

External Risk Perception across Firm Sizes in the Ocean and Fisheries Industry under Global Uncertainty

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In this study, we analyzed size-based differences in external risk perception among firms in the ocean and fisheries industry using business survey index data from the second quarter of 2025. On the basis of firms' single responses identifying the external factor that most affected management, contingency tables were examined using a chi-square test of independence and correspondence analysis (CA). Among industry type, sales volume, and employment size, only employment size was significantly associated with the distribution of responses, and the association was modest [$\chi^2(8, N = 191) = 15.959, p = 0.043$, and Cramer's $V = 0.204$]. Adjusted standardized residuals showed that the clearest departures from independence were concentrated in the 100–199 and 200–299 employee groups rather than being distributed uniformly across all five size groups. CA was used to visualize the relative category configuration, while group-specific interpretations were treated as descriptive unless supported by the residual analysis. Prior evidence on financial buffers, hedging capacity, and trade exposure provides plausible mechanisms for the observed patterns, but the cross-sectional survey does not identify causal effects. Because fisheries, shipping, ports, shipbuilding, and marine leisure increasingly rely on vessel monitoring, environmental sensing, cargo tracking, and port automation, perceived external risk also forms part of the investment environment for sensing technologies. The findings therefore support cautious, size-aware policy design rather than uniform support measures.

1. Introduction

1.1 Background

The ocean and fisheries industry is characterized by a high degree of external economic dependence and is therefore highly sensitive to fluctuations in the international economic and trade environment. Global supply chain restructuring, energy price volatility, unstable exchange

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and interest rates, strengthened environmental regulations, and geopolitical conflicts or trade disputes have all exerted direct and significant influence on the sector. In recent years, the global economy has continued to face persistent high inflation, an ongoing reorganization of supply chains, and heightened uncertainty in international trade. At the same time, energy transition driven by decarbonization efforts and rapid digital transformation fueled by AI-based technologies are reshaping industrial structures across the world. Within this context, the business environment surrounding ocean and fisheries enterprises has become increasingly complex, leading to heightened sensitivity to a wide range of external risk factors. As the industry's exposure to external volatility continues to grow, identifying corporate risk perception patterns has emerged as an important task for national policy development and corporate strategy formulation.

The ocean and fisheries sector is directly affected by real economic cycles and remains vulnerable to external shocks such as trade restrictions, financial market instability, and tightening climate and environmental regulations. In practice, the business survey index (*BSI*) for the industry experienced a sharp decline in the second quarter of 2020 during the initial phase of the pandemic, followed by a recovery. Nonetheless, volatility in business conditions continues to intensify in response to ongoing global changes. Under such heightened uncertainty, monitoring the external risk factors perceived by firms provides valuable foundational information that can support industrial, regulatory, and financial policy decisions.

The five sectors examined in this study—fisheries, shipping, ports, shipbuilding and marine equipment manufacturing, and marine leisure and tourism—are among the industries most extensively instrumented by sensing technologies. Coastal and offshore fishing operations rely on vessel monitoring systems, automatic identification systems, and acoustic and oceanographic sensors, while aquaculture depends on continuous water quality sensing for temperature, dissolved oxygen, and salinity. Shipping and port operations are managed through navigation, cargo tracking, and automated terminal equipment, and shipbuilding and marine equipment manufacturing supplies much of this instrumentation. Satellite-based remote sensing provides an additional layer of observation across all of these activities. The external shocks examined in this study—financial volatility, export contraction, and trade regulation—act on firms whose production, logistics, and safety operations are increasingly mediated by such sensing systems, and firms' investment in and adoption of these technologies are themselves conditioned by how they perceive external risk.

1.2 Need for the study

In Korea, *BSI*-related research and statistical analysis have primarily focused on the manufacturing and service sectors. For the ocean and fisheries industry, the Korea Maritime Institute compiles and publishes quarterly *BSI* data covering five major subsectors—fisheries, shipping, ports, shipbuilding and marine equipment manufacturing, and marine leisure and tourism. This *BSI* framework represents the only comprehensive quantitative survey system that captures business conditions across the broader ocean and fisheries domain. It includes evaluations and forecasts of business performance, as well as indicators related to sales,

employment, facility investment, raw material costs, and financial conditions. Moreover, the survey systematically identifies external environmental factors affecting firms each quarter and collects information on their policy needs, thereby enabling the direct observation of changes in corporate perceptions of external risks.

However, existing research remains limited in addressing a more granular and structural question: “How do perceptions of external risks differ across firms of different sizes?”. Prior studies using *BSI* data have mainly focused on diagnosing economic conditions in manufacturing or service industries, or on examining inter-industry differences and long-term trends within the ocean and fisheries sector. Although firms in this sector are exposed simultaneously to financial, real-economy, and institutional shocks, research on the structural differences in corporate risk perception—particularly those related to firm size—remains scarce.

Differences in risk perception based on firm size are not simply a matter of information availability; they reflect the combined effects of an enterprise’s resource structure, organizational capabilities, response strategies, and access to supply chains and finance. For example, small firms may be more exposed to short-term shocks such as financial market volatility, whereas large firms—owing to their extensive global networks and greater engagement in international transactions—are more sensitive to institutional or structural risks such as changes in global trade rules or disruptions in international supply chains. Understanding these differences provides essential knowledge for designing stage-specific policies, developing tailored support strategies, and building differentiated risk-response systems across firm types.

1.3 Research objectives

In this study, we aim to statistically identify the structural differences in external environmental perception across firms of different sizes within the ocean and fisheries industry, using raw data from the 2025 2Q Business Survey in the Ocean and Fisheries Industry. In particular, the analysis focuses on the survey questionnaire item asking respondents to identify the most influential external factor affecting business management. A contingency table is constructed on the basis of this item, and a chi-square test of independence is applied to verify whether differences in risk perception across firm sizes are statistically significant. To further elucidate the relative distances among categories and uncover latent patterns in perception structures—factors that cannot be fully interpreted through the chi-square test of independence alone—correspondence analysis (CA) is employed as a complementary method. CA enables a multidimensional interpretation of the linkages, similarities, and heterogeneity between firm size groups and external risk factors, as well as the underlying meaning of key dimensions derived from the analysis.

