

ORIGINAL SCIENTIFIC PAPER

THE IMPLICATIONS OF ENVIRONMENTAL UNCERTAINTY ON ENTERPRISE OPERATIONS, FINANCING, AND INVESTMENTS: A SYSTEMATIC LITERATURE REVIEW

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ABSTRACT

Environmental uncertainty (EU) ranging from geopolitical shocks to climate- and policy-related volatility has emerged as a critical challenge for firms worldwide. This systematic review integrates and updates recent research to clarify the multifaceted impacts of EU on corporate operations, financing, and investment. Using bibliometric and qualitative analyses of SSCI-indexed articles (2014–2024), we find that heightened EU consistently leads firms to adopt precautionary measures (e.g., increased cash holdings and supply-chain adjustments) and exacerbates information asymmetry and agency conflicts. In finance, EU raises external financing costs, for example through wider risk premiums, thereby slowing credit access for vulnerable firms. The effects on investment are complex: many studies report EU-induced investment slowdowns, although some contexts exhibit opportunistic investment (e.g., in innovation) when uncertainty is interpreted as an opportunity. This review contributes to the state of the science by (1) aggregating interdisciplinary evidence to resolve contested findings (e.g., whether EU inhibits or encourages investment), (2) uncovering emerging themes in recent work (e.g., the role of AI in mitigating climate-policy uncertainty), and (3) mapping critical gaps most notably the need for more regional and sectoral analyses. By systematically synthesizing these insights, we frame practical implications: managers are advised to strengthen risk management (e.g., diversify funding sources and invest in digital tools), while policymakers are encouraged to improve policy stability and support (e.g., through subsidies and supply-chain resilience initiatives) in order to mitigate the negative impacts of EU on firm performance.

Keywords: environmental uncertainty; corporate finance; operations management; investment decisions; risk management; ESG.

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INTRODUCTION

Global “black swan” events (e.g., pandemics, wars, and policy shifts) have made business environments more volatile than ever [1]. Scholars note that environmental uncertainty (EU) defined as the difficulty of predicting how external factors will affect a firm profoundly influences enterprise outcomes [2][3][4]. EU arises from macro-level factors (economic cycles, fiscal or trade policies, and geopolitical risks) as well as micro-level factors (market demand and price volatility, and technological change) ([2][5]. As uncertainty deepens, firms struggle to anticipate future states, thereby magnifying information asymmetries and investment risk [4].

Although many empirical studies have examined aspects of the impact of EU, the literature remains fragmented. Prior work often focuses on a single domain (operations, financing, or investment) or a single region, and reports mixed findings. For example, some research shows that EU discourages corporate R&D and capital expenditures, consistent with precautionary investment models [6]. Yet other studies suggest that EU can spur innovation or unrelated diversification in dynamic markets if firms view uncertainty as an opportunity, in line with agency and pecking-order theories [7][8]. Similarly, studies of capital structure under EU indicate that high uncertainty leads to higher debt costs; however, there is still no clear consensus on how EU affects internal financing. Moreover, the impact of EU on internal funding choices, as well as differential access to bank versus public markets, remains underexplored [9][10]. This review addresses these gaps by systematically mapping recent research on EU and deriving actionable insights. We analyze 44 carefully selected SSCI articles published between 2014 and 2024 and highlight contributions to theory and practice, particularly in the context of changing global dynamics (e.g., accelerating climate policies and shifting trade patterns).

This review contributes to the state of the science by (1) aggregating interdisciplinary evidence to resolve contested findings (e.g., whether EU inhibits or encourages investment), (2) uncovering emerging themes in recent work (e.g., the role of AI in mitigating climate-policy uncertainty), and (3) mapping critical gaps—most notably the need for more regional and sectoral analyses. By systematically synthesizing these insights, we frame practical implications: managers are advised to strengthen risk management (e.g., diversify funding sources and invest in digital tools), while policymakers are encouraged to improve policy stability and support (e.g., subsidies and supply-chain resilience measures) in order to mitigate the negative impacts of EU on firm performance.

METHODOLOGY

We followed a systematic review protocol [11][12], combining bibliometric mapping with qualitative synthesis.

