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Antifragility in entrepreneurial ecosystems: absorptive capacity, organizational learning, and startup performance

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ABSTRACT

Organizations increasingly face frequent and intense disruptions, requiring strategies that engage with uncertainty rather than simply absorb shocks. In entrepreneurial ecosystems characterized by institutional volatility, these challenges are compounded by economic instability and uneven support structures. This study examines how startups develop antifragile responses, defined as the capacity to benefit from disruption, through organizational learning and absorptive capacity. We analyse a two-wave survey of 209 Ghanaian startups using Partial Least Squares Structural Equation Modelling with lagged financial performance data. The findings are interpreted as time-ordered and predictive rather than causal. Results indicate that antifragility is associated with the relationship between organizational learning and financial performance, with this association stronger at higher levels of potential absorptive capacity. We further identify temporal and contextual variation in absorptive capacity. Potential absorptive capacity expands firms' ability to interpret external knowledge, while realized absorptive capacity reflects its application under conditions shaped by organizational readiness and environmental context. This relationship is non-linear, indicating delayed and context-sensitive capability activation. Organizational learning is associated with how firms interpret and respond to volatility, shaping variation in adaptive responses across firms.

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Antifragility; absorptive capacity; organizational learning; financial performance; resilience; Ghana

Introduction

The increasing frequency and intensity of disruptions in entrepreneurial ecosystems require a shift from stability-oriented strategies towards approaches that leverage volatility as a source of adaptation and growth (Ramezani and Camarinha-Matos 2020). Entrepreneurial ecosystems, defined as the institutional, cultural, and material environments that shape entrepreneurial processes within a specific geographic context (Wurth, Stam, and Spigel 2022), vary in their capacity to absorb and respond to shocks. In advanced economies, adaptive regulation and established institutional frameworks often mitigate disruption (Stojčić, Vujanović, and Baum 2025). In contrast, many emerging economies, particularly in West Africa, are characterized by persistent institutional instability. Political disruptions, including recent coups in Burkina Faso, Niger, Guinea, and Mali, have weakened

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trade networks and constrained market access (Ukoaka et al. 2024). The 2022–2023 currency volatility and inflation in countries such as Ghana and Nigeria have further destabilized financial planning and limited firms' ability to scale and innovate (Abotebuno Akolgo 2023). These challenges are compounded by climate pressures that intensify resource uncertainty, particularly in regions such as the Sahel (Monerie, Pohl, and Gaetani 2021).

These conditions expose the limitations of resilience, typically defined as the capacity to absorb shocks and restore prior functioning (Chaudhary et al. 2024; Vershinina and Rodgers 2023). While resilience remains relevant, it does not explain how firms improve through disruption. This limitation has prompted growing attention to antifragility, understood as the capacity to benefit from volatility and improve through exposure to stressors (Munoz, Billsberry, and Ambrosini 2022). In contexts characterized by persistent instability, antifragility provides a more appropriate lens for understanding entrepreneurial adaptation (Corvello et al. 2024). Yet firms do not respond uniformly to such conditions. Even within the same ecosystem, some startups remain reactive, while others develop responses that allow them to benefit from disruption (Mwangi 2025). This raises a central question: how can startups strategically develop antifragility to navigate environmental volatility and support financial performance in high-risk contexts? We focus on startups as they are especially exposed to volatility and face intensified learning demands (Nucci, Byrne, and Dimov 2024).

We address this question by arguing that startups' antifragility depends on their organizational learning and absorptive capacity. While organizational learning supports adaptation in volatile environments (Huber 1991; Khan, Lew, and Marinova 2019), it may not fully capture the growth potential inherent in antifragility. Absorptive capacity, conceptualized through its potential and realized dimensions (Jansen, Van Den Bosch, and Volberda 2005), offers a more comprehensive framework for understanding how startups can build antifragility. Potential absorptive capacity refers to a startup's ability to identify, acquire, and assimilate external knowledge, allowing it to view ecosystem variability as a strategic opportunity (Flatten et al. 2011). Realized absorptive capacity builds on this by enabling the transformation of assimilated knowledge into innovations, linking adaptive learning to performance through execution (Riquelme-Medina et al. 2023). We argue that this dual capacity is vital in volatile ecosystems, where external shocks may present competitive opportunities.

This study makes three contributions to research on entrepreneurial adaptation under institutional constraint. Using Ghanaian startups as the empirical setting, we theorize the conditions under which firms develop antifragile responses when volatility is persistent, institutional support is uneven, and resource constraints are acute. First, we conceptualize antifragility as an adaptive organizational pattern associated with how firms engage with institutional volatility. This perspective moves beyond approaches that treat risk and turbulence primarily as constraints to be managed (Nucci, Byrne, and Dimov 2024) by suggesting that environmental instability can function as a context for adaptive response. Antifragility does not characterize all firms exposed to disruption but reflects variation in how firms interpret and respond to volatility through their knowledge-processing routines. Firms with stronger learning processes and higher potential absorptive capacity are better positioned to engage with external conditions, shaping whether volatility is experienced as constraint or opportunity (Ramezani and Camarinha-Matos 2020; Riquelme-Medina et al. 2023). In this sense, antifragility is associated with how firms process and act on external knowledge under institutional instability.

Second, this study extends absorptive capacity research by clarifying temporal (i.e. time-lags in capability activation) and contextual variation (i.e. strategic alignment, ecosystem instability) in the relationship between its potential and realized dimensions under institutional constraint (Jansen, Van Den Bosch, and Volberda 2005). Rather than assuming a linear progression from knowledge acquisition to application (Flatten et al. 2011), we theorize absorptive capacity as a staged and context-dependent process. Potential absorptive capacity functions as a strategic reserve that expands firms' ability to recognize and interpret external knowledge, while realized absorptive capacity reflects the application of that knowledge through coordinated action. The relationship

between these dimensions is not immediate but shaped by organizational readiness and environmental conditions, suggesting a temporal decoupling between knowledge accumulation and application. This perspective highlights that knowledge acquisition does not uniformly translate into adaptive outcomes.

Third, we contribute to organizational learning theory by specifying how learning processes operate in contexts characterized by institutional volatility (Si et al. 2018). Rather than viewing learning as a stabilizing mechanism that supports incremental adaptation (Huber 1991), we conceptualize it as an iterative process through which firms interpret and respond to uncertainty. The interaction between knowledge acquisition and application enables ongoing adjustment, allowing some firms to engage more productively with changing conditions. This shifts the emphasis of organizational learning from stability towards adaptive responsiveness, where opportunity development emerges from how firms interpret and act on contextual volatility through their evolving knowledge structures (Clinton et al. 2021; Wales, Parida, and Patel 2013).

The remainder of this paper proceeds as follows. We first develop the theoretical framework and hypotheses. We then outline the research design and present the empirical results. Finally, we discuss the implications of our findings and conclude with limitations and directions for future research.

Theoretical background: absorptive capacity and antifragility in emerging markets

Traditional resilience frameworks, which emphasize stability and risk mitigation through strengthening internal resources, are often insufficient in emerging market contexts where firms must respond to persistent volatility (Williams et al. 2017). While resilience focuses on recovery, antifragility captures the capacity to improve through disruption. This distinction is particularly relevant in institutionally constrained environments, where firms cannot rely on stable external support and must instead adapt through internally driven processes (Sarfo 2025). In such settings, absorptive capacity, defined as the ability to recognize, assimilate, and apply external knowledge (Cohen and Levinthal 1990), provides a foundation for adaptive responses to volatility.