This study contributes to academic and policy discussions in three major respects. First, it extends the scope of *BSI*-based research by offering the first empirical analysis of firm size differences in external risk perception within the ocean and fisheries sector. Second, it proposes an analytical framework that integrates chi-square testing with CA, demonstrating a visually intuitive approach to reconstructing perception structures from categorical data. Third, it provides policy implications grounded in differentiated risk perception patterns across firm

sizes, thereby supporting the development of more refined industrial and governmental strategies under conditions of heightened global uncertainty.

By identifying and interpreting structural differences in external risk perception among ocean and fisheries enterprises, we provide empirical evidence that can strengthen industry adaptability and enhance policy responsiveness amid rapidly changing global conditions. In the following sections, we review relevant literature and theoretical foundations, describe the data and methodology employed, present empirical findings, and discuss key policy implications.

2. Literature Review and Theoretical Background

2.1 State of research on *BSI*: domestic and international perspectives

The *BSI* is derived from surveying businesses' perceived economic conditions and future business outlook. It has become the most widely used leading indicator among survey-based economic analysis methods.^(1,2) The *BSI* is used to calculate the proportion of positive, neutral, and negative responses on the basis of qualitative items such as "good", "average", or "bad", expressing the result as an index between 0 and 200. With a baseline of 100, values above 100 indicate an expansionary phase, while values below 100 signify a contractionary phase.⁽³⁾ This approach plays a crucial role in supplementing official statistics, which have publication lags, by proactively reflecting business people's perceptions of real variables such as production, sales, employment, and facility investment.⁽²⁾ Furthermore, the *BSI* is surveyed monthly or quarterly, enabling it to sensitively capture economic turning points. It is also evaluated as a useful indicator for comprehensively understanding the economic situation, as it can capture qualitative information such as funding conditions, management difficulties, and changes in the external environment.⁽¹⁾

Research on the utilization and interpretation of the *BSI* has been consistently conducted both domestically and internationally, primarily focusing on manufacturing and service industries. Domestically, the Bank of Korea and the Korea Institute for Industrial Economics & Trade compile *BSIs* for manufacturing and non-manufacturing sectors, covering business conditions, sales, and financial situations. Academically, research utilizing the *BSI* has also been conducted across various industrial sectors. For example, Jeong and Heo⁽³⁾ proposed a weighted *BSI* reflecting sales share for the ICT industry, demonstrating an improved representation of the real economy compared with the original index. Yoo⁽⁴⁾ analyzed the lead–lag relationship between the construction *BSI* and the industrial production index, empirically demonstrating the *BSI*'s validity as a construction business cycle indicator. Lee and Hwang⁽⁵⁾ developed an industry-tailored *BSI* that reflects the characteristics of the engineering industry, emphasizing the need for differentiated *BSIs* by industry. Chang⁽⁶⁾ empirically identified the factors affecting the *BSI* and the asymmetry in economic perception. These studies confirm that the *BSI* is an effective and sensitive tool for monitoring industrial business cycles and firms' managerial responses.

In the service sector, the *BSI* has also been utilized as foundational data for analyzing perceived economic conditions. Kim and Kim⁽⁷⁾ developed a tourism industry *BSI* focused on sectors such as tourism hotels and travel agencies, providing foundational data for tourism business cycle analysis. Kim⁽⁸⁾ utilized the *BSI* to analyze the quarterly business conditions of the tourism industry and the effects of the coronavirus disease 2019 pandemic.

Conversely, *BSI* research in the marine fisheries sector has been relatively limited. Given the industry's structural sensitivity to external risks, the value of utilizing the *BSI* is even greater. Jeong⁽⁹⁾ analyzed the correlation between shipping companies' *BSI* and performance indicators, confirming its potential as a shipping industry forecast indicator. The Korea Maritime Institute established a foundation for diagnosing the marine fisheries industry's economic conditions by regularly surveying and publishing *BSIs* for five major industries: fisheries, shipping, ports, shipbuilding and equipment manufacturing, and marine leisure tourism. This established a foundation for diagnosing the ocean and fisheries industry's economic conditions.⁽¹⁰⁾ However, most existing *BSI* studies in the ocean and fisheries industry have focused on analyzing average perceived business conditions, such as industry conditions, sales, and employment. There is a significant research gap in analyzing differences in risk perception by company size, the effects of external environmental factors by size, and differences in response to newly emerging external environments by company size. This represents a significant research gap, as the marine fisheries industry is vulnerable to external shocks and features a diverse corporate structure ranging from large corporations to small and medium-sized enterprises, yet analyses reflecting this heterogeneity remain scarce.

Internationally, the *BSI* has also been actively researched for its short-term predictive power regarding macroeconomic variables such as gross domestic product (GDP), production, employment, and prices. Hansson *et al.*⁽¹¹⁾ confirmed that the *BSI* exhibits leading properties for real GDP growth rates and key macroeconomic variables, whereas Białowolski *et al.*⁽¹²⁾ suggested that models combining various *BSIs* can enhance predictive power. These studies demonstrate that *BSIs* play a central role in analyzing economic cycles at the national and industrial levels.

While existing research demonstrates the *BSI*'s effectiveness as an indicator for industrial economic analysis and forecasting, most studies have focused on overall industry averages or specific sectors, failing to sufficiently analyze differences based on firm size or detailed industry structure. This need is particularly acute in industries such as the marine fisheries sector, where firm structures range from large corporations to micro-enterprises and are highly susceptible to external shocks. Here, identifying differences in external environment perceptions and risk structure heterogeneity across firm sizes is crucial. This study aims to fill this research gap by empirically analyzing differences in external environment perception and risk structure by company size across five major sectors of the marine fisheries industry, thereby expanding the existing *BSI* research.

