is channelled efficiently and that financially unsound firms are identified and dealt with more systematically. Finally, this study also offers valuable insights to public investors, equipping them to make more informed investment decisions by improving their ability to detect potential zombie firms.

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