

# Beyond Single Ratios: A Pattern-Based Validation of Financial Risk Resilience in Visegrad Economies

Research Paper

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**Abstract:** **Research purpose.** The growing frequency of macroeconomic shocks has reignited interest in the financial risk resilience of enterprises and their ability to absorb adverse disturbances. Existing empirical research relies predominantly on particular financial ratios to depict resilience, thus overlooking the overall impact of leverage and liquidity. The main aim of this paper is to empirically validate a pattern-based framework of financial risk resilience that encompasses combined liquidity-leverage configurations and to examine whether the distribution of these patterns differs systematically across post-transition economies. Focusing on enterprises operating in the Visegrad Group (V4) countries, the study investigates whether national financial environments contribute to persistent heterogeneity in financial risk resistance beyond firm-specific characteristics.

**Design / Methodology / Approach.** Using a large cross-country dataset of enterprises from Slovakia, the Czech Republic, Poland, and Hungary, enterprises are classified into four financial risk resistance patterns based on median thresholds of leverage and liquidity. The non-parametric Kruskal-Wallis tests, along with Dunn's post-hoc comparisons, are utilized to examine cross-country differences in financial constraints, supplemented by effect size estimates using epsilon squared to determine economic relevance. A multinomial logistic regression model is developed to test the robustness of the non-parametric findings and to account for firm-level heterogeneity while controlling for firm size and sectoral affiliation.

**Findings.** The findings reveal significant differences in financial risk resistance patterns across V4 economies. Hungarian and Polish enterprises have a higher prevalence of high-leverage and low-liquidity configurations, whereas Czech firms are predominantly characterised by low leverage and strong internal liquidity. Although non-parametric studies demonstrate statistically significant cross-country differences in leverage and liquidity, effect sizes imply that these differences are economically modest. The multinomial regression analysis shows that country affiliation remains a significant predictor of pattern membership even after controlling for firm size and sectoral composition.

**Originality / Value / Practical implications.** This study contributes to the literature by extending beyond single-ratio approaches and providing large-scale empirical validation of a pattern-based financial risk resilience framework in post-transition economies. The findings underscore the importance of considering combined liquidity-leverage configurations for measuring firm resilience and proposing policy interventions. From a practical perspective, the pattern-based classification facilitates the identification of financially vulnerable enterprises and encourages enhanced regulatory and risk management strategies.

**Keywords:** financial risk resilience • liquidity • leverage • firm-level analysis • Visegrad economies

**JEL codes:** C14; G32; G33; L25

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## Introduction

Periods of increased economic volatility expose enterprises to significant financial risks that might jeopardise their stability and long-term sustainability (Matuszewska-Pierzynka & Pieloch-Babiarz, 2025). Traditional risk management frameworks have habitually concentrated on risk transfer mechanisms (Kljucnikov et al., 2025), including insurance, hedging, and diversification (Balcerzak et al., 2025). However, systemic shocks such as the global financial crisis and the COVID-19 pandemic have exposed the limitations of these approaches, underscoring the critical role of corporate internal financial capacity in mitigating adverse events. This internal capacity is commonly referred to as financial risk resilience and reflects a capability to endure shocks without financial deterioration.

Existing research increasingly acknowledges that financial resilience is primarily determined by balance-sheet characteristics, particularly liquidity and leverage. Liquidity buffers enable enterprises to reduce cash-flow disruptions and maintain operational continuity, whereas excessive leverage increases refinancing risk and vulnerability during economic downturns (Feldhutter & Schaefer, 2023; Kalash, 2024). The importance of liquidity and leverage for assessing firms' financial vulnerability has long been recognised in bankruptcy prediction literature. Classical scoring models, most notably the Altman Z-score (Altman, 1968), as well as more recent discriminant and logistic regression approaches (Labosova et al., 2025; Vojtekova et al., 2026), incorporate liquidity- and leverage-related indicators to estimate the probability of corporate distress or failure. However, these approaches generally aggregate financial indicators into a single predictive score focused on bankruptcy risk. In contrast, the present study adopts a pattern-based perspective that examines heterogeneous liquidity-leverage configurations associated with varying levels of financial risk resilience rather than predicting firm failure itself. Despite growing empirical evidence on these relationships, most studies focus on single-country contexts or developed economies, limiting insights into cross-country differences in firm-level financial characteristics, particularly in post-transition contexts.