2.2 Framework of ocean and fisheries business survey

The Ocean and Fisheries Business Survey is a quarterly survey designed to capture firms' perceived business conditions and expectations regarding future market outlook across five major sectors of the ocean and fisheries industry: fisheries, shipping, ports, shipbuilding and marine equipment manufacturing, and marine leisure and tourism. The survey constructs a *BSI* for the industry by employing a representative sampling frame, standardized questionnaire items, and a weighting scheme based on employment size, thereby accounting for the sector's diverse industrial structure and heterogeneity in firm size. The sampling framework is presented in Table 1.

To ensure representativeness, the target population was defined according to the *Special Classification of the Ocean and Fisheries Industry*,⁽¹³⁾ which delineates the five sectors comprising the ocean and fisheries industry. From this target population, a total of 2400 firms with five or more employees were selected as the survey sample. The sample was constructed around leading enterprises to secure an adequate coverage of industrial activity, resulting in the survey sample representing approximately 65.8% of total employment in the population. This confirms that the sampling design sufficiently reflects the structural characteristics of the ocean and fisheries industry. Furthermore, the sample frame is updated annually to incorporate business closures, newly established enterprises, and other structural changes within each sector, thereby maintaining its accuracy and relevance over time. Table 1 shows the sampling framework of the Ocean and Fisheries Business Survey, including the target and survey populations, sampling method, sample size, and sampling error.

The Ocean and Fisheries *BSI* includes a set of core items that assess firms' business conditions across multiple managerial dimensions. These include overall business conditions, sales volume, employment, facility investment, sales prices, raw material costs, profitability, financial conditions, management difficulties, and issues related to external environmental changes. Business conditions are assessed in terms of evaluations for the current quarter and expectations for the next quarter, including the reasons for those assessments. Sales volume, employment, and facility investment are evaluated relative to the same quarter of the previous year, providing insights into firms' management activities. Sales price, raw material costs, profitability, and financial conditions are assessed both relative to the previous quarter and with

Table 1
Sampling framework of ocean and fisheries business survey.

Target population	Business establishments engaged in the five sectors defined under the Special Classification of the Ocean and Fisheries Industry (fisheries, shipping, ports, shipbuilding/equipment manufacturing, and marine leisure and tourism)
Survey population	Business establishments with five or more employees that can represent their respective industries
Sampling method	- Quota sampling (1) First-stage quota allocation across five major sectors and 13 subsectors (2) Second-stage stratification by employment size followed by judgmental sampling
Sample size and sampling error	- A total of 470 establishments nationwide and maximum allowable sampling error of $\pm 4.05\%$ at the 95% confidence level.

respect to next-quarter expectations, capturing firms' production-related assessments. Firms also report current management difficulties, coping strategies, environmental and supply-related factors affecting operations, and sector-specific keywords that characterize current industry conditions. Table 2 shows the major survey items of the Ocean and Fisheries Business Survey and their corresponding assessment criteria.

The Ocean and Fisheries *BSI* is derived from qualitative assessments provided by participating firms, using the standard tri-category response format of “good”, “normal”, and “bad”. These responses are converted into a numerical index ranging from 0 to 200.

In this framework, values below 100 indicate a contractionary business environment, a value of 100 reflects neutral or unchanged conditions, and values above 100 denote an expansionary phase. The *BSI* therefore serves as a concise measure of firms' perceived business conditions and short-term expectations.

2.3 Differences in risk perception across firm sizes

Recent studies on corporate risk perception have increasingly moved beyond examining average responses within a single industry or across the entire corporate sector. Instead, research has shifted toward identifying heterogeneity across firms—particularly differences by firm size, organizational capacity, resource accessibility, and managerial experience. Even when exposed to the same external conditions, firms may perceive and prioritize risks differently depending on their internal structures and capabilities.

Belás *et al.* (2015)⁽¹⁴⁾ compared micro, small, and medium-sized enterprises (SMEs) in the Visegrád Group (Poland, Czech Republic, Slovakia, and Hungary) and demonstrated that perceptions of financial, market, and operational risks differ significantly by firm size. Although financial risks exerted the strongest effect on overall business conditions, a substantial proportion of micro enterprises reported lacking the capacity to manage such risks effectively.

Table 2
Major survey items of ocean and fisheries industry business.

Category	Survey Items	
Business conditions	- Overall business conditions	- Current evaluation and next-quarter outlook
Production activities	- Sales prices, raw material costs, profitability, financial conditions, sales volume (domestic and export), employment (regular and temporary workers), facility investment	- Compared with previous quarter (diagnosis and outlook)
	- Sales volume (domestic and export), employment (regular and temporary workers), facility investment	- Compared with the same quarter of the previous year (diagnosis and outlook)
Management activities	- Management difficulties and coping measures; issues affecting business operations due to external environmental changes	- Current quarter (no comparison base)
Keywords	- Sector-specific keywords for ocean and fisheries industry	- Current quarter
Industry-specific items	- Environmental factors, supply–demand factors	- Current quarter

The authors further found that the perceived importance of credit risk increased after the economic crisis, and that small and medium-sized firms exhibited better understanding of commercial bank lending conditions and evaluated their transparency more positively than micro enterprises.

Hudáková and Dvorský (2019)⁽¹⁵⁾ also confirmed, using chi-square tests of independence, that the number of employees is statistically associated with differences in perceived market risk among SMEs in V4 countries. Through their study, conducted with 122 transport sector firms in Slovakia, Poland, Czech Republic, and Serbia, they identified “strong competitive pressure” as the most significant market risk factor. These findings suggested practical implications for designing targeted government support measures for SMEs in the transport industry.

Havierníková and Kordoš (2019)⁽¹⁶⁾ examined financial risk perception within clusters, applying chi-square tests, Z-scores, and Pareto analysis. They found statistically significant size-based differences for several financial risk indicators—such as credit guarantee and reputation risks—highlighting that micro enterprises tended to perceive certain financial risks as more severe. The results reinforced the importance of firm size as a determinant shaping the structure of financial risk perception.