This perspective aligns with the external enablers framework, which conceptualizes environmental shifts such as technological change, regulatory reform, or crises as conditions that can be strategically leveraged (Kimjeon and Davidsson 2022). However, this literature gives limited attention to the firm-level mechanisms that determine whether such conditions translate into capability development (Ramezani and Camarinha-Matos 2020; Sarfo 2025). We argue that absorptive capacity provides this mechanism. By enabling firms to identify, interpret, and apply external knowledge, it shapes how volatility is understood and acted upon, allowing some firms to adapt productively while others do not.

Absorptive capacity comprises two related but distinct dimensions: potential and realized capacity (Algarni et al. 2023; Zahra and George 2002). Potential absorptive capacity refers to the ability to identify, acquire, and assimilate external knowledge, expanding the firm's capacity to recognize opportunities in uncertain environments (Flatten et al. 2011; Hsieh and Pittaway 2025). In resource-constrained and high-variability contexts, this capability supports proactive decision-making by enabling firms to engage with diverse knowledge sources, including academic institutions, government programmes, and international development organizations (Rawhouser, Vismara, and Kshetri 2024). For example, in the Sahel, where climate change disrupts agricultural systems, startups with strong potential absorptive capacity can draw on environmental data to anticipate resource variability, redesign value chains, and pursue opportunities in climate-resilient agriculture (Monerie, Pohl, and Gaetani 2021).

Realized absorptive capacity reflects the transformation and application of acquired knowledge to generate tangible outcomes (Flatten et al. 2011). Under conditions of volatility, this process requires the alignment of external knowledge with internal routines, enabling firms to translate insights into coordinated action (Khan, Lew, and Marinova 2019). For instance, startups in West Africa

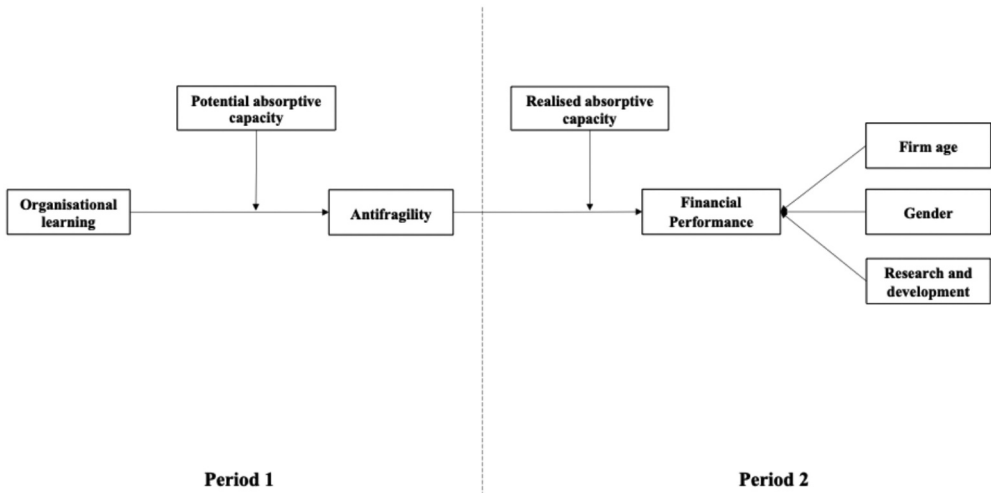


Figure 1. The conceptual framework (time-ordered predictive relationships).

facing currency fluctuations can draw on fintech knowledge ecosystems to adjust pricing strategies or implement financial hedging mechanisms, while firms operating in politically unstable contexts may rapidly adapt to regulatory shifts by redesigning products or services (Amankwah-Amoah and Hinson 2019; Ukoaka et al. 2024). These examples illustrate how realized absorptive capacity supports the execution of adaptive responses under uncertainty.

Both potential and realized absorptive capacities are critical for fostering antifragility in startups operating in emerging markets (Corvello et al. 2024). Startups that effectively acquire and apply external knowledge create a feedback loop where each disruption strengthens their adaptive capabilities, allowing continuous refinement and improved competitive positioning (Pérez López, Manuel Montes Peón, and José Vázquez Ordás 2004). This dynamic learning process turns external shocks, such as resource shortages or economic downturns, into opportunities for innovation, efficiency, and sustained growth (Clinton et al. 2021). We argue that antifragility emerges when these knowledge processes support adaptive responses to disruption. Firms that are able to both recognize opportunities and act on them are more likely to benefit from volatility, whereas firms that lack either capability may remain reactive or constrained. In this sense, absorptive capacity does not directly produce antifragility but shapes the conditions under which antifragile responses are more likely to occur. Figure 1 presents the proposed conceptual framework, illustrating the hypothesized relationships among organizational learning, absorptive capacity, antifragility, and financial performance.

Hypothesis development

Antifragility, organizational learning and financial performance

Learning-oriented firms actively acquire, share, interpret, and apply knowledge to refine strategies and operations (Pérez López, Manuel Montes Peón, and José Vázquez Ordás 2004). This fosters agility, enabling startups to adapt business models in response to shifting customer needs and environmental conditions. Empirical evidence links such adaptability to stronger product-market fit, higher customer retention, and improved financial outcomes (Matloob et al. 2025; Nakpodia et al. 2024). In volatile entrepreneurial ecosystems, learning-driven responsiveness is essential for revenue growth (Si et al. 2018).

Beyond financial gains, organizational learning also supports the development of antifragile capabilities. Startups that prioritize continuous learning are better equipped to experiment with novel solutions during crises, transforming shocks into opportunities for innovation (Nikookar, Stevenson, and Varsei 2024). While resilience enables firms to absorb disruption, antifragility involves reframing disruption as a trigger for strategic advancement (Munoz, Billsberry, and Ambrosini 2022). Learning processes such as double-loop learning and iterative feedback promote this shift by encouraging reflexive thinking and strategic renewal (Corvello et al. 2024). Organizational learning thus lays the groundwork for antifragility by embedding routines that engage with, rather than retreat from, volatility.

Antifragile firms are more likely to outperform competitors in turbulent markets. Rather than returning to pre-crisis operations, they innovate through disruption, gaining efficiency, expanding reach, and securing first-mover advantages (Chaudhary et al. 2024; Ukoaka et al. 2024). For instance, during macroeconomic shocks, antifragile startups may adopt flexible pricing, localize supply chains, or introduce countercyclical products that meet new demand (Jia et al. 2020; Munoz, Billsberry, and Ambrosini 2022). These actions convert uncertainty into growth, setting antifragile firms apart from resilient but static ones.

While learning builds knowledge-processing routines, antifragility applies them in ways that turn volatility into advantage. Organizational learning improves coordination and efficiency, but its full value emerges when it enables firms to thrive through disruption. Therefore, antifragility acts as a strategic conduit through which learning translates into superior financial performance.

Hypothesis 1: Antifragility is expected to account for the association between organizational learning and financial performance.

Potential absorptive capacity, organizational learning and antifragility

Organizational learning equips firms to adapt to changing circumstances by enhancing internal knowledge creation, problem-solving, and adjustment to environmental shifts (Clinton et al. 2021). However, adaptation alone does not constitute antifragility, which requires firms not only to withstand volatility but to grow stronger through it. Antifragility entails the active use of external turbulence to generate strategic renewal and innovation (Adobor 2024). Potential absorptive capacity bridges this gap by enhancing knowledge acquisition and internalization, allowing firms to transform disruptions into competitive advantages (Riquelme-Medina et al. 2023). It enables firms to forecast environmental shifts and reconfigure their strategies, accordingly, allowing organizational learning to evolve from a reactive mechanism into a proactive force for renewal.