Using the Web of Science (WoS) database, we searched for articles published between 2014 and 2024 using keywords related to environmental uncertainty, enterprise operations, finance, and investment (e.g., “environmental uncertainty” AND [firm, enterprise, company] AND [invest*, operat*, financ*]). The initial search yielded 381 articles, which were subsequently narrowed by filtering for SSCI-indexed journals, relevant disciplines (economics, management, and finance), the English language, and research and review article types. After title and abstract screening, 44 articles remained for full analysis (see **Error! Reference source not found.** for the selection flow).

We then conducted quantitative bibliometric analyses (publication trends and keyword co-occurrence) to identify dominant themes and research gaps. Key terms and citation counts were extracted, revealing “performance”, “innovation”, “supply chain”, “financing”, and “investment” as recurrent themes. Finally, each article was read in depth and qualitatively coded to assess the effects of EU on operations, financing, and investment, while noting moderating factors (e.g., firm size, sector, and region) and theoretical explanations (e.g., the resource-based view and agency theory).

Our analysis also incorporates updated sources, including working papers and journal articles published in early 2025, ensuring that the literature base reflects the most recent developments (for instance, a 2025 empirical study on the role of AI in mitigating climate-policy uncertainty in energy firms; [13]).

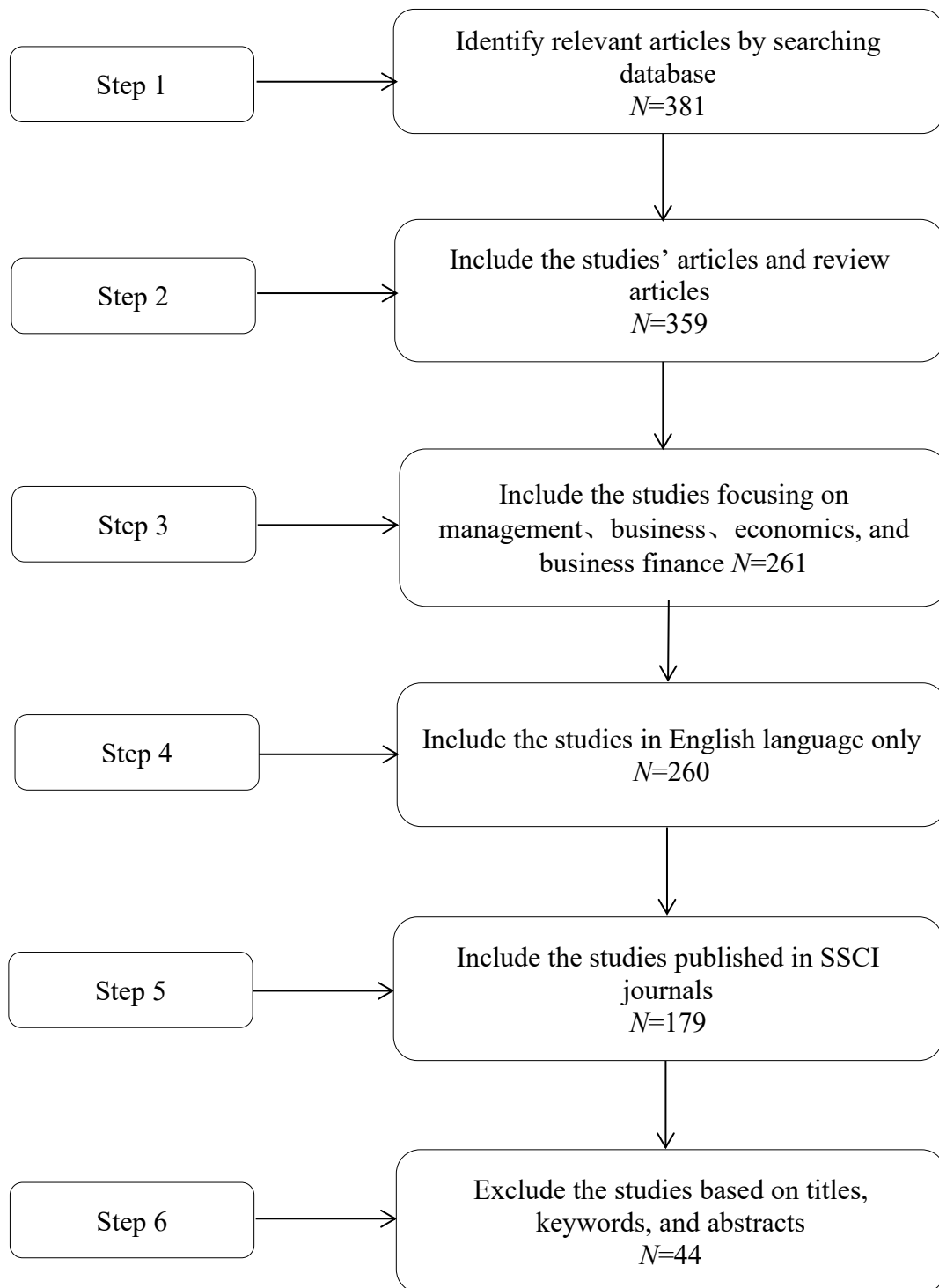


Figure. 1. The data selection process

PUBLICATION TRENDS AND THEMES

The number of publications on EU has grown steadily since 2014, with a marked increase during the period 2022–2024. China emerges as the most prolific country in this field. The average number of citations per article was 18.6, indicating a moderate level of scholarly engagement with this topic. The primary research themes identified were operations (strategic and supply-chain responses), innovation, investment, financing, and governance (**Error! Reference source not found.**; Figure). Co-word and network analyses show that terms such as risk, strategy, cash holdings, innovation, and uncertainty cluster together, reflecting the interdisciplinary nature of EU research (Fig).



