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FINANCIAL STABILITY AND MARKET STRUCTURE OF LOGGING CONTRACTORS: ASSESSING ECONOMIC RESILIENCE IN THE TRANSITION TO FOSSIL-FREE FORESTRY

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Abstract

The transition to fossil-free operations in the forestry sector is essential for meeting the EU's climate goals. Logging contractors (LCs), vital to the softwood lumber supply chain, face financial constraints due to their small scale and capital-intensive operations. This study assesses the financial stability of Swedish LCs using Altman's Z'-score and evaluates market structure through concentration ratio analysis from 2014 to 2023. Results from 871 LC show that over 60% consistently fell into the Distress or Gray zones, indicating widespread financial vulnerability. Meanwhile, industry concentration increased significantly, with the top 20% of LCs accounting for 74% of total turnover by 2023. These trends suggest a shift toward dominance by larger, financially stronger LCs, raising concerns about the long-term inclusiveness of the sustainability transition. By combining financial distress modelling with industry concentration metrics, this study provides a quantitative assessment of LCs economic resilience during the fossil-free transition, revealing potential barriers for smaller LCs to invest in sustainable technologies. Without policy support, the shift to fossil-free forestry may be driven primarily by larger LCs, risking exclusion of smaller contractors.

Key words: *logging contractors; market concentration; forest industry; economic resilience; sustainable transition.*

INTRODUCTION

The forestry industry is a pivotal sector in Sweden's economy, representing one of Sweden's largest export domains. Within this industry, various stakeholders operate, including individual LCs. LCs constitute a significant portion of the harvesting industry, playing a crucial role in the softwood lumber supply chain, by managing substantial forest operations (Kronholm *et al.* 2021). At the same time, the forestry sector is undergoing a transition to fossil-free operations to meet national and EU climate targets. This shift will require significant investments in e.g. new machinery and fuel technologies by contractors, making financial resilience more critical than ever. Predominantly, LCs are small enterprises, typically employing fewer than five individuals (Kronholm *et al.* 2021).

Research has underscored the financial difficulties confronting LCs, such as diminishing productivity and profitability (Nordfjell *et al.* 2010). Gustafsson (2017) further highlights that many LCs perceive the industry as capital-intensive, characterized by high turnover and narrow profit margins. This perspective is corroborated by other scholars, including Lefévre (2011) and Sandström (2014).

During 2023, pulpwood and timber prices increased steadily (Skogsstyrelsen 2023), reaching levels sufficient to cover stakeholders' costs in the softwood lumber supply chain. This meets forest owners' expectations for a return on investment (Bare and Waggener 1980). Therefore, appropriate pricing is essential to ensure efficient operations and sustained contributions to the supply chain.

In recent decades, the total work effort of LCs in Sweden has steadily increased, as they perform a substantial portion of forest operations (Kronholm *et al.* 2021). However, the critical role of LCs within the forest industry supply chain is not adequately reflected in their financial outcomes (Benjaminsson *et al.* 2019). Existing literature has explored the financial pressures faced by LCs, highlighting issues such as declining productivity and profitability (Nordfjell *et al.* 2010), as well as capacity losses (Sandström 2014).

A robust financial position is essential for facilitating investments for development in for instance new technologies and sustainable practices (Gleißner *et al.* 2022). It also supports long-term planning and the capacity to manage the initial costs. Without solid financial stability, LCs may be unable to implement

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necessary changes, potentially hindering the development of the entire harvesting industry. Companies must ensure long-term financial stability (Gundes and Atakul 2019). Hence, understanding the harvesting industry from a financial perspective is crucial for evaluating the stability of its stakeholders. One approach to assessing financial circumstances involves examining economic distress and predicting bankruptcy.