Although previous studies explore liquidity and leverage as determinants affecting firm resilience, empirical validation of pattern-based financial risk resistance frameworks in post-transition countries is limited. Particularly, there is limited evidence on whether liquidity-leverage configurations significantly differentiate enterprises across national institutional contexts or whether such patterns fundamentally reflect country-specific financial structures.

This study examines the differences in liquidity and leverage among enterprises in the V4 countries of Slovakia, the Czech Republic, Poland, and Hungary. Although these economies share a common historical background, they differ in terms of financial market depth, credit availability, and institutional arrangements, which may translate into distinct firm-level financial profiles. Accordingly, the analysis is guided by the following research questions:

**RQ1:** Do enterprises classified into different financial risk resistance patterns exhibit systematically different liquidity and leverage characteristics?

**RQ2:** Are the observed liquidity and leverage differences between financial risk resistance patterns consistent across V4 countries?

The main aim of this paper is to empirically investigate whether the core financial characteristics underlying financial risk resistance, particularly liquidity and leverage, exhibit statistically significant differences across V4 countries. To achieve this objective, the study employs non-parametric statistical methods, specifically the Kruskal-Wallis test and subsequent post-hoc comparisons, which are suitable given the distributional characteristics of firm-level financial ratio data. By emphasising cross-country differences in significant financial indicators, the paper contributes to the empirical confirmation of financial risk resilience in post-transition economies. This study contributes to the literature by providing the first large-scale, cross-country, empirical validation of a pattern-based financial risk resilience framework within post-transition economies.

The structure of the paper is as follows. The Literature review section explores significant theoretical perspectives and empirical results related to financial risk resilience and firm-level financial constraints. The Methodology section describes the dataset, variable compilation, and applied statistical methods. The Results and Discussion section presents and interprets empirical evidence on cross-country differences in liquidity and leverage. Finally, the Conclusions section describes the main contributions, practical implications, limitations, and opportunities for further research.

## Literature review

The ability of enterprises to withstand financial shocks without affecting solvency and continuity of operations is widely recognised as a critical determinant of long-term competitiveness (Hrynyuk et al., 2023). While early research on resilience focused predominantly on strategic adaptability and organisational flexibility, more recent studies increasingly emphasise the importance of internal financial structures as fundamental determinants of firms' shock-absorption capacity. In this regard, liquidity and leverage have emerged as two central balance-sheet dimensions shaping financial resilience (Sun & Duanmu, 2024; Xie, 2025).

Liquidity represents an immediate buffer that helps enterprises to withstand adverse shocks, such as revenue volatility or temporary disruptions in access to external finance (Tran & Nguyen, 2023). Enterprises with higher cash holdings are better positioned to maintain operations, avoid forced asset sales, and preserve investment possibilities during periods of economic crisis (Chen et al., 2024; Zheng, 2022). In contrast, leverage provides fixed repayment obligations that may constrain managerial flexibility and increase exposure to refinancing risk, particularly under adverse macro-financial conditions (Feldhutter & Schaefer, 2023). Elevated leverage reduces financial slack and heightens the possibility of covenant violations or credit downgrades during downturns (Nejadmalayeri & Usman, 2022).

Importantly, financial resilience does not depend on liquidity or leverage in isolation but on their combined structure. Empirical evidence reveals considerable heterogeneity in how enterprises incorporate these two dimensions across industries and organisational contexts (Allen et al., 2022; Rahman & Belas, 2024). Some enterprises utilise conservative financial strategies characterised by low leverage and high liquidity to maintain autonomy and flexibility, even at the cost of forgone tax benefits (Lu et al., 2025). Others operate with higher leverage but retain liquidity reserves to manage risk, particularly in capital-intensive or volatile industries (Nguyen et al., 2025). Conversely, enterprises combining high leverage with low liquidity are frequently recognised as the most vulnerable to financial distress (Wang & Liang, 2025), whereas low-leverage and low-liquidity configurations indicate strong dependence on external financing conditions (Chaigneau, 2024).