In high-volatility, resource-constrained environments, potential absorptive capacity shifts the role of organizational learning from solving immediate problems to creating long-term opportunities (Khan, Lew, and Marinova 2019). For instance, firms with high absorptive capacity may engage externally through industry experts or policy dialogue to anticipate regulatory changes and incorporate this foresight into innovative offerings (Adobor 2024; Wales, Parida, and Patel 2013). This transformation reflects antifragility, as external shocks are harnessed for competitive growth.

Moreover, potential absorptive capacity ensures that learning extends beyond internal efficiency by enabling the incorporation of external opportunities into strategic processes (Jansen, Van Den Bosch, and Volberda 2005). For firms operating in dynamic markets, this expanded capacity allows them to recognize and exploit emerging trends, turning disruptions into opportunities for differentiation and competitive advantage (Khan, Lew, and Marinova 2019). For instance, a tech startup in an emerging economy with strong absorptive capacity might adopt advanced technologies or methodologies from global markets, integrating these into their product development cycles to address local market gaps and anticipate future demands (Nakpodia et al. 2024). This process not

only supports innovation but also establishes the firm as a proactive market leader, leveraging volatility as a driver of growth (Bhatti et al. 2021).

While learning enables adaptation, absorptive capacity allows firms to strategically capitalize on disruptions, driving renewal and long-term evolution (Corvello et al. 2024). Startups in volatile economies can leverage external insights to redesign business models, enter new markets, or create innovative offerings, gaining a competitive edge (Bhatti et al. 2021). This renewal, fuelled by absorptive capacity, enables firms to move beyond resilience towards antifragility. By continuously adapting and strengthening through each disruption, firms create a feedback loop where external turbulence becomes a driver of strategic advancement (Adobor 2024).

Hypothesis 2: Potential absorptive capacity is expected to strengthen the association between organizational learning and antifragility.

Realized absorptive capacity, antifragility and financial performance

The ability to identify opportunities in uncertainty is not sufficient on its own to generate measurable financial outcomes (Taleb 2014). A critical mechanism is required to convert adaptive responses into actual economic gains. Realized absorptive capacity provides this mechanism (Corvello et al. 2024). It enables firms to process external information, adapt strategically, and implement changes that produce financial returns. Without realized absorptive capacity, the positive effects of antifragility may remain latent or inconsistently applied, resulting in missed opportunities or suboptimal financial outcomes (Adobor 2024).

In volatile economic contexts, realized absorptive capacity enables firms to operationalize anti-fragile responses effectively (Khan, Lew, and Marinova 2019). Firms with high-realized absorptive capacity adapt and innovate for both immediate and long-term financial gains. For instance, a firm facing exchange rate instability may redesign its procurement practices to rely less on foreign inputs, thereby reducing exposure to currency fluctuations (Ukoaka et al. 2024). This adjustment is associated with cost savings, more stable margins, and improved long-term profitability (Munoz, Billsberry, and Ambrosini 2022). Thus, realized absorptive capacity transforms antifragility from a conceptual strength into a driver of sustainable financial growth. Such outcomes require not only a disposition to adapt but also the internal capacity to implement and refine strategic responses.

Furthermore, realized absorptive capacity supports continuous experimentation, allowing firms to evaluate the financial impact of various strategic options under changing market conditions (Wales, Parida, and Patel 2013). This iterative process increases the likelihood that adaptive efforts are aligned with performance objectives. For example, during a recession, firms with strong realized absorptive capacity may explore different pricing structures, marketing strategies, or distribution networks, selecting those that yield the most favourable financial results (Lamprey and Ngoasong 2023; Siaw et al. 2023). This ability to iterate ensures antifragile responses are both timely and financially rewarding, especially in volatile environments where agility and efficiency are necessary (Matloob et al. 2025).

Over time, realized absorptive capacity contributes to the institutionalization of antifragile strategies within the firm's operating model (Ramezani and Camarinha-Matos 2020). In unstable regulatory environments, firms with strong realized absorptive capacity may develop operational systems that are modular and easily reconfigurable. These systems not only ensure compliance during periods of change but also provide a platform for future adaptation. As these practices become embedded in the firm's routines, they contribute to a consistent pattern of financial performance despite ongoing external shocks (Amankwah-Amoah and Hinson 2019). This institutionalization ensures that antifragility evolves from a situational response to a foundational

capability, continuously strengthening the firm's market position and profitability (Wales, Parida, and Patel 2013).

The relationship between antifragility and financial performance is therefore conditional on the presence of realized absorptive capacity. This capacity does not merely complement antifragility; it activates and amplifies its financial implications. In the absence of realized absorptive capacity, antifragility may result in fragmented or unsustained responses that fail to improve economic outcomes (Adobor 2024).

Hypothesis 3: Realized absorptive capacity is expected to strengthen the association between antifragility and financial performance.

Methods

Empirical research setting

Empirical studies have begun examining organizational resilience and learning in emerging markets (Jia et al. 2020; Ritter-Hayashi, Knoben, and Vermeulen 2021), but how startups build antifragile capabilities to turn volatility into growth remains underexplored. Emerging markets such as the BRICS economies of Brazil, Russia, India, China and South Africa, along with MINT countries like Mexico, Indonesia, Nigeria and Türkiye, are characterized by expanding entrepreneurial activity and persistent macroeconomic and institutional instability (Osinubi, Simatele, and Oyadeyi 2025). Entrepreneurs in these contexts routinely navigate regulatory uncertainty, currency fluctuations and financing constraints that shape their ability to acquire and apply knowledge.

Ghana provides a theoretically relevant setting for examining entrepreneurial adaptation under institutional constraint. For startups, volatility extends beyond market fluctuations and is reinforced by uneven formal support, inconsistent enforcement, and continued reliance on informal coordination. This makes the setting useful not as a proxy for emerging markets broadly, but as a context in which institutional conditions are partial, uneven, and unstable over time. Although Ghana ranks among Sub-Saharan Africa's most active startup ecosystems, business survival remains a significant challenge, with estimates suggesting that more than 70% of startups fail, reflecting the difficulties firms face in navigating persistent economic and institutional uncertainty (Nyabor 2021). Ghana therefore reflects many features associated with emerging market environments, including resource constraints, institutional experimentation, and exposure to macroeconomic shocks, while its scale and developmental trajectory allow close examination of how firms develop capabilities such as antifragility and absorptive capacity under persistent uncertainty (Amankwah-Amoah and Hinson 2019). This mix of formal and informal coordination also shapes information access and response capacity, influencing how absorptive capacity and learning translate into adaptive action.

Ghana's recent economic fluctuations reinforce this relevance. Growth slowed from 3.8% in 2022 to 2.9% in 2023 before recovering to 4.7 and 6.9% in early and mid-2024, illustrating the turbulence firms confront and the value of examining how startups may benefit from such disruptions (African Development Bank 2024). This recovery highlights Ghana's adaptive capacity, making it a strong case for studying how startups respond to and benefit from volatility.

Startups are vital to Ghana's economy, with small and medium sized enterprises (SMEs) comprising over 80% of new ventures, contributing more than half of national GDP (Ghana Statistical Services 2023). With 26,354 startups registered in 2022, Ghana ranks among Sub-Saharan Africa's top five countries for startup activity, reflecting its dynamic entrepreneurial landscape (World Bank 2022).