Strong financial health provides a stable foundation for future investments in new technologies and sustainable practices, which supports the industry's long-term growth and development (Gleißner *et al.* 2022). Additionally, understanding financial trends helps in making informed decisions that support the industry's overall economic resilience. This is particularly vital for the harvesting industry, which is largely composed of LCs who play a crucial role in the softwood lumber supply chain, contributing over half of the total annual forestry working hours (Kronholm 2021). Many of these contractors are family-run businesses, for instance, family members comprise over 40% of the workforce in such companies, which can influence their operational priorities and financial structures. Kronholm (2021) notes that many LCs operate with tight financial margins, limiting their ability to invest or absorb rising production costs. Gustafsson (2017) emphasizes that LCs view the sector as capital-intensive, characterized by high turnover and low profit margins. This concern is shared by other researchers, who point to persistent low profitability (Lefévre 2011) and capacity losses (Sandström 2014). Similarly, Jylhä *et al.* (2020) report that small Finnish LCs face comparable challenges. However, little research to date has examined LCs financial stability during the shift toward fossil-free operations, nor the interplay between their financial health and market structure in this context. This motivates further analysis of financial distress and market concentration among LCs during the fossil-free shift.

OBJECTIVE

The objective of this study is to examine the financial resilience of Swedish LCs during the transition to fossil-free operations. Specifically, the study aims to (1) assess the level and development of corporate economic distress among LCs over the period 2014-2023 using Altman's Z'-score, and (2) evaluate the industry's market structure through concentration ratio analysis. Exploring the level and development of corporate economic distress will reveal insights into existing trends or tendencies. Further, by studying potential relationship between financial distress and market concentration, the study seeks to understand how structural market conditions may influence LCs' capacity to invest in sustainable practices and maintain long-term economic viability. By achieving these objectives, the study directly addresses the lack of knowledge on LCs' financial stability and how industry structure may affect their ability to fund the fossil-free transition.

THEORETICAL REVIEW

One approach to understanding financial circumstances is by assessing economic distress and predicting bankruptcy. Numerous studies have focused on predicting a company's bankruptcy, including those by Beaver (1966), Alanis *et al.* (2023), Hillegeist *et al.* (2004), and Elliott *et al.* (2014). According to Crouhy *et al.* (2001), four primary methods are used to assess economic distress and predict bankruptcy, discriminant analysis models, linear probability models, probit models, and logit models. Among these, Altman's Z-Score model (adapted for private companies) (Altman 1968) has been particularly favored for its predictive accuracy (Elliott *et al.* 2014, Gunathilaka 2014).

Altman's Z-Score model, based on multiple linear discriminant analysis, aims to predict a company's bankruptcy within two years, with accuracy rates ranging from 75% to 90% (Altman *et al.* 2014). Titshabona (2014) and Puspitasari and Syifana (2024) even reported a 95% prediction probability five years before insolvency (Altman *et al.* 2014). Over time, Altman has revised the model to enhance its relevance across various industries and economies. These revisions have been documented by researchers such as Jones (2017), Prasetiyo *et al.* (2023), Lord *et al.* (2017), and Lindblad *et al.* (2017). The continuous improvement of the Z-Score model underscores its robustness and adaptability in predicting financial distress and bankruptcy across different contexts.

According to Altman (1968), the Altman's Z-Score model includes five key financial ratios: liquidity, profitability, operational efficiency, solvency, and leverage. The calculation for Altman's Z-Score model is as follows, see Equation (1):

$$Z' = 0.717X_1 + 0.847X_2 + 3.107X_3 + 0.420X_4 + 0.998X_5 \quad (1)$$

where:

- X_1 = Working capital / Total assets. This financial ratio measures liquidity.
- X_2 = Retained earnings / Total assets. This financial ratio reflects cumulative profitability.
- X_3 = Earnings before interest and taxes / Total assets. This ratio measures operational efficiency.
- X_4 = Book value of equity / Total liabilities. This financial ratio is connected to solvency of the company.
- X_5 = Sales / Total assets. This financial ratio reflects the leverage of the company.

The financial ratios are weighted and summed to produce the Z-Score, which can then be classified into zones of financial health assessment (of bankruptcy), see Figure 1 (Shumway 2001, Alanis *et al.* 2023, Rohim *et al.* 2024). The Altman's Z'-Score model (a variation of the original Z-Score adapted for private companies) which uses the weights from Altman *et al.* (2014).

- *Distress Zone*: Companies in this category face a high likelihood of bankruptcy within two years unless corrective measures are taken.
- *Gray Zone*: These companies experience financial uncertainty, and their future performance is unpredictable.
- *Safe Zone*: Companies in this category are considered financially stable with a low risk of bankruptcy (Jones, 2017, Rohim *et al.* 2024).