Figure 2. Word cloud of the titles



Figure 3. Word cloud of the keywords of the selected papers

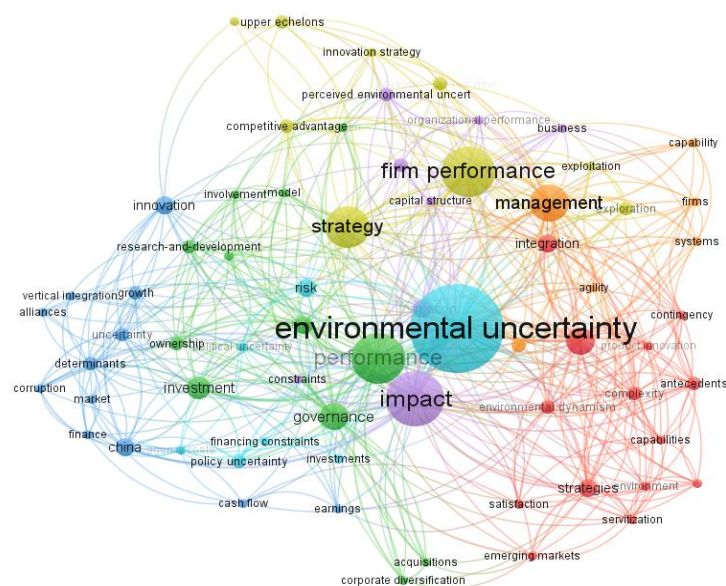


Figure 4. The network of articles published.

RESULTS & FINDINGS

KEY FINDINGS ON OPERATIONS

The literature consistently shows that EU prompts firms to reallocate resources and adjust operations in order to withstand shocks [14]. Under high EU, firms increase cash reserves as a precautionary buffer (precautionary savings theory) and prioritize investments in core, low-risk projects. For example, smaller or less leveraged firms tend to hoard more cash when uncertainty rises, due to limited access to external finance [15][16]. Supply-chain strategies also change: firms facing more volatile external conditions often seek to shorten or diversify supply networks, or invest in real-time monitoring systems to detect disruptions [17].

However, EU also exacerbates information asymmetry and agency problems [18]. When environments are unpredictable, managers may withhold private information or pursue overly conservative choices to protect their positions, as suggested by the agency theory. This can lead to suboptimal performance and increased managerial risk [19]. Some studies highlight that effective leadership or strong governance can mitigate these effects. For instance, competent CEOs and transparent disclosure practices help firms better navigate uncertain environments, consistent with the resource-based view and upper-echelons theories [20].

Lastly, innovation outcomes under EU are mixed. The prevailing view is that EU tends to inhibit radical innovation, as firms shy away from risky R&D investments when future returns are unclear [21][22]. Indeed, EU often discourages strategic change in otherwise stable firms. Yet, in high-uncertainty settings, some agile firms use uncertainty as a catalyst for creativity, investing selectively in new projects (an “opportunity-oriented” effect) [8]. Thus, the impact of EU on innovation depends on firm agility and managerial perception, namely whether uncertainty is framed as a threat or an opportunity [8].