Focusing on startups rather than SMEs highlights their distinct challenges and opportunities in high-uncertainty environments, where rapid innovation and scalability are essential for survival (Amankwah-Amoah and Hinson 2019). In Ghana's emerging market, startups contend with exchange

rate fluctuations, regulatory changes, and infrastructure gaps (Aidoo et al. 2021). Although government programmes like the National Entrepreneurship and Innovation Programme and Ghana Tech Lab, aligned with the Ghana Beyond Aid agenda, offer support (Mensah et al. 2021), they have not fully insulated startups from systemic instability.

Ghana's startup ecosystem reflects this tension: a young, tech-savvy workforce exists alongside persistent financial and operational risks (Acquah, Agyabeng, and Mensah 2024). Despite efforts to position Ghana as a regional tech hub, including Google's AI research centre (2018) and the e-Cedi digital currency (2021), startups still face an unpredictable landscape where public support alone cannot offset broader market pressures (Bank of Ghana 2024; International Trade Administration 2024).

This setting is therefore appropriate for examining capability development under institutional constraint, where the relationship between knowledge processes, adaptive response, and performance is unlikely to be linear. In this context, Ghanaian startups illustrate how firms draw on local knowledge and adaptive strategies to build antifragile capabilities and respond to persistent volatility.

Data collection

To examine the proposed relationships among organizational learning, absorptive capacity, anti-fragility, and financial performance, we collected survey data from Ghanaian startups and tested the conceptual framework empirically. We employed the tailored design approach (Dillman 2011) to develop a startup-focused questionnaire, ensuring construct validity through a comprehensive literature review and rigorous pre-testing with academic researchers and experienced startup managers. This process enhanced item clarity and contextual relevance, ensuring the instrument effectively captured the constructs under study.

To mitigate common method bias (CMB) and support time-ordered prediction, we employed a time-lagged data collection design following recommendations by Podsakoff, MacKenzie, and Podsakoff (2012). Organizational learning and potential absorptive capacity were measured in Phase 1, and antifragility, realized absorptive capacity, and financial performance were collected in Phase 2 one year later. This temporal separation reduces simultaneity and respondent bias, and it allows us to examine whether earlier capability-related conditions are associated with later outcomes. Consistent with absorptive capacity and organizational learning research (Jansen, Van Den Bosch, and Volberda 2005; Zahra and George 2002), we treat this as a predictive rather than causal design. The one-year interval represents a meaningful period over which changes in routines and knowledge-use processes can occur, particularly within Ghana's volatile macroeconomic context.

The sampling frame comprised startups formally registered with a research and business development centre at a leading Ghanaian university. Inclusion requires firms to be legally registered, actively operating, and engaged in structured support programmes such as incubation, training, or advisory services. The sample therefore captures startups with a minimum level of organizational formalization and engagement with institutional support structures. This sampling approach implies that the observed firms are more likely to be formalized and institutionally connected than the broader population of startups in Ghana. Firms operating purely informally or without access to university-linked support structures are not represented. The findings should therefore be interpreted as reflecting startups that are at least partially embedded within formal entrepreneurial support systems.

A total of 400 startup CEOs or senior managers were invited to participate, with surveys administered in person during workshops and mentorship sessions to ensure high-quality responses. CEOs and senior managers were selected as key informants because they are directly involved in strategic decision-making and possess comprehensive knowledge of organizational processes, learning practices, and external knowledge engagement. This approach is consistent with prior research on small firms, where decision authority and knowledge are highly centralized. Follow-up reminders were

sent two weeks after the initial contact in each phase. The first phase yielded 291 responses. By the second phase, 32 startups had ceased operations, reducing the sample to 259 firms, of which 228 provided responses. After quality checks based on Bernerth, Aguinis, and Taylor (2021), we excluded 16 incomplete responses and three that failed an attention check (e.g. 'Please select the colour blue'). This resulted in a final sample of 209 valid responses. The sample was predominantly male (79.83% men, 20.17% women) with an average business age of 4.04 years. Most startups were micro-enterprises, with over 70% employing fewer than five full-time staff.

To assess potential attrition bias, we compared firms that remained in the sample with those that exited after Phase 1 using baseline measures of organizational learning and potential absorptive capacity. No statistically significant differences were observed across these variables ($p > 0.10$), suggesting that attrition is unlikely to be systematically related to the key constructs. However, given that exited firms cannot be observed in Phase 2, some degree of selection bias cannot be fully ruled out. Firm exit may reflect an absence of antifragile capability, suggesting that attrition is not random but related to the underlying mechanisms examined.

Measures

All constructs were measured using established multi-item scales adapted to the startup context and assessed on a seven-point scale (see Table 1).

Table 1. Measurement of constructs including validity and reliability.

Construct and items	Factor loading
Financial performance (Cronbach's $\alpha = 0.906$, CR = 0.907, AVE = 0.780)	
During the past three years our firm has experienced ...	
... Sales growth	0.871
... Profitability	0.864
... Return on investment	0.900
... Customer retention	0.897
Organizational learning (Cronbach's $\alpha = 0.827$, CR = 0.852, AVE = 0.660)	
We constantly try out new ideas and approaches to improve how we work and perform	0.682
We regularly meet as a team to keep everyone informed about the latest innovations and updates in the startup	0.830
Sharing knowledge and experiences through teamwork is a core part of how we operate in our startup	0.879
Our startup has organized contact lists or directories by areas of expertise, making it easy to find the right person for specific questions or challenges at any time.	0.845
Antifragility (Cronbach's $\alpha = 0.890$, CR = 0.898, AVE = 0.695)	
Our startup quickly recognized new business opportunities or ways to strengthen our competitive position	0.862
We effectively gathered and understood information about new opportunities that could improve our market position	0.765
We rapidly identified, developed, and evaluated potential responses to unexpected challenges	0.883
We were able to promptly assemble a team of key members to address disruptions as they arose	0.807
Potential Absorptive Capacity (Cronbach's $\alpha = 0.907$, CR = 0.916, AVE = 0.684)	
In our startup, keeping up with relevant industry information is part of our daily routine	0.773
Our leadership encourages team members to actively use information sources related to our industry	0.874
Our leadership expects team members to also explore information beyond our industry for broader insights	0.807
In our startup, ideas and concepts are communicated across all teams.	0.893
Our leadership emphasizes support across teams to collaboratively solve challenges	0.876
We encourage regular meetings across teams to discuss new developments, challenges, and successes.	0.724
Realized Absorptive Capacity (Cronbach's $\alpha = 0.935$, CR = 0.947, AVE = 0.721)	
Our team members can effectively organize and use knowledge we've collected	0.816
Our team members are skilled at absorbing new knowledge, preparing it for future needs, and making it accessible to others	0.847
Our team members successfully connect existing knowledge with new insights	0.928
Our team members can apply new knowledge effectively in their day-to-day work	0.926
Our leadership encourages and supports the development of prototypes	0.862
Our startup frequently re-evaluates and adapts technologies in response to new insights	0.779
Our startup effectively improves operations by adopting new technologies	0.769

Financial performance

Financial performance was measured to assess startups' economic outcomes in the context of Ghana's 2022 financial crisis, which intensified post-COVID-19 challenges. By November 2022, the Ghanaian cedi had depreciated by 54.2% against the US dollar, exacerbating resource constraints and limiting market access (Abotebuno Akolgo 2023). In this setting, financial performance serves as an indicator of a firm's ability to adapt strategically and maintain competitive positioning under volatility (e.g. Corvello et al. 2024).