While existing studies provide compelling evidence on the role of liquidity and leverage in influencing corporate financial resilience, much of the empirical literature evaluates these characteristics in isolation. Such single-dimension approaches may yield incomplete conclusions because financial resilience emerges from the interaction between liquidity buffers and debt exposure rather than from isolated financial indicators. By focusing on particular ratios, these studies often overlook nonlinear interactions and trade-offs between internal liquidity buffers and debt capacity that jointly determine corporate ability to absorb financial shocks. These limitations have contributed to the development of typological frameworks that classify enterprises according to combined liquidity–leverage combinations rather than evaluating financial indicators independently.

These observations have promoted typological approaches that classify enterprises according to combined liquidity–leverage configurations rather than examining financial ratios. The financial risk resilience framework suggested by Wieczorek-Kosmala et al. (2018) separates enterprises based on liquidity constraints and debt capacity constraints, resulting in four financial risk resistance patterns. For such a typology to be analytically significant, however, enterprises classified into different patterns must exhibit systematic and statistically discernible variances in the underlying financial ratios. If no such differences are observed, the categorisation risks indicating arbitrary cut-offs rather than economically relevant heterogeneity.

Based on this reasoning, it can be expected that enterprises belonging to different financial risk resistance patterns differ significantly in their liquidity and leverage profiles. Accordingly, the following hypotheses are formulated:

- *H1a: Enterprises classified into different financial risk resistance patterns exhibit statistically significant differences in their levels of liquidity.*
- *H1b: Enterprises classified into different financial risk resistance patterns exhibit statistically significant differences in their levels of leverage.*

Beyond within-sample differentiation, institutional and macroeconomic environments may impact the extent to which these pattern-based differences are identified across countries. Although the V4 countries share a similar post-socialist legacy, they differ in financial market development, regulatory frameworks, and access to external capital (Iona et al., 2023). Such institutional differences may alter corporate financing behaviour and affect how consistently liquidity and leverage distinguish financial risk resistance patterns across national contexts.

If the financial risk resilience framework captures robust and generalizable mechanisms, the liquidity and leverage differences between patterns should persist across different country settings within the V4 region. This expectation leads to the following hypothesis:

- *H2: The liquidity and leverage differences between financial risk resistance patterns are consistent across the V4 countries.*

Moreover, existing research suggests institutional and macroeconomic circumstances may influence the extent to which liquidity and leverage distinguish resilience configurations across countries. Despite the growing relevance of this issue, evidence verifying pattern-based differences across post-transition countries remains sparse. Addressing this gap requires rigorous statistical testing capable of determining if observed differences in liquidity and leverage across financial risk resistance patterns are both statistically significant and robust across national environments.

## Research methodology

This study explores firm-level financial risk resistance patterns across the V4 countries using a large cross-sectional dataset derived from the ORBIS database, a highly recognised and reliable source of firm-level financial information. The dataset was pre-filtered to ensure completeness and subsequently cleaned to improve the data quality and robustness of the results. The final sample comprised 138,831 enterprises, including 23,616 Slovak, 31,243 Czech, 42,151 Polish, and 41,821 Hungarian enterprises. To mitigate the impact of short-term volatility and temporary fluctuations, firm-level indicators of liquidity and debt capacity were computed as mean values over the period 2018–2023. The choice of the V4 countries is motivated by their shared post-socialist legacy, geographic proximity, and comparable economic structures, combined with significant differences in financial market development that allow for comparative examination of financial risk resilience.

The analysis is grounded in the financial risk resilience framework presented by Wieczorek-Kosmala et al. (2018), which extends traditional risk assessment methodologies by simultaneously addressing two internal financial constraints, including liquidity constraint and debt capacity constraint. These limitations capture corporate capacity to absorb financial shocks internally rather than transferring risk externally. Based on the interaction of these constraints, enterprises are classified into four financial risk resistance patterns. Pattern A contains enterprises characterised by relatively high leverage combined with substantial liquidity buffers, enabling particular internal shock absorption despite constrained debt capacity. Pattern B comprises enterprises with low leverage and adequate liquidity, indicating the highest degree of financial flexibility and risk resistance. Pattern C comprises enterprises with low leverage but inadequate liquidity, showing dependence on external financing to withstand financial shocks. Pattern D involves enterprises with high leverage and low liquidity, demonstrating the highest level of financial risk due to limited internal reserves and strong reliance on external financing.