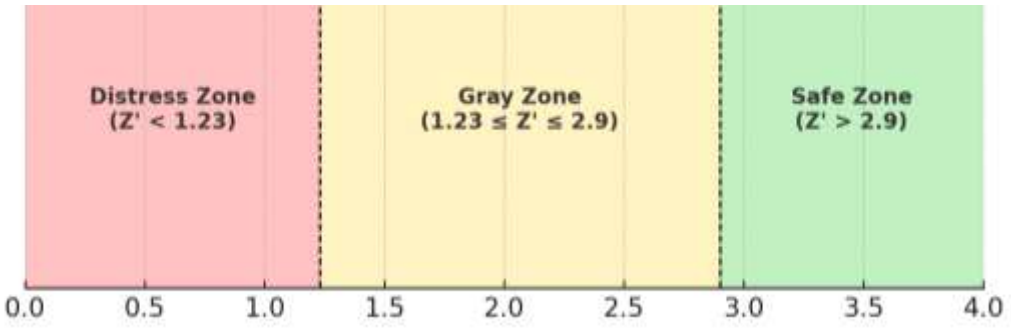

Fig. 1.
Altman's Z-value zones for financial health assessment. (Altman et al. 2014, Rohim et al. 2024).

One commonly used method for assessing market structure and concentration is the Concentration Ratio (CR_n), which measures the market share held by the top 'n' companies (Al-Muharrami and Matthews 2009). In this context, the CR_n among leading companies (LCs) has been analyzed to evaluate market concentration. This method provides valuable insights into the level of competition and the overall structure of a given industry (Koltay *et al.* 2023). To quantify market concentration, the total turnover of all companies operating within a specific market is calculated. The aggregate is then compared against the turnover of individual LCs to determine their market shares. This methodology offers a robust and systematic framework for evaluating the degree of market concentration (Matthes and Poetzsch 2007). High concentration ratios can indicate market dominance by a few large companies, which may lead to operational efficiencies. However, such dominance can also diminish competitive pressure on smaller companies, potentially affecting their risk profiles (Koltay *et al.* 2023). Beyond simply identifying the market power of top companies, concentration ratio analysis provides a deeper understanding of competitive dynamics. This makes it a useful tool for policymakers and industry stakeholders when crafting market regulations or competitive strategies (Koltay *et al.* 2023), as shown in Equation (2):

$$CR_n = \sum_{i=1}^{n} x_i \tag{2}$$

where: the CR_n describes the n largest companies competing on the specific market, generating x_i market share (%) for these companies (Matthes and Poetzsch 2007). The maximum value for CR_n is 100 %, which suggests a very dominant market position comparable to a monopoly situation.

METHODOLOGY

To address the objectives of this study, data were retrieved from a central database (www.allabolag.se) containing financial information for all limited companies (including LCs) in Sweden. To facilitate this research LCs were limited to all companies classified under the Swedish industry code SNI 02.102, corresponding to Logging, which includes companies involved in felling timber and producing raw wood materials like logs and roundwood. This classification is part of the Swedish Standard Industrial Classification (SNI 2007), aligned with the EU's NACE system. Financial data were collected for each year from 2014 through 2023, covering 871 active LC in 2023. This longitudinal dataset enables analysis of trends over the decade. This database is a reliable and valid source of financial data, ensuring the integrity of the information used in the study. The identified constructs ensure a clear and structured approach to gathering relevant empirical data. The dataset encompassed key financial indicators required to fulfill the study's objectives. As shown in Table 1, the original

sample size increased from 481 limited companies (LCs) in 2014 to 871 in 2023. After removing outliers, identified as the upper and lower 1.5×IQR (approximately 6–7% of values) each year using the interquartile range (IQR) method (Aguinis *et al.* 2013), the final samples used for analysis ranged from 449 to 814 companies per year. Outliers, representing extreme financial values, were excluded to mitigate their potential distortion of aggregate statistics.