Financial performance is operationalized as a managerially assessed, relative indicator rather than an objective accounting measure. Respondents evaluated their firm's performance relative to comparable competitors across profitability, revenue growth, and cash flow stability as of February 2023. This approach reduces reliance on absolute financial figures and captures decision-makers' assessments in a context where formal reporting may be incomplete or inconsistently applied. Consistent with prior research (e.g. Bhatti et al. 2021), we model financial performance as a multidimensional construct ($\alpha = 0.906$). As key decision-makers, CEOs and senior managers are well positioned to assess their firm's relative performance, even without standardized financial reporting.

Organizational learning

Organizational learning was measured as the extent to which startups acquire, interpret, disseminate, and apply knowledge to enhance adaptability and competitiveness. Based on Pérez López, Manuel Montes Peón, and José Vázquez Ordás (2004) and Huber (1991), this construct reflects how firms leverage knowledge to navigate dynamic environments. We used a four-item scale capturing key phases: knowledge acquisition, dissemination, interpretation, and application, adapted to the high-stakes, rapidly changing conditions of startups in emerging markets ($\alpha = 0.827$). This measure encapsulates the processes that strengthen operational resilience and strategic adaptability.

Antifragility

Antifragility was measured as a startup's ability to leverage disruptions for growth and improvement, distinguishing it from resilience by emphasizing post-disruption gains over mere survival (Taleb 2014). A four-item scale adapted to the Ghanaian startup context (Corvello et al. 2024) assessed responses to the 2022 financial crisis, including currency depreciation, energy instability, and new tax policies (Abotebuno Akolgo 2023). Items highlighted proactive adjustments and growth achieved under these conditions ($\alpha = 0.890$). The measure builds on frameworks of proactive resilience and adaptive capability, highlighting disruption's transformative potential in emerging markets (Jia et al. 2020). To reduce CMB and ensure construct validity, we excluded any direct references to performance outcomes from the antifragility items.

Potential absorptive capacity

Potential absorptive capacity was measured using a six-item scale adapted from Jansen, Van Den Bosch, and Volberda (2005) and Flatten et al. (2011), based on Zahra and George (2002)'s framework. It captures knowledge acquisition and assimilation, reflecting the firm's ability to identify, evaluate, and absorb external knowledge. Sample items assess the intensity and direction of external knowledge search ($\alpha = 0.907$), adapted to the startup context by focusing on how entrepreneurs engage with market, technological, and regulatory information.

Realized absorptive capacity

Realized absorptive capacity was measured using a seven-item scale adapted from Jansen, Van Den Bosch, and Volberda (2005) and Flatten et al. (2011). The items assess a startup's ability to transform and apply external knowledge by integrating new insights with existing knowledge to improve products, processes, or strategies. This construct reflects two key dimensions of realized absorptive capacity: knowledge transformation and application ($\alpha = 0.935$), these capabilities are especially critical in fast-changing environments where firms must act quickly to stay competitive.

Several control variables were included to account for factors influencing financial performance. *Firm age* was measured as the logarithm of operational years, capturing differences in growth trajectories. Young firms often grow rapidly through innovation, while older firms leverage established resources (Pollok, Lüttgens, and Piller 2019). *Research and development (R&D) investment* was controlled for its role in enhancing absorptive capacity and innovation, though excessive or misaligned spending can reduce effectiveness (Cassiman and Veugelers 2006). *Gender* was a binary variable (0 = male, 1 = female), examining structural barriers faced by female-led firms and the potential benefits of gender diversity in leadership (Salloum, Jabbour, and Mercier-Suissa 2019).

Analysis and results

We employed Partial Least Squares Structural Equation Modelling (PLS-SEM) to estimate a variance-based, predictive model of the relationships among organizational learning, absorptive capacity, antifragility, and financial performance. PLS-SEM is well suited for emerging research areas and complex frameworks involving moderation and mediation, as it prioritizes variance explanation, predictive relevance, and model robustness while avoiding issues such as inadmissible solutions and factor indeterminacy (Hair, Page, and Brunsveld 2019). The model therefore assesses whether the proposed time-ordered configuration of constructs is theoretically consistent and demonstrates predictive accuracy, rather than providing causal parameter estimates (Hair et al. 2014). By enhancing predictive accuracy, it offers deeper insights into how absorptive capacity optimizes organizational responses to disruption, particularly in high-velocity environments.

Measurement model

Table 1 reveals that all items, except for one, demonstrate loadings exceeding 0.702, underscoring strong indicator reliability. The single item with a loading of 0.682 falls within the acceptable range of 0.40 to 0.702, warranting an outer loading relevance test as recommended by Hair et al. (2014). The test confirmed that removing the item did not affect the composite reliability (CR) or average variance extracted (AVE) for the organizational learning construct. Hence, we maintained the item (Hair et al. 2014). In addition, the lowest Cronbach's alpha and CR values are 0.827 and 0.852, respectively, as shown in Table 1, exceeding established thresholds for reliability. These results collectively confirm the robustness and reliability of the reflective constructs employed in this study.

Convergent validity is also supported, as all constructs achieve AVE values above 0.5, with the lowest AVE at 0.662 (Hair, Page, and Brunsveld 2019). Discriminant validity was assessed using the Fornell-Larcker criterion and the heterotrait-monotrait (HTMT) ratio. As shown in Table 2, the square root of each construct's AVE surpasses its correlations with other constructs, indicating sufficient discriminant separation. Additionally, Table 3 reports a maximum HTMT value of 0.804, below the conservative threshold of 0.850 (Hair, Page, and Brunsveld 2019), further substantiating discriminant validity. These results collectively affirm the reliability and validity of the measurement model.

Table 2. Fornell-larcker criterion for discriminant validity.

Variable		1	2	3	4	5	6	7	8
1	Financial performance	0.883							
2	Organizational learning	0.679	0.813						
3	Antifragility	0.681	0.546	0.833					
4	Potential Absorptive Capacity	0.734	0.671	0.715	0.827				
5	Realized Absorptive Capacity	0.639	0.707	0.553	0.615	0.849			
6	Research and Development	0.151	0.166	0.121	0.108	−0.030	1.000		
7	Firm Age	−0.128	−0.188	−0.147	−0.098	−0.341	−0.132	1.000	
8	Gender	0.057	0.103	0.008	0.070	0.130	0.069	−0.174	1.000

Note: Bold diagonal elements are the square root of Average Variance Extracted (AVE).

Table 3. Heterotrait-monotrait (HTMT) values for discriminant validity.

Variable		1	2	3	4	5	6	7	8
1	Financial performance								
2	Organizational learning	0.768							
3	Antifragility	0.752	0.619						
4	Potential Absorptive Capacity	0.804	0.762	0.780					
5	Realized Absorptive Capacity	0.683	0.769	0.602	0.650				
6	Research and Development	0.157	0.168	0.128	0.132	0.075			
7	Firm Age	0.138	0.199	0.209	0.130	0.349	0.132		
8	Gender	0.118	0.116	0.047	0.084	0.127	0.069	0.174	
9	Realized absorptive capacity × Antifragility	0.249	0.451	0.139	0.301	0.590	0.073	0.221	0.232
10	Potential absorptive capacity × Organizational learning	0.312	0.663	0.274	0.461	0.536	0.015	0.149	0.087
								0.087	0.695

Table 4. Inner variance inflation factor (VIF) values for full collinearity test.

