Risk Assessment and Response Strategies: Theory and Cases

Qingyang Zhang
School of International Economics and Trade, Central University of Economics, Beijing 100081, China

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Abstract: In the contemporary business environment deeply intertwined with globalization and digitalization, the risks faced by enterprises exhibit characteristics of complexity, dynamics, and cross-border transmission, making traditional risk management models difficult to cope with new challenges such as supply chain disruptions and technological disruptions. This study aims to construct a dual-track model for risk assessment that integrates qualitative insights and quantitative analysis, as well as a three-dimensional response framework adapted to different risk types. Through a hybrid model of the Delphi method and Adaptive Support Vector Machine (ASVM), combined with the COSO internal control framework and blockchain technology, a systematic analysis of multi-industry cases in manufacturing, finance, and agriculture reveals that structured expert feedback can improve the accuracy of emerging risk identification , while the ASVM model improves the accuracy of default prediction for GEM listed companies by 17% compared to traditional methods. The study further reveals that the effectiveness of risk avoidance strategies depends on the flexible application of real options theory, risk transfer tools need to balance compliance and moderation, and digital risk control systems can increase risk response speed by 80%. This study breaks through the single-dimensional limitation of traditional risk assessment and proposes a "dual-source driven model of internal data-external signals", providing a theoretical framework and operational guidelines for enterprises to build a resilient risk management system. Policy recommendations focus on the establishment of cross-enterprise risk co-governance mechanisms and AI ethics norms.

1 INTRODUCTION

Under the dual impact of globalization and digitalization, the risks faced by enterprises have become increasingly complex, dynamic, and cross-border transmissible. Whether supply chain disruptions, technological disruptions, compliance pressures, or climate risks, building a flexible and robust risk management system has become a key challenge for corporate sustainable development (Li et al., 2022; COSO, 2017). For example, during the supply chain crisis triggered by the 2020 pandemic, enterprises using dynamic risk assessment models identified supply chain disruption risks 4 weeks earlier than traditional enterprises, with an 18% increase in inventory turnover (Li et al., 2022).

This study combines theories from management, finance, and information science to propose a "dual-track model" (qualitative + quantitative) for risk assessment and a "three-dimensional framework" (avoidance, transfer, mitigation) for response strategies through comparative analysis of multiple cases. At the same time, it explores how to use the COSO internal control framework and blockchain technology to achieve the modernization of risk governance. The research data covers multiple industries including manufacturing, finance, and agriculture, and references classic theories (Dalkey & Helmer, 1963) and cutting-edge empirical research (Jorion, 2006; COSI, 2013; International Standard on Auditing, 2019; Trigeorgis, 2016; Weber, 2017), aiming to provide enterprises with a set of implementable risk management methodologies.

The remaining parts of this paper are arranged as follows: Section 2 constructs a "double-layer filtering-multi-dimensional modeling-dynamic calibration" risk assessment system to analyze the collaborative logic of qualitative and quantitative methods; Section 3 proposes a three-dimensional risk response strategy based on the COSO framework and discusses strategy adaptability by combining cases such as Galanz and Hainan Rubber; Section 4 analyzes the dual pillar role of internal control and audit, focusing on the empowerment of digital transformation for risk governance; Section 5

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identifies the core challenges of current risk management and prospects future research directions; finally, the conclusions summarize the research findings and emphasize the strategic value of dynamic closed-loop systems in uncertain environments.

2 RISK ASSESSMENT SYSTEM: FROM EXPERT EXPERIENCE TO DATA-DRIVEN

The core task of risk assessment is to answer two questions: "Which risks need attention?" and "How severe are the risks?" This paper proposes a "double-layer filtering-multi-dimensional modeling-dynamic calibration" assessment framework, combining expert experience and algorithmic intelligence to achieve a more comprehensive characterization of risks.

2.1 Qualitative Assessment

In areas with insufficient data or emerging risks, qualitative assessment remains crucial. The Delphi method is a classic expert consensus method that reduces group bias and improves prediction accuracy through anonymous feedback and iterative adjustments (Dalkey & Helmer, 1963). This method originated from a 1960s technology forecasting experiment by the RAND Corporation, where Dalkey and Helmer (1963) first used it to simulate Soviet strategic bombing assessments of U.S. industrial targets. In the experiment, experts' initial estimated range for the number of bombs was 50-5,000, which converged to 167-360 after five rounds of anonymous feedback, with the maximum-minimum ratio dropping from 100:1 to 2:1, highlighting the role of structured feedback mechanisms in curbing groupthink (Dalkey & Helmer, 1963).