Table 1

Yearly sample sizes before and after outlier removal

Year	Original sample size	Outliers (IQR method)	Total sample size
2014	481	32	449
2015	527	37	490
2016	569	28	541
2017	599	46	553
2018	633	33	600
2019	670	35	635
2020	720	28	692
2021	791	39	752
2022	858	47	811
2023	871	57	814

According to Bryman and Bell (2017), the quality of empirical research is commonly assessed using construct validity, internal validity, external validity, and reliability. To achieve construct validity, this study employed well-established metrics recognized for their effectiveness in identifying industry structure from a financial perspective and describing financial conditions. These metrics ensure that the constructs measured accurately reflect the theoretical concepts they are intended to represent. Internal validity was strengthened by including all respondents in the dataset, thereby minimizing selection bias and ensuring that the findings are attributable to the variables under investigation rather than extraneous factors. To address external validity, or the generalizability of the findings, the study focused exclusively on LCs. By adopting a census approach, which includes every LC classified under SNI code 02.102, enhances the generalizability of the results (Hair *et al.* 2023). This comprehensive inclusion of LCs ensures that the findings are representative of the entire industry. The study's reliability was supported by using data from a dependable and standardized source for Swedish company information. This source guarantees consistency in financial reporting across companies, thereby ensuring that the data used in the study are reliable and can be replicated in future research. This methodological rigor contributes to the overall robustness and credibility of the study's findings.

RESULTS AND DISCUSSION

The application of Altman's Z'-score to Swedish LCs over a ten-year period provides evidence of financial fragility within the harvesting industry. Figure 2 illustrates the distribution of Altman's Z′-scores for the Swedish LCs from 2014 to 2023, categorized into Distress ($Z' < 1.23$), Gray ($1.23 \leq Z' \leq 2.90$), and Safe ($Z' > 2.90$) zones.

The year-to-year trend in Z′-scores shows mild fluctuations rather than dramatic change. For instance, average Z′-scores dipped slightly in the mid-2010s, suggesting a period of worsened financial health, possibly due to rising costs or market pressures. By the early 2020s, there is a modest recovery in average Z′, coinciding with improved market conditions (e.g. high timber prices in 2023) that may have bolstered liquidity and profitability for some LCs. Across 2014–2023, a considerable portion of LCs consistently fell into either the Distress or Gray zones, reflecting elevated bankruptcy risk or uncertain financial health. Such patterns are consistent with the predictive robustness of the Altman Z′-score model, as demonstrated by Altman *et al.* (2014) and Gunathilaka (2014). Specifically, in 2014, 41% of LCs were classified as in the Distress zone (183 out of 449), while 35% fell into the Gray zone and only 24% were in the Safe zone. These proportions varied over time but did not show a clear trend of improvement. By 2023, the distribution was 34% Distress, 27% Gray, and 39% Safe, indicating a modest shift toward greater financial stability, yet with over 60% of LCs still outside the Safe category.