To operationalise the financial risk resilience framework, two balance sheet ratios were selected. Debt capacity constraints were quantified using the ratio of total debt to total assets (DEBT/TOAS), a frequently used leverage indicator in corporate finance research, where higher values indicate tighter debt capacity constraints. Liquidity constraint was determined by the ratio of cash and cash equivalents to total assets (CASH/TOAS), representing corporate precautionary liquidity buffers, with larger values suggesting lower liquidity constraints. Both ratios were scaled to the 0-1 interval to ensure comparability across enterprises and countries. Given the pronounced skewness of financial ratios, median values were used as classification thresholds to reduce the influence of extreme observations. Median-based thresholds were applied to classify enterprises into financial risk resistance patterns to ensure robustness and comparability across countries. The median provides a distribution-free and sample-invariant cut-off that is less susceptible to extreme values and skewness, which are apparent in firm-level financial ratios. Alternative threshold choices, such as quartile- or percentile-based cut-offs, may exaggerate differences at the tails of the distribution and lead to highly imbalanced group sizes, particularly in large cross-country samples. Pilot sensitivity analyses using various percentile criteria yielded qualitatively similar pattern structures and did not appreciably affect the main results. Consequently, the median was retained as a conservative and robust classification criterion.

**Table 1.** Descriptive statistics of classification indicators (V4 sample) (Source: own elaboration)

| Indicator | Pattern | Median | IQR   | Mean  |
|-----------|---------|--------|-------|-------|
| DEBT/TOAS | A       | 0.657  | 0.263 | 0.675 |
|           | B       | 0.205  | 0.206 | 0.210 |
|           | C       | 0.231  | 0.234 | 0.222 |
|           | D       | 0.705  | 0.273 | 0.711 |
| CASH/TOAS | A       | 0.344  | 0.269 | 0.408 |
|           | B       | 0.456  | 0.316 | 0.403 |
|           | C       | 0.079  | 0.092 | 0.082 |
|           | D       | 0.067  | 0.082 | 0.075 |

The descriptive statistics provided in Table 1 indicate a strong separation of the four financial risk resistance patterns along the leverage and liquidity dimensions, supporting the internal consistency of the classification.

The Kruskal-Wallis H test was utilised to empirically examine whether enterprises classified into distinct financial risk resistance patterns indicate significant differences in liquidity and leverage. This non-parametric method is appropriate due to the commonly observed non-normal distribution and heteroscedasticity observed in firm-level financial ratios. The examination explored differences in CASH/TOAS and DEBT/TOAS across the four financial risk resistance patterns. To evaluate the consistency of these differences across the V4 countries, the analysis was additionally conducted within national subsamples. To identify whether specific pattern pairs differed substantially, post hoc pairwise comparisons using Dunn's test with Bonferroni correction were performed when statistically significant differences were observed.

Despite statistical significance, effect sizes were evaluated to account for the large sample size and to determine the practical importance of the observed differences. Effect sizes for the Kruskal-Wallis tests were computed using epsilon squared ( $\epsilon^2$ ). Following standard practice, negative  $\epsilon^2$  values arising from sample variability were reduced to zero. The interpretation of effect sizes followed previously established benchmarks, with values around 0.01 denoting small effects, around 0.06 representing medium effects, and values exceeding 0.14 indicating large effects.

Although the applied methodology provides robust evidence on pattern-based differences in liquidity and leverage, significant limitations must be acknowledged. Financial indicators serve as proxies and do not capture all qualitative aspects of financial risk resilience. The cross-sectional design also limits the investigation of dynamic adjustments and temporal responses to macroeconomic shocks. Consequently, the results should be regarded with caution when extrapolating beyond the study period and sample. Future research may enhance the present framework by incorporating longitudinal data and additional indicators of financial resilience. Furthermore, the cross-sectional structure of the analysis does not allow causal inference regarding the institutional or macroeconomic determinants of financial risk resilience patterns.

To determine whether the cross-country differences in financial risk resistance patterns reported by the non-parametric analysis persist after accounting for firm-level heterogeneity, a complementary robustness analysis was conducted using a multinomial logistic regression model. The dependent variable was the financial risk resistance pattern (A-D), with Pattern B used as the reference category since it represents the low-leverage and high-liquidity benchmark configuration. Country affiliation, firm size, and sectoral classification were included as explanatory variables.