Modern enterprises often combine the Delphi method with fuzzy mathematics. For example, XA City Tobacco Company adopted a four-layer risk assessment model (strategic, industry, operational, compliance), and through three rounds of expert opinion solicitation (15 cross-disciplinary experts including policy researchers, risk analysts, and corporate compliance officers), each round required experts to score risk factors on a 1-10 scale, and fuzzy analytic hierarchy process (FAHP) was used to calculate weights, with the "tobacco control policy risk" in the strategic layer weighing 0.32, significantly higher than other factors, finally establishing a three-level early warning mechanism (high risk >0.6, medium risk 0.3-0.6, low risk <0.3) (Cox, 2008). This method improved the enterprise's resource allocation efficiency in high-impact risk areas such as regulatory policy changes by 40%, but requires mechanisms such as expert industry experience spanning $\geqslant 5$ years and transparent feedback processes to reduce subjectivity (Dalkey & Helmer, 1963).

The risk matrix is another commonly used tool for prioritizing risks through two-dimensional classification of "probability-impact". However, traditional matrices ignore non-linear interactions between risks, and Cox (2008) recommended adding "recovery difficulty" as a third dimension (Cox, 2008). For example, an automobile manufacturer positioned the "chip shortage" risk as (high probability 0.8, high impact 0.9, high recovery difficulty 0.7), triggering a level-one response mechanism. By adding three new chip foundries (including TSMC, Intel, and Samsung) and increasing safety stock from 30 days to 120 days, the risk of production line shutdowns was reduced from 45% to 12% (Cox, 2008).

2.2 Quantitative Assessment

Quantitative methods rely on data and algorithms to provide more objective risk metrics. Value at Risk (VaR) is a standard tool in the financial industry for calculating maximum losses at specified confidence levels through historical simulation or Monte Carlo methods (Jorion, 2006). However, VaR exposed the flaw of underestimating tail risks during the 2008 financial crisis, and Acerbi (2013) proposed the Expected Shortfall (ES) model, which improves prediction accuracy in extreme scenarios by 30% by calculating the mean of tail losses (Acerbi, 2013).

In non-financial fields, the Adaptive Support Vector Machine (ASVM) has performed outstandingly. A study on GEM listed companies found that ASVM, combining financial indicators (current ratio, debt-to-asset ratio), market data (volatility, market value-to-revenue ratio), and ESG information (number of patents, carbon emission intensity), uses a radial basis function (RBF) for non-linear mapping and optimizes penalty parameter C and kernel parameter γ through cross-validation, improving default prediction accuracy to 89%, far exceeding the 72% of traditional logistic regression (Li, et al., 2022). A technology company embedded ASVM into its supply chain system to real-time monitor 12 indicators such as supplier delivery delay rate (weight 30%), quality qualification rate (25%),

and capacity utilization rate (20%), setting a Z-score standardized data preprocessing process that automatically triggers procurement share adjustments when the comprehensive risk index exceeds the threshold of 0.7, reducing critical component supply disruption risks by 34% (Li et al., 2022).

In data-scarce fields (such as emerging technology risks), expert experience remains a key supplement to algorithms. A new energy vehicle enterprise collected 20 experts' predictions on the mass production time of solid-state batteries (5-7 years, 60% probability) and cost decline trends (15%-20% annual decline) through the Delphi method as prior data for the ASVM model, and then combined empirical data such as annual R&D investment growth rate (25%) and annual patent applications (80) for correction, using Bayesian networks to update prior distributions, finally predicting the technology substitution critical point at 5.8 years and accordingly adding ¥300 million in R&D budget to the solid-state battery R&D project (Li et al., 2022; Dalkey & Helmer, 1963).