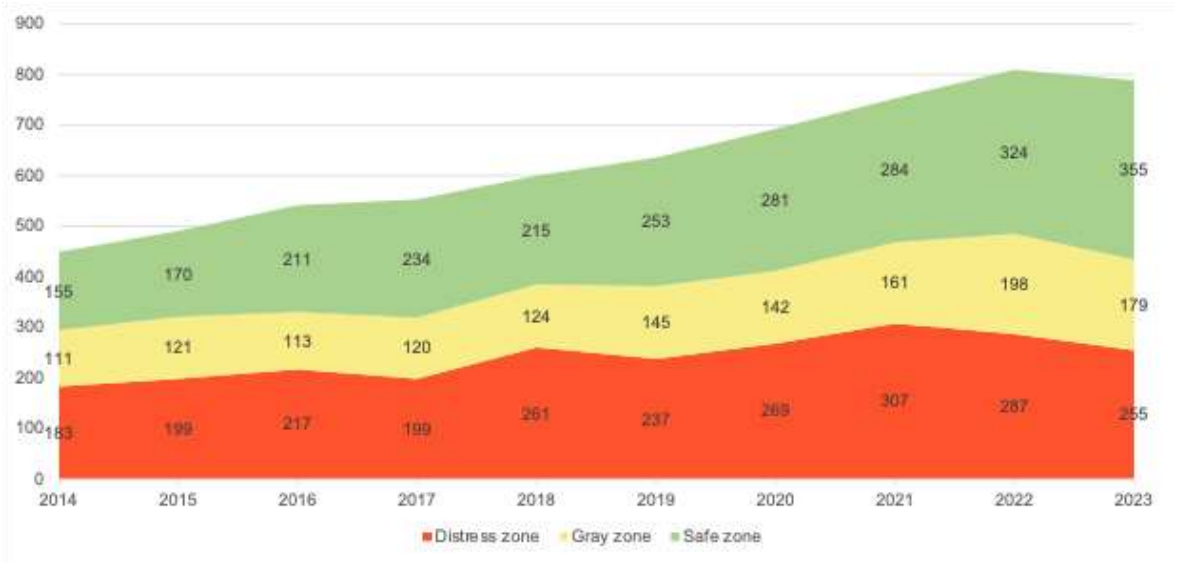

Fig. 2.
Proportion of Swedish LCs in Distress, Gray, and Safe zones of Altman Z'-score (2014–2023).

Figure 2 shows that in 2014, 41% of LCs were in distress, 35% in gray, and 24% safe. By 2023 these proportions were 34%, 27%, and 39%, respectively. This modest shift toward safety still leaves over 60% of companies vulnerable. The average annual Z'-score increased from 2.48 in 2014 to a peak of 2.84 in 2017, followed by a decline to 2.41 in 2023. This suggests a temporary improvement in financial health mid-period, potentially driven by favorable market conditions, but followed by renewed financial pressure. The sustained presence of a large number of LCs in the Gray zone is particularly notable, as this group remains vulnerable to adverse shifts in the economic environment and typically lacks the capital buffer to invest in transformative technology. These findings reinforce the broader literature highlighting the difficult financial position of small-scale LCs. Previous studies have noted the capital-intensive nature of the industry, high turnover, and thin margins as core challenges (Gustafsson 2017, Benjaminsson et al. 2019), as well as the long-standing issues with productivity and profitability noted by Nordfjell *et al.* (2010). However, even by 2023 the distribution had not shifted radically, many LCs remained in the Gray zone and a sizeable number in distress, indicating that the harvesting industry's overall financial resilience did not substantially improve over the decade. This persistent pattern of middling Z′-scores implies that systemic issues continue to constrain LCs' financial stability despite cyclical upturns raising concerns about the harvesting industry's resilience and adaptability in the face of policy-driven sustainability transitions.

The market structure of the harvesting industry has undergone notable consolidation during the study period. In 2014, the top 20% (by turnover) of LCs accounted for 63.4% of total industry turnover. By 2023, this figure had risen to 73.6%, underscoring a growing concentration of market power. This concentration trend reflects similar dynamics discussed by Koltay et al. (2023) in other consolidating industries, where dominant players shape both market structure and competitive outcomes. The CR_n data suggest that this consolidation has been gradual but consistent, with the top-tier LCs increasing their share of value creation in the industry.

Figure 3 presents the trend of the average market CR for LCs in each quartile of the dataset. This rise in concentration may reflect an efficient-structure dynamic, where more financially stable and operationally efficient LCs increase their market share. Supporting this interpretation, the average Z'-score among the top 20% LCs (those contributing to CR_n) remained higher than the population average for most of the study period. For example, in 2015, the average Z'-score for the top 20% was 2.66, compared to a population average of 2.50, indicating relatively greater financial resilience among the largest LCs.