Firm size was determined as the natural logarithm of total assets, while sectoral affiliation was captured using the main sections of the NACE categorisation. The multinomial regression framework enables the simultaneous assessment of country impacts while controlling for firm size and sectoral composition, thereby supplementing the distribution-based evidence obtained from the Kruskal-Wallis tests. This analysis serves as a robustness check rather than a primary inferential approach and does not alter the core pattern-based analytical framework of the study.

## Research results and discussion

The empirical analysis of data from enterprises in the V4 countries indicates a heterogeneous distribution across the four identified patterns of risk self-resistance. Pattern B, characterised by low debt levels and relatively high

liquidity, is the most prevalent concept, accounting for 41,717 enterprises. This pattern demonstrates a benchmark financial structure in which limited reliance on external debt is combined with substantial internal liquidity buffers, a configuration associated with higher shock-absorption capacity during adverse economic conditions. This finding is consistent with previous evidence regarding the protective role of cash holdings during systemic shocks, including the COVID-19 pandemic.

Patterns D and A are also prominently represented, with 41,487 and 27,861 enterprises, respectively. Pattern D indicates enterprises combining high leverage with low liquidity, implying heightened financial vulnerability due to constrained internal buffers and substantial fixed repayment obligations. Pattern A, by contrast, comprises enterprises that rely heavily on debt financing while holding comparatively higher liquidity reserves, implying a moderate degree of shock-absorption capacity. Pattern C, containing 27,766 enterprises, is characterised by moderate leverage combined with binding liquidity constraints, demonstrating a stronger dependence on continued access to external financing when confronted with adverse shocks. Taken together, the pattern structure indicates that financial resilience is not generated by leverage or liquidity in isolation, but by their combined configuration.

Table 2 provides an overview of the distribution of financial risk resilience patterns across the V4 countries. Hungary and Poland demonstrate a higher prevalence of Pattern D, indicating that a sizeable percentage of enterprises in these countries operate under simultaneous leverage pressure and limited liquidity buffers. This configuration may partly reflect differences in macro-financial conditions and corporate financing environments across the V4 countries. However, since institutional factors were not directly measured in the present study, these interpretations should be regarded as indicative rather than causal explanations. In contrast, Pattern B dominates in the Czech Republic, suggesting a configuration of low leverage and strong internal liquidity. This distribution is consistent with a more mature banking sector and conservative dividend and cash management practices, which may facilitate internal financing and reduce dependence on debt. Slovakia exhibits a mixed structure, with Pattern D most frequent, followed by Pattern A. The relatively high occurrence of Pattern A in Slovakia suggests a strategic preference for retaining liquidity buffers even in the presence of higher leverage, potentially reflecting precautionary behaviour under less favourable credit conditions. Overall, the cross-country pattern distributions demonstrate that national financial infrastructures and macroeconomic environments systematically impact corporate leverage–liquidity configurations, beyond idiosyncratic firm-level decisions.

Recent research examines how environmental policy and green credit initiatives further affect the cash balances and leverage decisions of enterprises, adding more business finance institutional sophistication (Yuan & Gao, 2022). These findings across countries correspond with institutional finance studies indicating how differences in the maturity of credit markets, interest rate schemes, and government support programs influence business behaviour (Cam & Gumrukcu, 2025; Iona et al., 2023). The balanced situation in the Czech Republic may signify advanced

**Table 2.** Cross-country comparison of enterprises by financial risk resistance patterns across individual V4 countries (Source: own elaboration)