Despite these contributions, studies examining structural differences in external risk perception among firms in the ocean and fisheries industry remain scarce. The existing literature provides limited insights into how firms in this sector perceive external shocks depending on their size and characteristics. Against this backdrop, the present study contributes to the literature by empirically analyzing size-specific differences in the perception of external environmental changes using the Ocean and Fisheries *BSI*. This allows for a systematic understanding of how heterogeneous firms within the industry interpret external risks.

2.4 Firm size, trade exposure, and external risk channels

Empirical evidence on exchange rate exposure indicates that the salience of financial volatility among smaller firms may reflect their limited capacity to absorb it rather than a larger underlying exposure. Applying an exchange rate exposure model to Korean SMEs over 2007–2010, Choi⁽¹⁷⁾ found that a substantial number of firms were significantly exposed to exchange rate movements. The number of significantly exposed firms also increased during the period of large exchange rate fluctuations from September 2008 to May 2009. Badshah and Borgersen⁽¹⁸⁾ similarly argued that smaller financial buffers and difficulties in implementing both financial and operational hedging make exchange rate risk particularly challenging for SMEs. Financial volatility may therefore affect smaller firms through changes in costs and liquidity that cannot be fully mitigated through hedging. This mechanism is consistent with the proximity of small firms to exchange rate and interest rate volatility in the CA reported below.

Trade exposure, by contrast, is structurally concentrated among the largest firms. Bernard *et al.*⁽¹⁹⁾ reported that only 4% of firms in the United States exported in 2000 and that the top 10% of exporters accounted for 96% of export value; within the same industry, exporters employed approximately 97% more workers than non-exporters, and the 13.7% of exporters serving five or more destinations generated 92.9% of export value. These findings indicate that larger firms

operating across multiple international markets are more directly exposed to changes in trade policy and international regulations. Amiti *et al.*⁽²⁰⁾ further showed that the tariffs introduced by the United States in 2018 were passed through almost completely into the domestic prices of imported goods and accompanied by substantial changes in supply chain networks and reductions in the availability of imported varieties. Although these studies do not directly test the firms included in the present survey, they provide an objective basis for interpreting why trade disputes and export/import regulations may be more salient to large firms with established international supply chains.

Taken together, this literature suggests that the size-based associations observed in this study may reflect underlying firm characteristics rather than employment size alone. These characteristics include the degree of participation in international trade, the structure of foreign-currency transactions, the size of financial buffers, and the capacity to manage exchange rate risk. The cited evidence provides plausible mechanisms: smaller financial buffers and difficulties in implementing financial and operational hedging can make currency and interest-rate movements more salient to smaller firms, whereas participation in multi-country and multi-product trade can expose larger firms more directly to tariff changes, trade disputes, and supply chain reconfiguration. Because the present survey contains neither firm-level financial statements nor trade records, these mechanisms are used to interpret—not causally identify—the perceptual patterns reported in Sects. 4.2 and 4.3.

3. Methodology

In this section, we present the methodological framework used to analyze firm size differences in the perception of external environmental changes within the ocean and fisheries industry. In Sect. 3.1, we outline the formula for calculating the industry's *BSI*, derived from the enterprise survey and incorporating employee-size-based weighting. In Sect. 3.2, we describe the procedure for converting the single-response external environment questionnaire item into case-based frequency data, constructing contingency tables, and defining the key variables for analysis. In Sect. 3.3, we explain the application of the chi-square test of independence to examine whether the selection of external risk factors varies across firm characteristics. Finally, in Sect. 3.4, we describe in detail the use of CA, which visualizes the relative distance and structural relationships between firm size groups and major external risk factors in a two-dimensional space.

3.1 Calculation method for ocean and fisheries *BSI*

The *BSI* for the ocean and fisheries industry is derived from the Quarterly Business Survey conducted by the Korea Maritime Institute. To enhance its correspondence with economic indicators, the *BSI* is calculated by a weighted method that assigns different weights on the basis of employee-size categories. Firms in the five major sectors of the ocean and fisheries industry are classified into four employment size strata (1–49, 50–99, 100–299, and 300 or more employees), and weights are assigned accordingly. The formulas used to calculate the *BSI* by major industry category are as follows.

BSI by major sector:

$$BSI_i = \sum_{k=1}^4 w_{ik} \left\{ \frac{1}{n_{ik}} \sum_{j=1}^{n_{ik}} \left[\frac{X_{ijk} - 1}{3} \right] \times 100 \right\}. \quad (1)$$

Employment-weighted index:

$$BSI = \sum_{i=1}^5 W_i BSI_i. \quad (2)$$

Here, X_{ijk} denotes the response value measured on a seven-point Likert scale (1 = very bad, 2 = bad, 3 = somewhat bad, 4 = neutral, 5 = somewhat good, 6 = good, and 7 = very good), while n_{ik} represents the number of respondents. The subscript i refers to the five major sectors of the ocean and fisheries industry, j denotes an individual respondent, and k denotes the employment size group. In addition, w_{ik} is the employment weight applied to each size stratum, BSI_i is the *BSI* for sector i , and W_i indicates the industry-level weight.⁽²¹⁾

3.2 Data and variables

In this study, we utilized data from the 2025 Q2 Ocean and Fisheries Business Survey, specifically the survey questionnaire item asking respondents to identify “the external environmental change that most affected firm management”. This item requires each firm to choose a single external factor that exerted the greatest effect during the quarter, using a single-response format. More broadly, risk-perception research emphasizes that perceived risk reflects judgment about the significance of external hazards and can provide useful information for risk analysis and policy design.⁽²²⁾ The listed external environmental factors include global economic and exchange rate fluctuations, oil price volatility, export-related regulations, global supply chain disruptions, the diffusion of AI and digital technologies, and global environmental regulations. These items are designed to reflect the main external shocks or risks affecting firms in the ocean and fisheries industry.

The survey results are provided as cross-tabulated distributions by industry type, subsector, sales volume, and employment size. Because the raw data present response ratios, we reconstructed the dataset into observed frequencies, which are required for the chi-square test of independence and CA, by multiplying each ratio by the number of firms in each employment size group. Among the external factors, three categories with sufficiently large response counts were selected for analysis:

1. export decline,
2. exchange rate and interest rate volatility, and
3. trade disputes and export/import regulations.