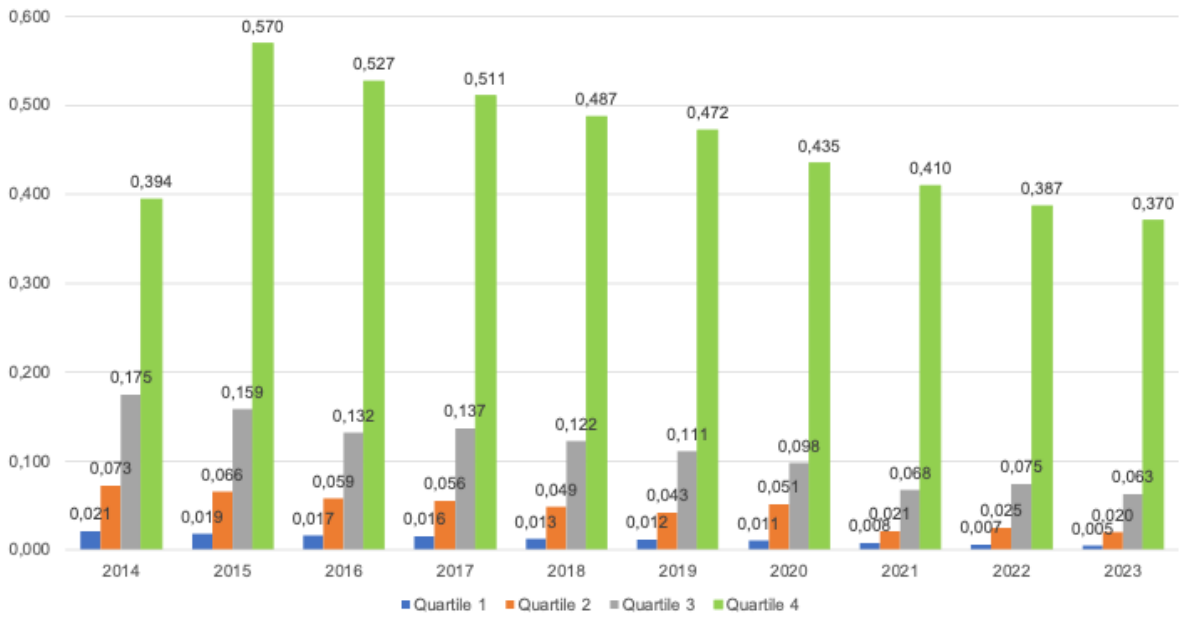

Fig. 3.
Annual concentration ratios (CR) for each quartile of LCs.

However, increased concentration also poses risks. Smaller LCs may be marginalized, finding it harder to compete for contracts or secure financing. In this industry, scale advantages and favorable conditions allow larger LCs to expand faster than smaller LCs. The influx of new, mostly small LCs (the population grew from 481 in 2014 to 871 in 2023) did not reverse this trend: the largest incumbents continue to dominate an increasing share of the market. Such dynamics could lead to regional monopolies or oligopolies, weakening competition and increasing supply chain vulnerability (Koltay *et al.* 2023).

Although the simple linear correlation was insignificant, descriptive trends suggest that, on average, larger LCs tended to have higher Z′-scores. In other words, even if there is no strict linear relationship overall, scale appears to offer some resilience (perhaps via higher equity or stable contracts). While the average Z'-score and the share of LCs in the Safe zone both show modest improvement in some years, these gains appear largely concentrated among larger LCs. In contrast, the share of smaller LCs in the Distress zone remains high, especially in years such as 2018 and 2020, when over 43% of companies were classified as Distress. This size-related resilience pattern is consistent with findings in other contexts, for example, Jylhä *et al.* (2020) observed that larger Finnish wood harvesting companies tended to perform better financially than smaller ones.

The LCs in the Safe zone of Z′-scores are predominantly among the larger ones, whereas Distress zone LCs tend to be smaller operators. Over time, as market concentration increased (Figure 3), the average Z′-score of the harvesting industry showed slight improvement (Figure 4), hinting that the financial health of the LCs may be bolstered by the growing weight of financially stronger LCs. However, this relationship is not one-to-one. Not all large LCs are financially robust (some experienced bouts of distress, as evidenced by individual large LCs occasionally dipping into the Distress zone), and many small LCs manage to avoid immediate distress despite modest Z′ values.

To examine this relationship further, we computed the Pearson correlation across all available years between CR and Z′-scores. The result was $r = –0.005$, $p = 0.681$, indicating no significant linear association. This suggests that, in this dataset, CR does not statistically predict a company's Z′-score.

Overall, the descriptive evidence indicates a positive but complex association where the harvesting industry's increasing concentration suggests that larger LCs with higher market shares generally have better financial stability, which aligns with the notion that scale can enhance resilience (e.g. through higher equity levels or more stable contracts). At the same time, the persistence of numerous LCs in the Gray or Distress zones underscores that size alone does not guarantee safety; efficient management and favorable economic conditions are also critical. In summary, the data reveal two parallel trends, (1) a steady but uneven financial state among LCs, with most LCs in a cautionary Gray zone and limited overall improvement in Z′-scores, and (2) a shifting market structure that became more top-heavy, raising the possibility that the financially strongest LCs are gradually shaping harvesting industry outcomes. This divergence raises concerns about long-term harvesting industry resilience and inclusiveness, especially as it prepares for transformative shifts related to the fossil-free transition.