| Country |           | Pattern A | Pattern B | Pattern C | Pattern D | Total   |
|---------|-----------|-----------|-----------|-----------|-----------|---------|
| SK      | N         | 6,978     | 5,759     | 2,575     | 8,304     | 23,616  |
|         | % country | 29.55%    | 24.39%    | 10.90%    | 35.16%    | 100.00% |
|         | % pattern | 25.05%    | 13.80%    | 9.27%     | 20.02%    | 17.01%  |
| CZ      | N         | 8,910     | 12,111    | 3,938     | 6,284     | 31,243  |
|         | % country | 28.52%    | 38.76%    | 12.60%    | 20.11%    | 100.00% |
|         | % pattern | 31.98%    | 29.03%    | 14.18%    | 15.15%    | 22.50%  |
| PL      | N         | 6,440     | 11,174    | 10,600    | 13,937    | 42,151  |
|         | % country | 15.28%    | 26.51%    | 25.15%    | 33.06%    | 100.00% |
|         | % pattern | 23.11%    | 26.79%    | 38.18%    | 33.59%    | 30.36%  |
| HU      | N         | 5,533     | 12,673    | 10,653    | 12,962    | 41,821  |
|         | % country | 13.23%    | 30.30%    | 25.47%    | 30.99%    | 100.00% |
|         | % pattern | 19.86%    | 30.38%    | 38.37%    | 31.24%    | 30.12%  |
| V4      | N         | 27,861    | 41,717    | 27,766    | 41,487    | 138,831 |
|         | % country | 20.07%    | 30.05%    | 20.00%    | 29.88%    | 100.00% |
|         | % pattern | 100.00%   | 100.00%   | 100.00%   | 100.00%   | 100.00% |

financial market maturity, whereas the conservative liquidity strategy in Slovakia is a response to unfavourable credit conditions. Specifically, the national dominance of specific patterns reflects both structural national constraints and strategic business behaviour.

To statistically evaluate the observed heterogeneity, Kruskal-Wallis tests were employed to assess differences in leverage (DEBT/TOAS) and liquidity (CASH/TOAS) across V4 countries (Table 3). The results confirm statistically significant differences for both indicators. However, effect size estimates demonstrate that these differences, while robust, are economically modest, with  $\epsilon^2$  values corresponding to small effects for leverage and small-to-moderate effects for liquidity. Post-hoc pairwise comparisons reveal significant differences across all country pairs. Slovakia consistently has lower leverage relative to the other V4 countries, whereas enterprises in the Czech Republic demonstrate significantly higher liquidity ratios. These findings support the interpretation that country-level factors contribute to systematic variations in financial constraints but also indicate that considerable heterogeneity occurs at the firm level.

While the non-parametric tests demonstrate statistically significant cross-country differences in liquidity and leverage, they do not account for firm-level heterogeneity. To determine whether these differences persist after adjusting for firm size and sectoral composition, a multinomial logistic regression was performed (Table 4), with Pattern B specified as the reference category. The multinomial logistic regression results reveal that country affiliation remains a statistically significant predictor of financial risk resistance pattern membership even after accounting for firm size and sectoral effects. Enterprises operating in Hungary possess a significantly higher likelihood of belonging to Pattern D relative to enterprises in the other V4 countries, indicating that the prevalence of high-leverage and low-liquidity configurations in Hungary is not driven solely by firm size or industry composition. This indicates that country-level financial conditions consistently affect corporate leverage-liquidity trade-offs beyond firm-specific characteristics. Firm size demonstrates a strong and monotonic association with pattern membership, with larger enterprises being increasingly likely to deviate from the low-leverage, high-liquidity benchmark. This pattern is consistent with theoretical expectations that larger enterprises have more debt capacity and are more actively engaged in leverage optimisation strategies. Sectoral controls are simultaneously significant, indicating the importance of industrial structure as a conditioning factor.

Taken together, the results from the non-parametric and regression-based studies provide consistent evidence that financial risk resistance patterns are impacted by both firm-level characteristics and country-level financial environments. Importantly, the multinomial regression does not undermine the conclusions derived from the

**Table 3.** Kruskal-Wallis test results and post-hoc pairwise comparisons of financial constraints across V4 countries (Source: own elaboration)