The analytical procedure consists of two steps. First, response ratios were converted into observed frequencies to construct contingency tables. Second, these tables were used to conduct the chi-square test of independence and CA.

3.3 Chi-square test of independence

To identify whether perceptions of external environmental factors differ by firm characteristics, we conducted a chi-square test of independence. This non-parametric method is commonly used to examine whether two categorical variables are statistically independent and is appropriate for categorical survey data. The data used for analysis are the single-response selections of the most impactful external environmental factor, categorized by industry type, sales volume, and employment size. Because the survey provides results in percentage form, we converted the response ratios into observed frequencies using each group's sample size before constructing contingency tables. In addition to the chi-square statistic, degrees of freedom, and p-value, Cramer's V was calculated to report the magnitude of association. For the statistically significant employment size table, adjusted standardized residuals were examined as post-hoc diagnostics to identify the cells contributing most strongly to the overall association. Residuals with absolute values around 1.96 or greater were treated as notable departures from independence for interpretation, rather than as separate multiplicity-adjusted hypothesis tests.

3.4 CA

Since the chi-square test is limited to assessing statistical independence and does not provide information on the relative positioning of categories, CA was employed to visualize and interpret the structural relationships between firm size groups and external risk factors. CA is an exploratory data analysis technique that projects contingency table data onto a low-dimensional space. In this study, CA was conducted using a contingency table consisting of five employment size groups and three external environmental factors. Response ratios were first converted into observed frequencies. Because a 5×3 contingency table has at most $\min(5-1, 3-1) = 2$ nontrivial CA dimensions, the two-dimensional map necessarily contains all CA inertia. Accordingly, the percentages assigned to Dimensions 1 and 2 describe how total inertia is partitioned between the two axes; they are not interpreted as a goodness-of-fit measure or as evidence of a strong association. The CA map is therefore used as a descriptive complement to the chi-square test, Cramer's V, and the adjusted standardized residuals.

4. Results

In this section, we present the empirical results based on the results of the 2025 Q2 Business Survey for the ocean and fisheries industry, focusing on overall business conditions and firm size differences in external risk perception. In Sect. 4.1, we provide a time-series overview of the *BSI* from 2018 Q4 to 2025 Q2 in the ocean and fisheries industry. In Sect. 4.2, the chi-square test of independence indicates that only employment size exhibits statistically significant differences

in external risk perception. In Sect. 4.3, we apply CA to visualize the relative distances and structural relationships between employment-size categories and major external risk factors in a two-dimensional space, enabling an intuitive interpretation of the underlying perceptual patterns beyond what frequency counts or statistical tests alone can reveal.

4.1 BSI in ocean and fisheries industry

Figure 1 shows the quarterly time-series trends of the *BSI* in the ocean and fisheries industry from 2018 4Q to 2025 2Q. Before the pandemic, the *BSI* generally remained within the 70–80 range, but the onset of the pandemic in 2020 pushed the sector into a pronounced downturn. In particular, the *BSI* for 2020 2Q fell to 42.8—the lowest point in the entire series—reflecting the combined effects of global restrictions, disruptions in international logistics, and reduced offshore and coastal fishing activities. Beginning in 2021, however, the industry entered a recovery phase and gradually returned to pre-pandemic levels. This rebound was affected by the partial normalization of global supply chains and a recovery in international demand for fisheries products. Since 2022, both the assessment and outlook indices have remained around 90, indicating a more stabilized pattern and notably lower volatility than during the pre-pandemic period.

The period from 2023 to 2024 showed further stabilization in business conditions. Beyond the recovery from the pandemic shock, the industry began to benefit from accelerated digital transformation, the adoption of AI-based systems in each industry section, expanded port and logistics automation, and advancements in smart technologies. At the same time, international evidence suggests that digital transformation is uneven across firm sizes, as SMEs often face greater capacity constraints in adopting advanced digital technologies.⁽²³⁾ These improvements contributed to enhanced operational efficiency, reduced production and logistics management costs, and increased resilience to external uncertainties—all of which supported greater stability

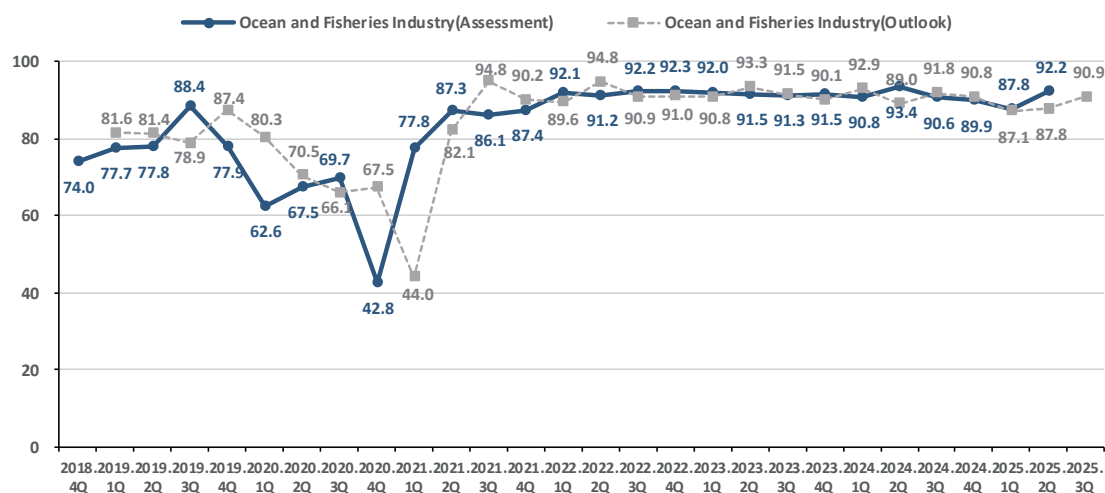


Fig. 1. (Color online) *BSI* in ocean and fisheries industry.