KEY FINDINGS ON FINANCING

Most studies agree that EU raises the cost of external financing. High uncertainty leads investors and banks to demand higher risk premia and collateral, thereby tightening financial frictions [23]. Empirical evidence indicates that firms reporting high levels of uncertainty experience lower growth and pay more for loans [24]. From a theoretical perspective, EU increases perceived risk, supporting precautionary and pecking-order theories; consequently, firms with volatile prospects often see declines in share prices and bond values, making equity and debt issuance more expensive or dilutive [25].

New evidence underscores this effect. In the European Union, for example, firm-level survey data show that a one-point rise in uncertainty correlates with a one percentage point decline in employment growth and a three-point fall in investment rates, largely due to financing constraints [26]. In China, research finds that higher EU significantly worsens firms’ KZ index (a proxy for financial constraints), thereby hampering ESG initiatives [5]. Importantly, corporate governance factors moderate these outcomes: studies report that strong ESG performance can reduce firm risk and ease access to financing under uncertainty [5][8]. Moreover, government subsidies and heightened investor attention are shown to mitigate the adverse effects of uncertainty on financing constraints, suggesting that public policy and stakeholder engagement play a buffering role [5].

Despite the broad consensus on higher financing costs, several questions remain unresolved. For example, the impact of EU on internal funding choices or on differential access to bank versus public markets remains underexplored. It is also notable that research on EU’s effects on debt maturity structures or on emerging financial technologies (such as fintech) is still scarce.

KEY FINDINGS ON INVESTMENT

The literature on EU and investment is the most diverse. A dominant view is that uncertainty discourages investment, in line with real-options theory, whereby firms delay or cancel long-term projects when outcomes are unclear [27][15]. Many studies report that following an uncertainty shock (e.g., a policy change or crisis), aggregate corporate investment and R&D spending decline [15]. One multi-country survey found that if uncertainty had remained at 2021 levels, investment in 2022 would have been one percentage point higher [26].

However, some findings point to countervailing effects [28]. In certain contexts, firms with strong capabilities actually increase strategic investments despite EU, leveraging uncertainty as an opportunity to restructure or innovate. For instance, technology adoption such as AI in manufacturing or green technologies may be accelerated under EU in order to gain competitive advantage. A recent study of Chinese energy firms shows that climate-policy uncertainty substantially inhibited their investment by worsening financing constraints [13]. Notably, the same study finds that AI adoption in energy firms can buffer this effect, reducing investment losses under policy uncertainty. This suggests that advanced technologies and risk-management tools can partially offset the deterrent effect of EU on investment.

Overall, our synthesis reveals no universal consensus: EU can either delay investment (the “risk-averse effect”) or, in some cases, spur investment (the “opportunity effect”), depending on factors such as industry characteristics, firm strategy, and government policy. For example, export-oriented firms in volatile markets often stockpile cash instead of expanding, while highly diversified conglomerates may pursue unrelated acquisitions to hedge risk [29][30]. We also identify a research gap: relatively few studies examine how different types of uncertainty (e.g., market, policy, or climate uncertainty) distinctly affect investment across sectors (see the next section).

DISCUSSION

COMPARATIVE REGIONAL AND SECTORAL IMPACTS

To unpack contextual nuances, we compare Asia and Europe, as well as different sectors (energy, manufacturing, and technology), in which environmental uncertainty manifests differently.

Asia vs. Europe: Asian firms (especially in China and other emerging markets) often face rapid policy shifts and volatile growth rates. Recent studies from China highlight that EU has compounded firms’ tendencies toward financialization (e.g., allocating resources to financial assets) [31] and has hampered ESG performance [5]. In China, government policies (subsidies and stimulus measures) and internal incentive structures strongly influence how firms manage uncertainty [31]. In contrast, European firms typically operate in more stable regulatory regimes but have recently experienced intense geopolitical shocks (e.g., the Russia–Ukraine war). Firm-level analyses in Europe show that uncertainty has led to notable declines in investment and employment growth [26]. Europe’s energy-dependent economies have responded with policy shifts toward renewables and distributed energy resources in order to enhance resilience. Table 1 summarizes these contrasts.