| Kruskal-Wallis test statistics                                         |                  |             |              |
|------------------------------------------------------------------------|------------------|-------------|--------------|
| Indicator                                                              | Kruskal-Wallis H | Asymp. Sig. | $\epsilon^2$ |
| DEBT/TOAS                                                              | 3,536.201        | 0.000       | 0.025        |
| CASH/TOAS                                                              | 9,167.644        | 0.000       | 0.066        |
| Post-hoc pairwise comparisons (Dunn's test with Bonferroni correction) |                  |             |              |
| DEBT/TOAS                                                              | Test Statistics  | Sig.        | Adj. Sig.    |
| SK-CZ                                                                  | -14,982.402      | 0.000       | 0.000        |
| SK-PL                                                                  | -16,354.244      | 0.000       | 0.000        |
| SK-HU                                                                  | -18,345.878      | 0.000       | 0.000        |
| CZ-PL                                                                  | 1,371.842        | 0.000       | 0.000        |
| CZ-HU                                                                  | 3,363.476        | 0.000       | 0.000        |
| PL-HU                                                                  | -1,991.634       | 0.000       | 0.000        |
| CASH/TOAS                                                              | Test Statistics  | Sig.        | Adj. Sig.    |
| SK-CZ                                                                  | 13,161.231       | 0.000       | 0.000        |
| SK-PL                                                                  | -12,251.904      | 0.000       | 0.000        |
| SK-HU                                                                  | -11,384.266      | 0.000       | 0.000        |
| CZ-PL                                                                  | 25,413.135       | 0.000       | 0.000        |
| CZ-HU                                                                  | 24,545.497       | 0.000       | 0.000        |
| PL-HU                                                                  | 867.638          | 0.002       | 0.010        |

**Table 4.** Multinomial logistic regression results for financial risk resistance patterns (robustness analysis) (Source: own elaboration)

| Parameter estimates              |          |        |             |           |                                | 95% Confidence Interval for Exp(B) |           |
|----------------------------------|----------|--------|-------------|-----------|--------------------------------|------------------------------------|-----------|
| Pattern                          |          | B      | Std. Error  | Wald      | Sig.                           | Exp(B)                             |           |
| A                                | LN(TOAS) | 0.135  | 0.006       | 481.084   | 0.000                          | 1.145                              | 1.131     |
|                                  | SK       | -0.523 | 0.023       | 514.076   | 0.000                          | 0.593                              | 0.567     |
|                                  | CZ       | -1.022 | 0.024       | 1,769.704 | 0.000                          | 0.360                              | 0.343     |
|                                  | PL       | -0.805 | 0.024       | 1,093.629 | 0.000                          | 0.447                              | 0.426     |
| C                                | LN(TOAS) | 0.237  | 0.006       | 1,574.563 | 0.000                          | 1.268                              | 1.253     |
|                                  | SK       | -0.500 | 0.031       | 265.445   | 0.000                          | 0.607                              | 0.571     |
|                                  | CZ       | 0.587  | 0.028       | 449.871   | 0.000                          | 1.798                              | 1.703     |
|                                  | PL       | 0.622  | 0.028       | 487.788   | 0.000                          | 1.863                              | 1.763     |
| D                                | LN(TOAS) | 0.295  | 0.005       | 2,961.107 | 0.000                          | 1.343                              | 1.329     |
|                                  | SK       | -.198  | 0.024       | 2,501.226 | 0.000                          | 0.302                              | 0.288     |
|                                  | CZ       | -0.351 | 0.022       | 258.772   | 0.000                          | 0.704                              | 0.674     |
|                                  | PL       | -0.317 | 0.022       | 201.429   | 0.000                          | 0.728                              | 0.697     |
| Model diagnostics                |          |        |             |           |                                |                                    |           |
| -2 Log Likelihood (final model)  |          |        | 351,135.376 |           | Likelihood Ratio $\chi^2$      |                                    | 22,079.45 |
| Nagelkerke Pseudo R <sup>2</sup> |          |        | 0.157       |           | McFadden Pseudo R <sup>2</sup> |                                    | 0.058     |

Note: Sectoral coefficients are included in the model but not reported for brevity.

Kruskal-Wallis analysis but rather strengthens them by indicating that cross-country heterogeneity exists after controlling for compositional effects. These findings underscore the usefulness of a pattern-based approach to financial resilience, as it reveals nonlinear interactions between leverage and liquidity that are obscured in single-ratio analysis. From a policy perspective, the prevalence of Pattern D in specific countries highlights the need for targeted interventions addressing cumulative leverage and liquidity pressures, while the dominance of Pattern B illustrates the stabilising role of conservative financial structures in enhancing resilience to systemic shocks.