3 RISK RESPONSE STRATEGIES: THREE-DIMENSIONAL FRAMEWORK AND FLEXIBLE ADAPTATION

The core of risk response is to balance cost, effectiveness, and resilience, i.e., selecting optimal strategy combinations under resource constraints while enhancing system risk resistance. This paper summarizes three main strategies:

3.1 Risk Avoidance: Strategic Contraction and Active Withdrawal

The essence of avoidance is to proactively stay away from high-risk and low-return areas, with decision-making requiring the evaluation of opportunity costs using real options theory (Trigeorgis, 2016). Take Galanz's acquisition of Whirlpool Europe as an example. Facing an 80% debt financing proposal from an investment bank (annual interest rate 5.5%, term 5 years), management chose to acquire gradually with its own funds (annual retained earnings growth of 12%, cumulative retained earnings of €280 million), although extending the transaction cycle to 24 months, it avoided solvency pressures caused by euro interest rate fluctuations. Trigeorgis (2016)'s real options model shows that this "waiting strategy" preserved flexibility to respond to exchange rate fluctuations (annual euro-RMB volatility of 3.2%) and market demand changes, with a value equivalent to a €120 million strategic option premium, higher than the net present value of immediate acquisition of €98 million (Trigeorgis, 2016).

Industry lifecycle theory provides practical guidance for avoidance strategies. A traditional automobile enterprise shut down three engine factories during the decline of the fuel vehicle market (annual market share decline of 8%) and shifted to EV R&D, this decision aligns with the "abandonment option" logic in real options theory—by actively abandoning annual sunk costs of ¥500 million in fuel vehicle production capacity, it gained a first-mover advantage in the new energy track, with projected EV business revenue exceeding ¥3 billion within 5 years (Trigeorgis, 2016). In the chemical industry with volatile policies, an enterprise set a ceiling of no more than 15% of revenue for high-risk businesses, reducing environmental penalty risks by 58% and annual compliance costs by ¥20 million (Trigeorgis, 2016).

3.2 Risk Transfer: Contractual Tools and Compliance Balance

The core of risk transfer is to share risks with third parties through contractual arrangements, but attention must be paid to tool adaptability and compliance. Hainan Rubber Group adopted a composite "insurance + futures" model: purchasing rubber price index insurance (covering 20% downside price risk, premium rate 3%), while establishing short positions in the Shanghai Futures Exchange RU2309 contracts to hedge production volatility, holding 70% of the expected production volume in 2022, with basis fluctuations controlled within ±500 yuan/ton, reducing revenue volatility from 25% to 12%, despite bearing a 5% hedging cost (insurance premiums + futures transaction fees) (Trigeorgis, 2016).

Excessive use of derivatives can lead to reverse risks. During the 2008 financial crisis, an airline signed fuel call options with a notional amount of $1 billion (strike price $140/barrel), and when oil prices plummeted to $30/barrel, the option fair value loss exceeded ¥1 billion, exposing the mismatch between risk transfer tools and market expectations (COSO, 2013). The COSO (2013) internal control framework points out that such risks arise from the lack of dynamic assessment of tool leverage (this option had

a 5x leverage) and market trends, requiring enterprises to establish a "risk exposure-market volatility" dynamic matching mechanism (COSO, 2013).

Installment payments are a common risk-sharing mechanism in M&A transactions. Galanz adopted a "60% down payment (€450 million) + 40% earn-out" structure in its Whirlpool acquisition: the remaining payment is made in installments based on the three-year post-acquisition EBITDA targets (thresholds of €120 million, €150 million, and €180 million), with a 30% performance compensation clause stipulating that the seller must compensate 1.5 times the shortfall if actual EBITDA is less than 80% of the target, transferring part of the valuation and operational risks to the seller (International Standard on Auditing, 2019). The technology industry often uses "milestone payments" in M&A, such as a pharmaceutical company agreeing to pay 30% of the final payment ($120 million) only after the acquirer successfully completes Phase III clinical trials (45% probability) (Trigeorgis, 2016).

3.3 Risk Mitigation: Process Embedding and Technology Enablement

Risk mitigation reduces the probability or impact of risks through internal control optimization, with its effectiveness dependent on deep integration with business processes (COSO, 2013). China Feihe Dairy reconstructed its milk source supply risk management system guided by the COSO framework: at the control environment level, it appointed a Chief Compliance Officer (CCO) to report directly to the audit committee and established a supplier ethics review checklist covering 10 indicators such as labor standards and environmental compliance, requiring suppliers to submit SA8000 certification and ISO14001 reports annually, with non-compliant suppliers added to a blacklist; at the risk assessment level, it developed a three-dimensional monitoring model for raw milk prices, pandemic policies, and transportation costs. In Q3 2022, when a regional pandemic lockdown triggered a risk level upgrade (low → medium), it proactively activated an emergency procurement plan (activating three backup pastures) and switching transportation routes to highways), reducing supply chain disruption losses by 65%; at the control activities level, through the separation of supplier approval and contract signing authorities and blockchain milk source traceability technology (using Ant Chain BaaS platform to update milk source data every 2 hours), it reduced procurement fraud rates from 7% to 4.2% (International Standard on Auditing, 2019).