Table 1: Comparison of Asia and Europe

Region	Key Uncertainty Factors	Enterprise Responses/Impacts
Europe	Climate and policy uncertainty (e.g., EU regulations); geopolitical shocks (e.g., war, Brexit)	Firms delay investment and reduce exposure to riskier projects; financing costs rise; energy and industrial sectors accelerate efficiency improvements and renewable investments.
Asia	Rapid policy shifts (e.g., China’s technology and environmental regulations); volatile markets	Firms increase cash holdings and financial asset allocation; EU harms ESG performance and raises financing constraints; SMEs rely on entrepreneurial motivation to sustain performance.

Sectoral Differences: Environmental uncertainty affects industries unevenly (Table 2). The **energy sector** is highly exposed to climate and policy uncertainty. For example, Chinese energy firms significantly reduced investment under climate-policy uncertainty (CPU), mainly due to tighter financing conditions [13]. However, firms that adopted AI technologies experienced much smaller investment declines [13], suggesting that digital tools can help manage EU in the energy sector. The recent European energy crisis (gas supply disruptions after 2022) similarly spurred a rapid shift toward renewables and decentralized energy systems, reshaping investment priorities.

Manufacturing firms face pronounced supply-chain and demand uncertainties (e.g., trade wars and pandemics). The COVID-19 pandemic exposed critical vulnerabilities, as factory shutdowns in Asia led to global component shortages. Industrial surveys (e.g., Deloitte, 2025) report that, despite high uncertainty,

many manufacturers continue to invest in automation and digital supply-chain solutions to enhance resilience. Weaker demand has pushed manufacturers to optimize inventories, while persistent skills shortages and rising costs have encouraged productivity improvements through technology. In contrast, capital-intensive sectors such as heavy manufacturing, characterized by long investment cycles, often adopt conservative spending strategies until uncertainty subsides.

The technology sector operates within rapid innovation cycles, meaning that some technology firms invest aggressively even under EU in order to maintain competitive advantage. Nevertheless, high policy uncertainty (e.g., US–China trade tensions) can disrupt global technology supply chains. A notable example is Apple: in 2024, 150 of its top 187 suppliers were located in China, exposing the firm to tariff and geopolitical risks. Consequently, technology firms increasingly diversify production locations (e.g., relocating semiconductor manufacturing to Taiwan or India). In addition, technology companies face evolving regulatory uncertainty (e.g., data protection and AI governance), which complicates long-term planning. On the positive side, technology firms often possess strong balance sheets and may capitalize on uncertainty by expanding market share or acquiring distressed assets.

Table 2: Sectoral Impacts of Environmental Uncertainty

Sector	Uncertainty Factors	Impacts on Firms
Energy	Climate and policy uncertainty; geopolitical risk (e.g., wars)	Investment cuts and financing constraints; rapid shift toward renewables; increased need for distributed energy resources. Stronger focus on resilience (inventory buffers, supplier diversification); cautious capital expenditure under high interest rates; continued investment in automation and digital tools.
Manufacturing	Supply-chain shocks (pandemics, trade disruptions); cost pressures	Sustained R&D and agile strategic responses; exposure of supply chains to geopolitical risk; emphasis on data and AI, which can both mitigate and amplify uncertainty.
Technology	Rapid technological change; regulatory and trade uncertainty	

Case examples reinforce these patterns. For instance, SMEs in Indonesia (Aceh Province) were found to maintain robust growth under uncertainty through high entrepreneurial motivation: motivated SMEs continued to innovate and sustain performance despite COVID-19 and conflict-related shocks [32]. In practice, this suggests that internal factors, such as leadership drive, can moderate external EU. In the energy sector, as noted, Chinese firms adopting AI experienced smaller declines in investment under climate-policy uncertainty, illustrating how technology can buffer sector-specific EU [13]. In Europe, a business climate survey of Swedish firms operating in India (2023) indicated that clear regulation and stable institutions are critical for alleviating uncertainty faced by exporters. Although these findings lie beyond our formal selection criteria, they underscore the importance of policy stability in shaping firm responses to EU.

PRACTICAL RECOMMENDATIONS FOR MANAGERS AND POLICYMAKERS

Our synthesis yields several practical implications. For business leaders, the findings suggest the following:

Diversify Resources and Funding: Build cash reserves and flexible financing options (e.g., revolving credit lines) to cushion shocks [5]. Maintain diverse supplier networks and adapt supply chains (e.g., dual sourcing and onshoring) in order to reduce disruption risk.