in business conditions. At the same time, strengthened environmental regulations and growing pressure for sustainable management also shaped industry performance. As examples, International Maritime Organization environmental rules, expanded European Union eco-labeling requirements for fisheries products, and stricter marine pollution regulations underscored the global shift toward sustainability and environmental responsibility. Although these developments initially imposed additional compliance costs on firms, they are expected to support a more stable industrial transition in the medium term by stimulating demand for eco-friendly equipment and smart technologies. This broader policy context also reflects the growing emphasis on enabling SMEs to participate in the twin sustainable and digital transitions while accounting for their heterogeneous needs and capabilities.⁽²⁴⁾

The *BSI* for 2025 2Q recorded 92.2, marking an improvement from the 2025 1Q. Overall, the ocean and fisheries industry experienced a sharp decline during the pandemic but recovered rapidly thereafter, returning to moderate levels of business activity by 2022 amidst increasing technological transformation and sustainability pressures. The conditions observed in 2024–2025 indicate that, beyond short-term economic effects, structural shifts—such as AI-enabled digitalization, automation, environmental, social, and governance requirements, and environmental regulations—are playing a growing role in reinforcing the industry’s stability and long-term resilience.

4.2 Results of chi-square test of independence

The chi-square test of independence was applied to identify whether the distribution of external environmental factor responses differed by industry type, sales volume, and employment size. The results are summarized in Table 3. Industry type and sales volume showed no statistically significant association with the response distribution at the 5% level. By contrast, employment size showed a statistically significant but modest association [$\chi^2(8, N = 191) = 15.959$, $p = 0.043$, and Cramer’s $V = 0.204$]. The expected-count condition was also acceptable: no expected cell count was below 1 and only one of the 15 cells (6.7%) was below 5. Adjusted standardized residuals were therefore examined to identify where the overall association was concentrated. The largest departures from independence occurred in the 100–199 and 200–299 employee groups, rather than uniformly across all five size groups. This result establishes an association in the 2025 Q2 sample; it does not establish that employment size causes the observed differences in risk perception.

Table 3
Chi-square test results on differences in external environmental factor perception across firm characteristics.

Group	χ^2	df	p -value	Cramer's V	Result
Industry type	12.904	8	0.1152	0.184	Not significant
Sales volume	11.653	8	0.1673	0.175	Not significant
Employment size	15.959	8	0.04297	0.204	Significant ($p < 0.05$)

Note: $N = 191$ for each test. Cramer's V is reported as an effect-size measure; the employment size association is modest ($V = 0.204$).

Table 4 shows the first-priority response frequencies for the three key external risk factors—export decline, exchange rate and interest rate volatility, and trade disputes and export/import regulations—by employment size, together with adjusted standardized residuals. The residuals show that the statistically significant association is concentrated primarily in the 100–199 and 200–299 employee groups. Figure 2 is then used to visualize the relative category configuration, but spatial proximity is not treated as evidence that every employment size group contributes equally to the association.

Table 4

Frequencies of first-priority external environmental factors affecting business operations by employment size characteristics.

Employment size	Export decline	Exchange rate/interest rate volatility	Trade disputes and export/import regulations
1–49 employees	19 (−0.46)	46 (1.67)	16 (−1.47)
50–99 employees	10 (−0.22)	18 (−1.01)	14 (1.39)
100–199 employees	12 (2.05)	9 (−2.36)	9 (0.67)
200–299 employees	4 (−0.30)	13 (2.00)	1 (−2.01)
300+ employees	3 (−1.10)	9 (−0.45)	8 (1.62)

Note: Observed frequencies are followed by adjusted standardized residuals in parentheses. Absolute residuals of approximately 1.96 or greater identify the cells contributing most strongly to the overall chi-square association; the residuals are used diagnostically rather than as separate multiplicity-adjusted tests.

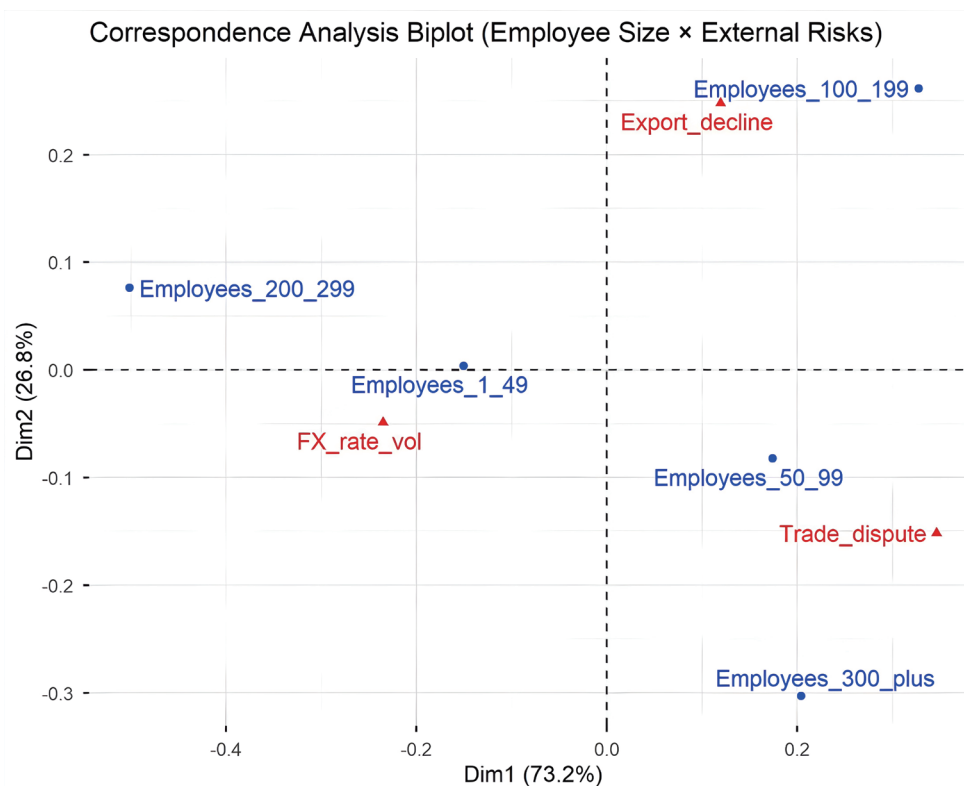


Fig. 2. (Color online) CA biplot of employment size and external risk factors.