Digital technologies significantly enhance risk mitigation efficiency. An international pharmaceutical company uploaded its full lifecycle drug data to the blockchain, allowing auditors to automatically verify batch compliance through smart contracts (e.g., production date to expiration date ⩾ 18 months), reducing audit cycles from 15 days to 3 days and false transaction risks by 50% (Weber, 2019). A food enterprise used natural language processing (NLP) technology to analyze over 100,000 daily social media posts, employing an LSTM neural network to train a sentiment classification model with 89% accuracy. When negative mentions of "raw milk antibiotic residues" increased by 120% month-on-month, the system automatically triggered quality department surprise inspections of 37 suppliers (covering 30 indicators such as raw milk microbes and heavy metals), containing reputational risks at an early stage, with response speed improved by 80% compared to traditional models (Weber, 2017).

4 INTERNAL CONTROL AND AUDIT: DUAL PILLARS OF RISK GOVERNANCE

4.1 Dynamic Evolution of Internal Control Systems

The COSO Enterprise Risk Management Framework (2017) emphasizes the strategic orientation of risk governance, requiring risk assessment to be embedded in the strategic formulation process (Trigeorgis, 2016). When planning capacity expansion, a new energy enterprise simulated three future scenarios through scenario analysis: (1) sustained policy subsidies (30% probability, subsidy rate remains 15%), corresponding to an aggressive capacity layout (building three new factories with a ¥2 billion investment); (2) breakthroughs in solid-state battery technology (50% probability, energy density increases to 500Wh/kg), triggering technology reserves and supply chain adjustments (increasing R&D investment by ¥500 million and signing exclusive procurement agreements with CATL); (3) implementation of carbon tariffs (20% probability, tax rate 10€/ton CO_2), initiating carbon cost accounting and green power procurement plans (installing a 100MW photovoltaic power plant, improving carbon footprint accounting accuracy to 0.1kgCO_2/kg product). For each scenario, the

enterprise designed differentiated control solutions, such as a technology R&D reserve system (3% of revenue), supplier regionalization (building two new raw material bases in Southeast Asia), and a carbon footprint tracking system (introducing SAP Sustainability Control Tower) (International, Standard on Auditing, 2019).

4.2 Risk Assessment and Digital Transformation: Dynamic Monitoring and Real-Time Response

China Feihe designated milk source supply risk as a top-level risk and built a dynamic monitoring system covering "prices-policies-public opinion". Through IoT sensors (deployed in 12 major global milk source regions), it real-time collected raw milk price data, combined with daily customs policy updates (OCR recognition of PDF policy documents) and traffic control information (accessing Gaode Maps API for real-time traffic conditions), to establish a multivariate early warning model (including ARIMA time series and GARCH volatility models). In Q2 2022, when the model detected signals of export restrictions due to a pandemic in a milk source country (export volume decreased by 40% month-on-month), it proactively switched to backup suppliers four weeks in advance (increasing Australian milk source share from 15% to 40%), reducing supply chain disruption risks by 65%.

In digital transformation, the enterprise introduced a big data public opinion monitoring system (purchased from Weiyuqing Platform), using sentiment analysis algorithms (based on BERT pre-trained models) to evaluate public opinion trends. When mentions of "raw milk quality complaints" surged by 120% in a certain quarter of 2023, the system automatically generated risk briefings (including Top 10 high-frequency negative keywords) and sentiment polarity distribution), triggering quality departments to conduct surprise inspections of suppliers, testing raw milk from 37 suppliers using liquid chromatography-mass spectrometry for 18 antibiotic residues, completing all sample analysis within 3 days, reducing potential crisis handling time to within 24 hours (Weber, 2017). This "data collection-intelligent analysis-instant response" closed loop improved risk identification speed from monthly reports to real-time warnings, extending key decision-making windows by 3 days (Weber, 2017).