Invest in Agility and Technology: Adopt digital tools (e.g., AI and data analytics) to improve forecasting and mitigate specific sources of uncertainty. For example, firms operating in volatile regulatory environments may use AI to manage customer risk and identify market opportunities, as shown in studies of Chinese energy firms. Encourage corporate innovation that aligns with uncertain trends (e.g., sustainable R&D and modular product lines).

Strengthen Governance and ESG: Enhance transparency and stakeholder engagement to reduce information asymmetry. The literature shows that strong ESG performance can lower firm risk and ease access to financing under uncertainty [8]. Managers should therefore continue investing in environmental and social initiatives, as these strengthen reputation, attract stable investors, and, in some cases, mitigate the negative effects of EU.

Employee Motivation and Culture: Cultivate a motivated and resilient workforce. Evidence from the Aceh SME case indicates that entrepreneurial motivation helps firms sustain innovation and operations under EU [32]. Training and leadership development that foster adaptability can make organizations more robust to shocks.

For policymakers, recommendations include the following:

Provide Policy Stability and Clear Signals: Reduce uncertainty by committing to stable and transparent policies (e.g., clear climate targets and long-term infrastructure plans). Unpredictable regulatory changes in areas such as trade, energy, and technology have been shown to deter investment. Where volatility is unavoidable, policymakers should communicate clearly and engage with industry to manage expectations.

Financial Support and Incentives: Use targeted subsidies, guarantees, or low-cost loans to help firms sustain investment and ESG objectives. Evidence shows that government subsidies can mitigate the negative impact of EU on firms' financing constraints and ESG performance. For example, subsidizing green projects or export credit schemes can encourage continued investment during periods of crisis.

Strengthen Institutions and Partnerships: International cooperation (e.g., on trade rules and supply-chain security) can reduce geopolitical uncertainty. Policymakers should support public–private collaboration in critical sectors (such as energy grids and semiconductors) to avoid single points of failure, as highlighted by RAND's analyses of semiconductor disruption risks.

SME and Talent Development: Given the importance and vulnerability of SMEs, governments should implement programs (training, access to credit, and networking) that enhance resilience. Motivated SME entrepreneurs, as observed in the Aceh study, can adapt effectively under uncertainty when supported by appropriate institutional frameworks [32].

These recommendations align with broader policy analyses. For instance, the European Investment Bank emphasizes that policy measures are needed to counteract uncertainty's dampening effect on investment. Similarly, the International Energy Agency highlights the benefits of distributed renewable resources in reducing vulnerability in the energy sector. By heeding such guidance, managers and policymakers can help enterprises navigate and potentially capitalize on an increasingly uncertain environment.

CONCLUSION

This systematic review integrates recent scholarship to deepen understanding of how environmental uncertainty affects enterprise operations, financing, and investment. The findings show that EU has pervasive effects: it prompts firms to build financial and operational buffers, elevates the cost of external capital, and often leads to more cautious investment behavior. Crucially, the analysis identifies important nuances: advanced technologies (such as AI) and strong ESG practices can mitigate some of the costs associated with uncertainty, while high entrepreneurial motivation can support SME success under EU.

For scholars, this review fills an important gap by connecting previously fragmented studies and highlighting underexplored areas, notably the need for further research on regional differences (e.g., Europe versus Asia) and sector-specific impacts. It also outlines directions for future research, including deeper examination of EU effects in service sectors and developing economies, as well as investigation of the interaction among different types of uncertainty (market, policy, and climate).

For business leaders and policymakers, the findings translate into clear guidance. Firms should diversify resources, invest in resilience, and strengthen governance in order to withstand shocks, while governments should stabilize policy frameworks, support critical investments, and empower SMEs and innovation. By implementing these strategies, stakeholders can reduce the negative drag of uncertainty on economic performance and harness potential opportunities associated with EU, such as digitalization and green transformation.

In sum, this study advances the state of the science on environmental uncertainty by synthesizing recent evidence and translating it into actionable insights. It is expected to serve as a valuable reference for both academia and practice—supporting researchers in framing future studies on EU and assisting decision-makers in strengthening enterprise stability and growth in turbulent times.

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