The raw frequencies and residuals provide different but complementary information. Firms with 1–49 employees most frequently selected exchange rate/interest rate volatility, but none of this group’s adjusted residuals reached an absolute value of approximately 1.96. The same is true for the 50–99 and 300+ groups; their CA positions are therefore interpreted descriptively rather than as statistically distinctive group-specific effects. By contrast, the 100–199 group selected export decline more often than expected under independence (adjusted residual = 2.05) and exchange rate/interest rate volatility less often than expected (–2.36). The 200–299 group selected exchange rate/interest rate volatility more often than expected (2.00) and trade disputes/export-import regulations less often than expected (–2.01). These two groups account for the clearest cell-level departures underlying the overall employment size association.

4.3 Results of CA

In the preceding chi-square test of independence, employment size was identified as the only firm characteristic that exhibited statistically significant differences in the perception of external environmental factors. Building on this, the present subsection visualizes the relative relational structures between employment size groups and external risk factors using CA based on the same contingency table. Figure 2 shows the two-dimensional biplot illustrating the associations between employment size and external risks.

CA positions categories in a spatial configuration according to their response profiles, allowing the relative configuration of row and column categories to be visualized. Dimensions 1 and 2 accounted for 73.2 and 26.8% of total inertia, respectively. Because the 5×3 table permits only two nontrivial dimensions, these two percentages necessarily sum to 100%; they indicate only how total inertia is partitioned between the axes and should not be interpreted as a goodness-of-fit measure or as evidence of a strong association. The total inertia was 0.0836 ($\chi^2/N = 15.959/191$), consistent with the modest effect size reported by Cramer’s V (0.204). The axes are therefore interpreted descriptively, with the residual analysis used to identify which cells contribute most strongly to the association.

First, firms with 1–49 employees are located on the negative side of Dimension 1 and closest to “exchange rate/interest rate volatility”. The raw frequency for this category is also the highest within the group. However, the adjusted residual for exchange rate/interest rate volatility is 1.67, below the approximately 1.96 diagnostic threshold used here. Accordingly, the CA proximity is treated as a descriptive feature of the map rather than evidence of a statistically distinctive small-firm effect.

Second, firms with 50–99 employees are positioned on the positive side of Dimension 1 and the negative side of Dimension 2, between “exchange rate/interest rate volatility” and “Trade_dispute”. Although the map points toward the trade policy category relative to some other groups, none of the adjusted standardized residuals for the 50–99 group is large (–0.22, –1.01, and 1.39). Its CA position should therefore be interpreted only as a relative configuration in the two-dimensional map, not as evidence of elevated or statistically distinctive sensitivity to trade policy risk.

Third, firms with 100–199 employees appear in the upper-right quadrant of the biplot, close to “Export_decline”. This pattern is supported by the residual analysis: export decline was

selected more often than expected under independence (adjusted residual = 2.05), whereas exchange rate/interest rate volatility was selected less often than expected (−2.36). The 100–199 group is therefore one of the principal contributors to the overall chi-square association.

Fourth, firms with 200–299 employees are located in the upper-left region of the plot and distinctly oriented toward “exchange rate/interest rate volatility”. The previous interpretation of this group as being closer to the origin and having a relatively balanced or diversified risk profile was incorrect and has been removed. The adjusted standardized residuals show a positive departure for exchange rate/interest rate volatility (2.00) and a negative departure for trade disputes and export/import regulations (−2.01). Thus, this group is also one of the principal contributors to the overall association.

Finally, firms with 300 or more employees are situated on the positive side of Dimension 1 and the negative side of Dimension 2, closest to “Trade_dispute”. This position indicates relative proximity in the CA map, but it does not mean that trade disputes were the most frequently selected response or that this group contributes significantly more than the others. Table 4 shows nine responses for exchange rate/interest rate volatility and eight responses for trade disputes and export/import regulations, while the adjusted residual for the trade policy category is 1.62. The large-firm placement is therefore interpreted descriptively, with financial volatility remaining similarly important in the raw counts.

5. Discussion

The empirical results show that employment size is associated with how firms classified the external factor that most affected management in 2025 Q2, but the magnitude of this association is modest (Cramer’s $V = 0.204$). Industry type and sales volume were not significantly associated with the response distribution. Importantly, the post-hoc residual analysis shows that the employment size association is not distributed uniformly across all five groups: the clearest departures from independence occur in the 100–199 and 200–299 employee groups. CA is therefore used as a descriptive visualization of the overall category configuration rather than as evidence that every group displays an equally strong size-specific pattern. This result extends previous studies that identified size-related heterogeneity in financial and market risk perception among European SMEs.^(14–16) The associations should nevertheless be interpreted as descriptive and relational because organizational capacity, trade participation, financial structure, and other unobserved characteristics were not directly measured. This cautious interpretation is also consistent with foundational research on risk perception and with international policy frameworks that emphasize firm heterogeneity and digital transformation among SMEs.^(22–24)

For firms with 1–49 employees, the CA map places the group closest to exchange rate and interest rate volatility, and this category has the highest raw frequency within the group. However, the adjusted residual does not identify this cell as one of the strongest departures from independence. The small-firm pattern should therefore be treated as descriptive. Its direction is nonetheless consistent with the possibility that financial market fluctuations become more salient when firms have smaller financial buffers and limited capacity to manage exchange rate risk. The International Finance Corporation,⁽²⁵⁾ Choi,⁽¹⁷⁾ and Badshah and Borgersen⁽¹⁸⁾ provide plausible contextual mechanisms, but not direct evidence for the firms in this survey.