Variable		1	2	3	4	5	6	7	8
1	Financial performance		2.763	2.654	2.603	2.713	2.766	2.324	1.863
2	Organizational learning	2.574		2.643	2.507	2.183	2.251	2.764	2.485
3	Antifragility	2.131	2.324		1.953	2.255	2.454	2.110	1.338
4	Potential absorptive capacity	2.696	2.832	2.531		2.935	3.009	2.653	2.213
5	Realized absorptive capacity	2.669	2.281	2.677	2.782		1.270	2.560	3.155
6	Research and development	1.130	1.097	1.138	1.139	1.046		1.103	1.195
7	Firm Age	1.224	1.227	1.226	1.218	1.090	1.098		1.338
8	Gender	1.050	1.049	1.043	1.049	1.047	1.053	1.049	

Controlling for common method bias testing

We addressed concerns about CMB by implementing a time-lagged research design and conducting a full collinearity diagnostic following Kock (2017). Inner VIFs were assessed using the recommended threshold of 3.3, with the highest value in our analysis being 3.155 (Table 4), indicating minimal CMB risk and supporting the robustness of our findings. Consistent with Kalnins and Praitis Hill (2025), who caution against mechanical reliance on VIFs alone, we supplemented this approach with an assessment of dimensionality and shared variance.

To further evaluate potential collinearity, we conducted a Principal Component Analysis (PCA). The first component accounted for only 9% of the total variance, and eigenvalues declined gradually across 29 components, with several exceeding the Kaiser criterion (Table 5). This pattern indicates well-dispersed variance, low likelihood of collinearity, and the suitability of the indicators for formative modelling. In this context, the first component is treated not as a method factor but as part of the full-collinearity diagnostic.

Analytical model

We evaluated the significance of path coefficients in the inner model using the bootstrapping procedure with 5,000 subsamples, as recommended by Hair et al. (2014). The results, presented in Table 6, show that the explained variance for financial performance ($R^2 = 0.599$, $p < 0.001$) and antifragility ($R^2 = 0.518$, $p < 0.001$) exceeds the recommended minimum threshold of 0.10 (Falk and Miller 1992). Additionally, our model fit evaluation shows a Standardized Root Mean Square Residual (SRMR) of 0.080, meeting the threshold for acceptable fit, and a Normed Fit Index (NFI) of 0.922, exceeding the cut-off of 0.90. These results confirm the model’s satisfactory fit and robustness.

We employed the Cross-Validated Predictive Ability Test (CVPAT) method to evaluate the out-of-sample predictive relevance of the model, as outlined by Sharma et al. (2023). This method compares the model’s average loss value against two benchmarks: the naive benchmark, derived from indicator averages (IA), and the conservative benchmark, based on a linear model (LM) forecast. Superior performance is demonstrated when the PLS-SEM model’s average loss is significantly lower

Table 5. Principal Component Analysis for full collinearity test.

Component	Eigenvalue	Variance Proportion	Cumulative Variance
1	2.601	0.09	0.09
2	2.423	0.084	0.174
3	2.306	0.079	0.253
4	2.179	0.075	0.328
5	2.007	0.069	0.397
6	1.884	0.065	0.462
7	1.763	0.061	0.523
8	1.646	0.057	0.58
9	1.533	0.053	0.633
10	1.426	0.049	0.682
11	1.321	0.046	0.728
12	1.221	0.042	0.77
13	1.122	0.039	0.809
14	1.03	0.036	0.845
15	0.945	0.033	0.878
16	0.872	0.03	0.908
17	0.799	0.028	0.936
18	0.735	0.025	0.961
19	0.67	0.023	0.984
20	0.608	0.021	1.005
21	0.567	0.02	1.025
22	0.523	0.018	1.043
23	0.484	0.017	1.06
24	0.451	0.016	1.076
25	0.421	0.015	1.091
26	0.394	0.014	1.105
27	0.368	0.013	1.118
28	0.341	0.012	1.13
29	0.315	0.011	1.141

Table 6. Structural equation modelling results.

Endogenous construct	R^2				
Financial performance	0.599***				
Antifragility	0.518***				
Structural path	Coefficients	SD	CI 95%		f^2
			LCI	UCI	
Organizational learning → Financial performance	0.308**	0.100	0.131	0.531	0.110
Antifragility → Financial performance	0.360**	0.123	0.115	0.588	0.204
Organizational learning → Antifragility	0.198*	0.090	0.024	0.380	0.037
Potential absorptive capacity → Antifragility	0.646***	0.079	0.466	0.786	0.487
Realized absorptive capacity → Financial performance	0.304**	0.120	0.053	0.523	0.076
Research and Development → Financial performance	0.145 [†]	0.152	-0.144	0.451	0.011
Firm Age → Financial performance	0.077	0.064	-0.046	0.202	0.013
Gender → Financial performance	0.033	0.169	-0.287	0.381	0.000
Potential absorptive capacity × Organizational learning → Antifragility	0.101**	0.045	0.009	0.186	0.028
Realized absorptive capacity × Antifragility → Financial performance	0.074	0.069	-0.060	0.207	0.014
Indirect effects					
Potential absorptive capacity → Financial performance	0.232**	0.041	0.063	0.441	
Potential absorptive capacity × Organizational learning → Financial performance	0.036 [†]	0.022	0.004	0.093	
Organizational learning → Antifragility → Financial performance	0.071 [†]	0.041	0.012	0.178	
Potential absorptive capacity → Antifragility → Financial performance	0.232**	0.097	0.063	0.441	
Potential absorptive capacity × Organizational learning → Antifragility → Financial performance	0.036 [†]	0.022	0.004	0.093	

Note: $p^{\dagger} < .10$, $p^* < .05$, $p^{**} < .01$, $p^{***} < .001$; two-tailed test. SD: Standard deviation, CI: Confidence interval, LCI: Lower confidence interval, UCI: Upper confidence interval, f^2 : Effect size.

Table 7. Results of out-of-sample predictive relevance (CVPAT).

Variable	Average loss difference	t value	p-value
CVPAT PLS-SEM vs IA			
Financial performance	−0.320	3.850	0.000
Antifragility	−0.295	3.100	0.002
Overall	−0.310	3.720	0.001
CVPAT PLS-SEM vs LM			
Financial performance	0.680	10.215	0.000
Antifragility	0.420	7.450	0.000
Overall	0.605	11.530	0.000

than these benchmarks, reflected by a significantly negative difference in loss values (Hair et al. 2014).

Our results, detailed in Table 7, confirm that the PLS-SEM model outperforms the naive benchmark, indicating its predictive relevance. However, it does not meet the threshold established by the conservative benchmark, suggesting areas for further refinement to enhance predictive capabilities. This outcome highlights the model's relative strengths while indicating opportunities to improve its performance under more stringent conditions.

Hypothesis 1 suggests that antifragility mediates the relationship between organizational learning and financial performance. As presented in Table 6, the analysis shows a significant association between organizational learning and antifragility ($\beta = 0.198$, $p < 0.05$, $f^2 = 0.037$), and between antifragility and financial performance ($\beta = 0.360$, $p < 0.01$, $f^2 = 0.204$). The indirect effect of organizational learning on financial performance through antifragility is also significant ($\beta = 0.071$, $p < 0.1$), with a 95% confidence interval [0.012, 0.178]. Even when controlling for antifragility, the direct relationship between organizational learning and financial performance holds ($\beta = 0.308$, $p < 0.01$, $f^2 = 0.110$).