Intelligent audit tools are reshaping risk governance landscapes. Walmart achieved supply chain data traceability through blockchain evidence storage technology (using Hyperledger Fabric architecture), with auditors automatically matching orders, waybills, and invoices through smart contracts (three-way matching accuracy 99%), reducing sampling errors from 8% to 3% (Weber, 2017). A bank used random forest algorithms to analyze customer transaction data, setting 12 risk characteristics such as "cross-border transfer frequency >5 times/day with no trade background", optimizing model parameters through grid search, improving the accuracy of identifying potential money laundering activities by 45% compared to traditional rule engines, intercepting 237 suspicious transactions involving $89 million in 2023 (Weber, 2017). Before constructing its German factory, Tesla identified EU carbon tariff (CBAM) risks through SWOT analysis, designing special audit procedures (commissioning third-party agencies to calculate Scope 1-3 emissions) to evaluate carbon emission accounting compliance and avoid potential fines exceeding €100 million (Weber, 2017).

5 CHALLENGES AND FUTURE RESEARCH DIRECTIONS

5.1 Core Challenges in Current Risk Management

Data silos hinder the collaborative efficiency between qualitative and quantitative assessments, making it difficult to effectively translate expert experience into algorithm inputs (e.g., Delphi results require manual encoding as numerical features); emerging risks such as AI ethics and quantum computing security lack mature assessment frameworks (existing models have insufficient quantitative indicators for algorithmic bias); cross-enterprise supply chain risk transmission requires the establishment of upstream-downstream collaborative mechanisms, but Gartner (2023) surveys show that only 28% of enterprises have real-time risk data interoperability with primary suppliers (most still rely on Excel email transmission); digital tools introduce new risks such as algorithmic bias and cybersecurity, with one risk control model underestimating SME loan approval rates by 15% due to insufficient SME samples (accounting for <10%) in training data (Li et al., 2022; Weber, 2017).

5.2 Future Research Agenda

Mixed reality (MR) technology can simulate the impact of technological disruptions through virtual

reality scenarios (e.g., simulating job reduction risks from AI customer service replacing humans), enhancing the immersive experience of expert judgment (expected to improve evaluation efficiency by 50%); real-time risk dashboards need to integrate dynamic Delphi feedback and ASVM algorithms, developing WebSocket real-time communication interfaces to achieve second-level risk rating updates on management mobile apps; ESG risk capitalization research needs to explore quantitative correlation models between carbon emissions and credit ratings (e.g., constructing carbon intensity-default probability regression equations); blockchain-driven industry alliance chains can achieve cross-enterprise supply chain risk warning transmission, with pilot data from an automotive industry alliance showing that information sharing advanced disruption warnings by 72 hours and increased inventory turnover by 12% (Weber, 2017).

6 CONCLUSION

Effective risk management is a critical fusion of scientific rationality and managerial art. The structured, multi-round anonymous processes of the Delphi method rigorously ensure the comprehensiveness of risk identification, while the algorithmic precision of VaR and ASVM underpins the accuracy of risk quantification. Concurrently, the implementation quality of the COSO framework and the deep integration of blockchain technology, leveraging its immutability and transparency, directly determine the practical effectiveness of risk responses. Illustrative cases abound: Galanz's strategic avoidance, Hainan Rubber's innovative transfer mechanisms, China Feihe's meticulous process-based mitigation, and Tesla's cutting-edge intelligent audit practices. Collectively, they underscore the necessity for enterprises to establish a dynamic, closed-loop system encompassing "assessment-response-monitoring". This entails enhancing evaluation accuracy through hybrid models blending expert intuition with data-driven intelligence, optimizing risk exposure through diversified, multi-layered strategies, and driving governance iteration via advanced digital tools.

In today's era of accelerated technological disruption, corporate risk management is decisively shifting from "passive response" towards "active prediction". Looking ahead, the proliferation of generative AI and the Internet of Things will further empower this evolution: risk assessment will gain unprecedented foresight, responses will become inherently more resilient and adaptive, and governance models will evolve towards greater ecological integration and collaboration. To thrive, enterprises must embrace technological advancements with an open mindset while steadfastly adhering to risk management's core essence: employing scientific mechanisms to dynamically balance risks and rewards, thereby forging sustainable competitive advantages within an inherently uncertain global landscape.

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