For firms with 50–99 employees, the CA map places the group between financial volatility and trade policy risk. Because none of its adjusted standardized residuals is large, the map does not support a claim of statistically distinctive trade policy sensitivity. Accordingly, the previous statement that trade policy influence was stronger in this group has been removed; its position is retained only as a descriptive configuration.

Firms with 100–199 employees show the clearest positive departure for export decline (adjusted residual = 2.05) and a negative departure for exchange rate/interest rate volatility (−2.36). This pattern indicates that this group contributes materially to the overall employment size association. The result is consistent with the possibility that firms at this stage of scale are particularly responsive to overseas demand and export-order conditions, although the present survey does not directly observe export dependence. Policy implications for this group should therefore be framed as targeted hypotheses for export market information and demand monitoring support rather than as causal conclusions.

Firms with 200–299 employees also contribute materially to the overall association. They selected exchange rate/interest rate volatility more often than expected under independence (adjusted residual = 2.00) and trade disputes/export-import regulations less often than expected (−2.01). This evidence contradicts the previous interpretation of the group as having a more balanced or diversified risk profile. The revised interpretation is that financial volatility is comparatively distinctive for this group in the 2025 Q2 response distribution.

For firms with 300 or more employees, the CA map places the group closest to trade disputes and export/import regulations, but the raw counts are nearly balanced between exchange rate/interest rate volatility (nine responses) and trade policy risk (eight responses), and the adjusted residual for the latter is 1.62. The large-firm position should therefore be interpreted descriptively rather than as a statistically distinctive group effect. Bernard *et al.*⁽¹⁹⁾ and Amiti *et al.*⁽²⁰⁾ still provide a plausible basis for why trade policy and regulatory risks may be salient to internationally connected large firms, but they do not establish that mechanism in the present sample.

Overall, the 2025 Q2 evidence supports a modest association between employment size and external-risk responses, with the strongest cell-level departures concentrated in the 100–199 and 200–299 groups. The locations of the remaining groups in the CA map provide useful descriptive context but should not be interpreted as equally strong effects. Prior studies on exchange-rate exposure, hedging constraints, exporting, and supply chain exposure remain useful for interpreting possible mechanisms, but the present cross-sectional survey cannot establish that firm size itself causes a particular risk perception. Longitudinal and linked firm-level analyses are needed to test whether the observed patterns persist and whether the proposed mechanisms explain them.

These results suggest that policy design may benefit from attention to firm heterogeneity, but the implications should be treated as indicative rather than as evidence of statistically distinct needs for every employment-size group. The clearest empirical basis in this sample concerns the 100–199 group's relative emphasis on export decline and the 200–299 group's relative emphasis on financial volatility. Descriptive CA patterns for smaller and larger firms may still guide the design of market information, financial risk, and regulatory monitoring tools, but such measures

should be validated with repeated or linked firm-level data before being presented as size-specific causal responses.

6. Conclusions

In this study, we examined how external-risk responses varied across firm size groups using the 2025 Q2 *BSI* for the ocean and fisheries industry. The chi-square test identified a statistically significant but modest association only for employment size [$\chi^2(8, N = 191) = 15.959, p = 0.043$, and Cramer's $V = 0.204$]; industry type and sales volume were not significantly associated with the response distribution. Adjusted standardized residuals showed that the overall association was concentrated primarily in the 100–199 and 200–299 employee groups.

Specifically, firms with 100–199 employees selected export decline more often than expected under independence and exchange rate/interest rate volatility less often than expected, whereas firms with 200–299 employees selected exchange rate/interest rate volatility more often and trade policy risk less often than expected. The CA map provides a descriptive visualization of the relative positions of all five size groups, but the proximity of the 1–49, 50–99, and 300+ groups to particular risk categories should not be interpreted as equally strong group-specific effects. Prior firm-level studies provide plausible explanations through differences in hedging capacity, financial buffers, international-trade participation, and supply chain exposure, but these mechanisms were not directly observed in this survey.

The findings therefore support cautious, size-aware policy design rather than a one-size-fits-all approach. In the present sample, the strongest empirical signals suggest attention to export demand and market information support for the 100–199 group and financial volatility management for the 200–299 group. Patterns observed for smaller and larger firms may still guide exploratory policy design, but they should be validated with repeated observations and firm-level financial or trade data before being treated as statistically distinct needs.

The results also remain relevant to sensing technology deployment in the ocean and fisheries industry. Vessel monitoring, aquaculture water quality sensing, cargo tracking, satellite observation, and port automation all require investment decisions under external uncertainty. However, because the present residual analysis does not establish equally strong size-specific effects for every group, implications for sensing adoption should likewise be framed cautiously. Technology support programs may need to account for heterogeneous financial, export demand, and regulatory constraints, but sensing adoption itself was not measured in the survey and should be examined directly in future linked-data research.

Nevertheless, this study has several limitations. The analysis relied on cross-sectional data from a single quarter (2025 Q2), focused on three external-risk categories, and used reconstructed frequencies from published cross-tabulations. The survey does not collect firm-level financial statements, export/import shares, hedging behavior, or sensing technology investment. Accordingly, the mechanisms proposed in Sect. 2.4 could not be tested directly, and the analysis supports association rather than causal inference. A necessary next step is to link repeated *BSI* responses—subject to confidentiality safeguards—to firm-level financial statements, customs or trade records, and technology-investment indicators. Such linked longitudinal data will permit direct tests of whether financial structure and trade exposure

mediate the relationship between employment size and risk perception. Despite these limitations, this study provides empirical evidence of size-related heterogeneity in the ocean and fisheries industry and a foundation for more targeted policy design.

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Conceptualization and design of the business survey index, S. Kim, J.-I. Chang, S. Jeong, and Y. Oh; formal analysis, S. Kim and Y. Oh; data curation, S. Kim and J.-I. Chang; writing—original draft preparation, S. Kim and Y. Oh; writing—review and editing, S. Kim and Y. Oh; supervision, S. Kim. All authors have read and agreed to the published version of the manuscript.

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