Fig. 4.
Average Altman Z'-score and average concentration ratio (CR) for Swedish logging contractors, 2014-2023.

Achieving a fossil-free supply chain within the forestry industry requires substantial investment in new machinery (e.g. switching from diesel-powered harvesters to electric or biofuel-powered equipment), digital systems, and sustainable practices. However, the findings show that only a minority of LCs have the financial capacity to undertake such investments without external support. In particular, LCs in the Distress or Gray zones lack the liquidity and retained earnings needed for capital-intensive innovation. This supports findings by Gleißner *et al.* (2022), who argue that financial stability is a critical enabler of long-term sustainability investments, especially under capital-intensive conditions. This suggests that without targeted financing mechanisms or policy interventions, the transition to fossil-free operations may be led only by the largest LCs, exacerbating existing inequalities and risking the exclusion of smaller companies from the sustainability agenda.

CONCLUSIONS

This study investigated the financial resilience and market structure of Swedish LCs from 2014 to 2023, focusing on the implications for sustainable transition. The application of Altman's Z'-score revealed that a substantial proportion of LCs remained in the Distress or Gray financial zones throughout the period, with only marginal improvements. Although the average financial stability improved temporarily, particularly around 2017, it declined again by 2023. This volatility indicates a fragile economic foundation for a large share of the contractor population.

Simultaneously, the industry's CR has increased, with the top 20% of LCs controlling over 70% of the market by 2023. These LCs generally exhibit stronger financial health, suggesting that the market is shifting toward a model where a few large LCs dominate operations. While this may enhance efficiency, it risks diminishing competition and creating structural barriers for smaller LCs. Similar warnings have been raised by Koltay *et al.* (2023), who point out that increased concentration can weaken competition and worsen existing imbalances in the system.

The interplay between financial health and market concentration suggests that economic inequality is growing within the LCs, potentially limiting broad-based participation in the fossil-free transition. Larger companies generally exhibit stronger financial health, reflected in higher Z′-scores, suggesting that scale can contribute to resilience. This dynamic appears to be mutually reinforcing: financially robust LCs are better positioned to invest and expand, while growth can enhance efficiency and profitability. However, this is not a uniform trend. Many smaller LCs continue to operate under precarious financial conditions, and market share alone does not fully account for the variation in financial outcomes.

Although the harvesting industry's consolidation has marginally improved aggregate financial stability by shifting activity towards more robust LCs, it appears not to have resolved its underlying vulnerabilities. From a policy and management perspective, these findings indicate that size alone does not guarantee resilience.

Sound financial practices and enabling operational conditions remain critical across the board. The harvesting industry's transition toward fossil-free operations is likely to amplify existing disparities where larger LCs are structurally better equipped to lead this shift, whereas smaller, financially constrained LCs may face significant barriers. Without targeted support, such as investment facilitation, revised contracting models, or collaborative arrangements, the risk of further marginalization or exit among small LCs remains high. This echoes Gundes and Atakul (2019), who emphasize that proactive policy measures are essential to mitigate persistent financial issues in construction and forestry-related industries. Without such financial support, there is a risk that sustainability goals (e.g. widespread adoption of fossil-free practices) will be delayed or unevenly achieved, as only the largest contractors can afford the transition. In sum, the financial resilience of the harvesting industry remains uneven. Addressing this imbalance is essential, not only to safeguard business continuity but to enable a broad-based, inclusive transition toward sustainable forestry.

Policymakers and industry stakeholders must therefore consider mechanisms to support smaller LCs, such as targeted subsidies, low-interest financing for green technology, or cooperative investment platforms.

Future research

This study highlights that financial resilience is a prerequisite for environmental sustainability. Strengthening the economic foundation of LCs, particularly small and mid-sized, will be essential to ensure a just, inclusive, and effective transition to a fossil-free harvesting industry. However, during the course of the study, several new topics arose as development fields for future research:

- Developing industry-specific financial risk models that better capture the dynamics of forestry contracting.
- Investigating the actual adoption of fossil-free technologies among LCs of different financial strengths.
- Evaluating the effectiveness of policy interventions aimed at improving LCs solvency.
- Exploring collaborative models (e.g. cooperatives) that might enhance economies of scale for small LCs without necessitating consolidation.

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