Hypothesis 2 posits that potential absorptive capacity moderates the relationship between organizational learning and antifragility. The results in Table 6 indicate a positive and significant association between potential absorptive capacity and antifragility ($\beta = 0.646$, $p < 0.001$, $f^2 = 0.487$), with a 95% confidence interval [0.466, 0.786]. Moreover, the interaction effect between potential absorptive capacity and organizational learning is positive and significant with antifragility ($\beta = 0.101$, $p < 0.01$, $f^2 = 0.028$), with a 95% confidence interval [0.009, 0.186]. Figure 2 further illustrates that higher levels of potential absorptive capacity increase the positive effect of organizational learning on antifragility, whereas this influence is comparatively diminished in startups with lower potential absorptive capacity.

Hypothesis 3 posits that realized absorptive capacity moderates the relationship between antifragility and financial performance. The results in Table 6 reveal a positive and significant association between realized absorptive capacity and financial performance ($\beta = 0.304$, $p < 0.01$, $f^2 = 0.076$), with a 95% confidence interval [0.053, 0.523]. However, the interaction effect between realized absorptive capacity and antifragility on financial performance is not statistically significant, indicating that realized absorptive capacity does not fully moderate this relationship.

Post-evaluation of findings

To provide additional context for the quantitative findings, we conducted six semi-structured interviews with startup founders in Ghana's entrepreneurial ecosystem. Following recommendations that qualitative follow-up can enrich the interpretation of quantitative results (Pappas and Woodside 2021), the interviews were used to explore how founders experienced organizational learning, absorptive capacity, and environmental volatility in practice.

Participants consistently described volatility as a persistent feature of entrepreneurial activity rather than an occasional disruption. Currency instability, policy uncertainty, infrastructure constraints, and fluctuating demand were viewed as ongoing conditions requiring continuous

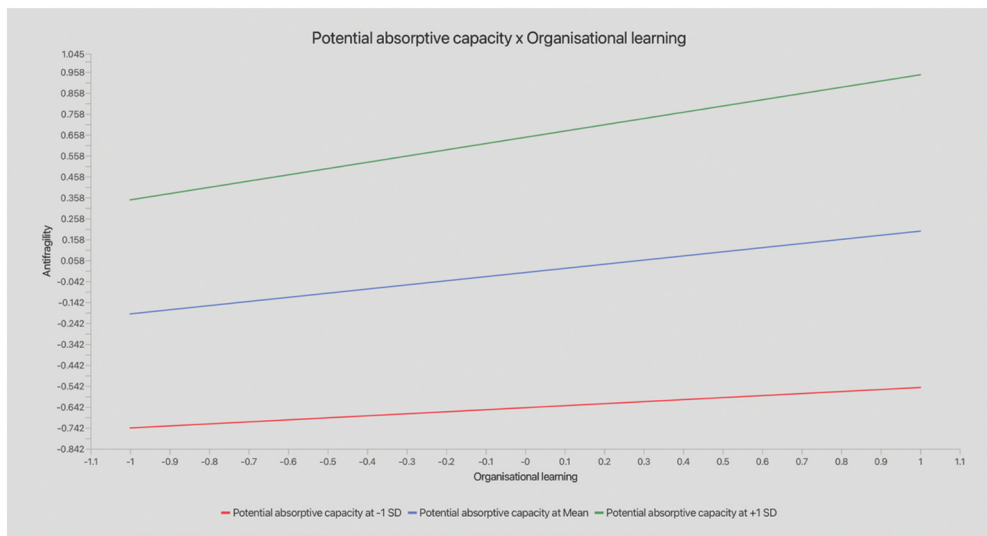


Figure 2. The moderating effect of potential absorptive capacity $\times$ organizational learning on antifragility.

adjustment. As a result, founders emphasized environmental scanning, experimentation, and strategic flexibility rather than recovery from isolated shocks.

The interviews were particularly informative in explaining the role of potential absorptive capacity. Founders frequently described engagement with mentors, industry networks, universities, development agencies, and international partners as investments in future preparedness. Knowledge acquired through these relationships was often not applied immediately but became valuable when changing circumstances created new opportunities. This suggests that potential absorptive capacity expands the range of opportunities firms are able to recognize and evaluate under uncertainty.

The interviews also shed light on the non-significant moderating role of realized absorptive capacity. Participants noted that applying knowledge often depended on access to finance, infrastructure, regulatory conditions, and organizational readiness. Several founders reported possessing valuable knowledge but lacking the resources or conditions needed for implementation, indicating that knowledge application is a context-dependent rather than automatic process.

Participants rarely attributed growth to a single disruptive event. Instead, they described antifragility as emerging through repeated exposure to volatility, which gradually altered how opportunities were identified and pursued. Startups that had navigated multiple disruptions appeared more willing to experiment with new markets, partnerships, technologies, and business models. These accounts suggest that antifragility may be better understood as an adaptive orientation that develops through ongoing engagement with uncertainty, supported by organizational learning and absorptive capacity.

Discussion and theoretical implications

This study examines how startups develop antifragile responses under conditions of persistent volatility. The findings should be interpreted as time-ordered and predictive rather than causal. The results indicate that antifragility is associated with the relationship between organizational learning and financial performance, and that this association is stronger at higher levels of potential absorptive capacity. These patterns suggest that learning and knowledge-processing routines operate as evolving organizational investments that are shaped by contextual conditions rather

than as fixed firm attributes (Flatten et al. 2011; Zahra and George 2002). During the study period, Ghanaian startups faced sustained macroeconomic and regulatory instability, conditions that likely influenced how firms searched for, accessed, and utilized external knowledge (Abotebuno Akolgo 2023). The variation observed in antifragility reflects differences in how firms engaged with these conditions through their internal routines.

This research contributes to emerging views on contextual volatility in strategy by moving beyond perspectives that treat risk and turbulence primarily as constraints to be managed (Nucci, Byrne, and Dimov 2024). The findings suggest that under conditions of institutional volatility, antifragility is associated with how firms engage with environmental instability as a context for adaptive response. This does not imply that all firms benefit from disruption. Rather, the results indicate variation in how firms interpret and respond to volatility. Firms characterized by stronger learning routines and higher potential absorptive capacity exhibit broader search activities, deeper assimilation of external knowledge, and more effective internal circulation of insights (Ramezani and Camarinha-Matos 2020). Relational embeddedness expands the range of information available for interpretation, while internal processes support experimentation and strategic adjustment. In this sense, antifragility reflects differences in how firms process and act on external knowledge under conditions of institutional volatility.

This study also contributes to absorptive capacity research by clarifying temporal and contextual variation in the relationship between its potential and realized dimensions. The findings suggest that these capabilities do not unfold as a linear progression from knowledge acquisition to application (e.g. Jansen, Van Den Bosch, and Volberda 2005) but instead develop asynchronously and in ways shaped by contextual conditions. Potential absorptive capacity functions as a strategic reserve that expands firms' ability to recognize and interpret opportunities, while realized absorptive capacity reflects the application of that knowledge through coordinated action. The observed temporal lag between these dimensions is consistent with the idea that firms accumulate knowledge in anticipation of conditions that allow its effective use (Flatten et al. 2011), indicating a staged rather than immediate activation of absorptive capacity.