These results confirm the conceptual model within cross-country contexts and contribute to supporting the argument that both leverage and liquidity constraints are driven by national financial infrastructures and strategic firm-level decisions. The strong liquidity profile of the Czech Republic is defined by institutional strengths and conservative managerial approaches. On the contrary, the restricted use of debt in Slovakia may simultaneously serve as a limiting factor and as a deliberate finance stance because of inferred credit market frictions. These nuances indicate that resilience strategies are not merely passive reflections of external conditions but rather conscious calibrations of financial risk exposures through active management (Xie, 2025). This active managerial decision aligns with findings illustrating how monetary policy and liquidity restrictions contribute together to corporate financial decisions (Almgren et al., 2022) and how the management of liquidity drives the corporate debt cost and valuation (Nejadmalayeri & Usman, 2022). Empirical evidence also reveals liquidity effects on adjustments in leverage during periods of financial crises (Fu et al., 2024).

This study contributes to financial resilience theoretical theory-building at the firm level by empirically confirming the financial risk resilience theory within post-transition economies. These results reinforce the growing evidence that corporate performance and resilience are significantly affected by surplus cash as well as credit access (Kalash, 2024; Kusnierikova et al., 2025). Moreover, the ability of digitalisation to buffer against financial distress and enhance corporate resilience is empirically supported (Lee et al., 2024; Siminica et al., 2025). Policymakers can leverage such evidence to develop targeted regulation and support policies that improve financial resilience. Practically, classification of enterprises by particular patterns of financial risk resilience provides for enhanced detection of financial distress. Particularly, the prevalence of Pattern D emphasises the need for targeted interventions into enterprises that are facing cumulative debt and liquidity constraints. Firms with Pattern B suggest successful internal risk management and thus may serve as a proxy for the success of cautious financial conduct as a buffer against external shocks. The fact that country-level variation exerts a relatively modest impact indicates these results encourage the implementation of granular, firm-level analysis in advanced risk management strategies and policy frameworks.

## Conclusions

This paper examined firm-level financial risk resilience in the V4 countries using a pattern-based framework grounded in liquidity and debt capacity constraints. By utilising non-parametric statistical testing, the study empirically validated the financial risk resilience typology and proved that enterprises classified into different financial risk resistance patterns exhibit significant differences in their underlying financial characteristics. The results confirm that liquidity and leverage jointly comprise meaningful and economically relevant dimensions of financial resilience.

In response to the research questions, the findings reveal that enterprises allocated to different financial risk resistance patterns differ significantly in both liquidity and leverage, hence supporting the analytical validity of the pattern-based classification. Enterprises characterised by low leverage and strong liquidity buffers represent the most financially resilient configuration, while enterprises combining high leverage with low liquidity exhibit the weakest financial profiles and greatest vulnerability to adverse shocks. Intermediate configurations further highlight that resilience is not binary but exists along a spectrum defined by the combination of financial constraints.

The analysis also indicates that these pattern-based differences are largely consistent across the V4 countries. Although absolute levels of liquidity and leverage differ between national environments, the relative financial ordering of patterns remains stable. This finding implies that the financial risk resilience framework contains generalizable mechanisms of firm-level financial behaviour that transcend country-specific institutional settings. As such, the results suggest that internal financial structures contribute to firms' capacity to absorb financial shocks, although the relatively modest effect sizes indicate that considerable heterogeneity remains at the firm level.

From a practical perspective, the findings highlight the usefulness of pattern-based approaches for detecting firm-level financial vulnerability. Policymakers and financial institutions may apply such classifications to identify enterprises exposed to heightened financial risk and to devise targeted support measures during periods of systemic stress. For business owners, the results underscore the importance of balancing leverage and liquidity in establishing financial resilience and influencing strategic decisions on capital structure and cash management.

Despite its contributions, the study has limitations. The cross-sectional approach restricts the study to static financial configurations and does not capture dynamic adjustments over time. Moreover, reliance on accounting-based ratios may not accurately reflect qualitative aspects of financial decision-making or access to informal liquidity sources. Future research could expand the present framework using panel data to assess transitions between financial risk resistance patterns and to explore how enterprises adjust their financial strategies in response to economic shocks, regulatory changes, or differences in credit conditions.

Overall, this study contributes to the growing literature on financial resilience by empirically confirming a multidimensional framework of financial risk resistance in post-transition economies. It indicates that resilience is structured rather than homogeneous and is determined by deliberate financial choices embedded within broader institutional frameworks.

## Disclosure statement

No potential conflict of interest was reported by the author(s).

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## Declaration of generative AI in scientific writing

During the preparation of this work the author(s) have not used any type of generative AI or AI-assisted technologies.

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