The influence of realized absorptive capacity further highlights this conditionality. Although it is associated with innovation and performance, its role depends on organizational readiness and environmental stability (Sarfo 2025). The absence of a direct moderating relationship between realized absorptive capacity and antifragility in relation to financial outcomes suggests that capability activation may be uneven and delayed, resulting in a temporal decoupling between knowledge accumulation and application (Khan, Lew, and Marinova 2019). This finding extends research on external enablers by showing that macro-level shocks do not translate into strategic opportunities in the absence of firm-level processes that support knowledge interpretation and use (Kimjeon and Davidsson 2022). While prior work emphasizes enabling conditions (Algarni et al. 2023), the results indicate that such conditions are insufficient without internal capabilities that shape how disruption is engaged and acted upon.

Finally, this study contributes to organizational learning theory by clarifying how learning processes operate under conditions of institutional volatility. Traditional perspectives often treat learning as a stabilizing mechanism that supports incremental adaptation (Huber 1991). The findings here suggest a different pattern. Iterative feedback processes are associated with how firms interpret and respond to uncertainty, positioning volatility as a condition for adaptive response and capability development. By linking knowledge acquisition through potential absorptive capacity with knowledge application through realized absorptive capacity, organizational learning functions as a mechanism through which firms engage with changing conditions and adjust their strategic responses (Wales, Parida, and Patel 2013).

This perspective departs from models in which stability represents the endpoint of learning (Khan, Lew, and Marinova 2019). Instead, the results indicate that in dynamic environments, learning processes are associated with ongoing adaptation, where the transition from knowledge accumulation to application is shaped by organizational readiness and contextual conditions (Nikookar,

Stevenson, and Varsei 2024; Si et al. 2018). These cumulative processes are consistent with the emergence of antifragility, understood as a pattern associated with how firms respond to environmental disturbance through evolving knowledge structures (Munoz, Billsberry, and Ambrosini 2022). In this sense, opportunity development can be understood as a learning-driven process in which firms interpret and act on contextual volatility through their knowledge-processing routines (Clinton et al. 2021).

Practical implications

Small businesses and startups in Africa operate in environments characterized by persistent volatility, where survival-oriented resilience strategies may be insufficient. The findings suggest that antifragile approaches, which emphasize adaptation and improvement through disruption, are associated with more favourable outcomes under such conditions (Nikookar, Stevenson, and Varsei 2024). This highlights the importance of developing capabilities that allow firms to interpret and respond to volatility rather than simply absorb shocks.

Incubators, accelerators, and innovation hubs, play a central role in shaping these capabilities. While prior research shows that such actors create enabling conditions for entrepreneurial activity (Kimjeon and Davidsson 2022), our findings indicate that their influence operates through firm-level knowledge processes. Specifically, support organizations appear to broaden knowledge search and improve access to market, technological, and regulatory information, which is associated with stronger potential absorptive capacity (Flatten et al. 2011; Jansen, Van Den Bosch, and Volberda 2005). They also support experimentation, mentoring, and the integration of external insights into organizational routines, which is associated with realized absorptive capacity (Corvello et al. 2024). These mechanisms suggest that the value of ecosystem support lies not only in resource provision but in shaping how firms acquire, interpret, and apply knowledge under uncertainty.

For policymakers and ecosystem builders, this implies that strengthening entrepreneurial outcomes requires attention to these internal processes. Interventions such as innovation grants, technology hubs, and cross-border platforms (Ramezani and Camarinha-Matos 2020) may be most effective when they are designed to enhance firms' capacity to acquire, transform, and apply knowledge, rather than focusing solely on resource provision. Facilitating interaction among firms, research institutions, and development organizations can further support these processes by enabling access to diverse knowledge sources and promoting adaptive learning (Nucci, Byrne, and Dimov 2024; Wurth, Stam, and Spigel 2022).

Institutionalizing organizational learning within ecosystems is also important. Practices such as feedback loops, real-time data use, and collaborative problem-solving support continuous adjustment under volatile conditions (Riquelme-Medina et al. 2023; Si et al. 2018). Policy efforts that support data-sharing platforms, research collaboration, and experiential learning environments may therefore contribute to the development of absorptive capacity and, in turn, to more adaptive firm behaviour (Lamptey and Ngoasong 2023).

At the same time, promoting antifragility raises normative considerations. Efforts to encourage firms to benefit from disruption should be accompanied by attention to ethical and societal implications, as adaptive responses may not always align with broader social or environmental goals. Incorporating accountability mechanisms and values-based guidance into support programmes may help ensure that capability development contributes to responsible and sustainable outcomes.

Limitations and directions for future studies

A key limitation concerns the sampling frame. The data are drawn from startups affiliated with a university-based support centre, implying selection towards firms that are more formalized, institutionally connected, and potentially better resourced than the broader

startup population. The findings may therefore not capture the behaviour of purely informal or resource-isolated firms, where access to knowledge, learning structures, and external support is more limited. Future research could examine whether the relationships observed here hold across less formalized contexts and compare environments with varying degrees of institutional stability to clarify when antifragility or resilience is more salient (Williams et al. 2017).

A second limitation relates to construct clarity. The study does not fully distinguish between absorptive capacity and antifragility as individual-level attributes versus organizational capabilities. Given the small size of firms in the sample, some measures may reflect founder or team characteristics rather than firm-level processes. Future research could adopt multi-level designs to disentangle these effects and examine how such capabilities become embedded within organizational structures as firms scale. More parsimonious measurement approaches may also help refine construct boundaries where theoretical overlap exists.

A third limitation concerns temporal scope. Although the study highlights the role of absorptive capacity, it does not capture how its potential and realized dimensions evolve over time. The two-phase design introduces temporal separation but does not allow examination of longer-term capability development. Longitudinal studies with additional waves could trace how knowledge acquisition and application unfold across organizational stages and identify when these capabilities shift from reactive adjustment to more proactive adaptation.

A fourth limitation relates to measurement. Financial performance is assessed using managerially reported, relative indicators, which may reflect perceptual bias or variation in reporting practices. In addition, some survey items include positively valenced phrasing, which may introduce minor response effects. Future research could incorporate objective performance measures, alternative indicators such as survival or growth, and more behaviourally grounded items to strengthen measurement validity.

A further limitation concerns the normative interpretation of antifragility (Aven 2015). While the findings indicate that firms with stronger learning and knowledge-processing capabilities perform better under uncertainty, the study does not distinguish between value creation that is socially constructive and outcomes that may arise through exploitative or ethically ambiguous practices. Future research using qualitative or mixed-method approaches could examine how firms interpret and enact antifragility in ways that align with or diverge from broader societal interests.

Finally, although the design introduces temporal ordering, it does not allow for strong causal inference. The observed relationships should therefore be interpreted as predictive associations rather than causal effects. Future studies employing multi-wave longitudinal data and cross-lagged models could provide more robust tests of directionality. Expanding the range of outcomes to include survival, long-term growth, and capability development would also offer a more comprehensive understanding of firm success in volatile environments.

Author contributions

CRedit: **Christian Sarfo**: Conceptualization, Data curation, Investigation, Methodology, Project administration, Writing – original draft, Writing – review & editing; **Joseph Owusu**: Conceptualization, Data curation, Funding acquisition, Project administration, Writing – review & editing; **Andrea Caputo**: Conceptualization, Formal analysis, Supervision, Validation, Writing – review & editing; **Konan A. Seny Kan**: Formal analysis, Project administration, Supervision, Writing – review & editing.

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