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Article

# Conceptualizing a nexus between agility, unobserved differences of dynamic capability, and sustainable performance of microfirms

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**Abstract:** Recent studies have highlighted commonalities in the relationship between dynamic capabilities and firms' sustainable performance. However, the impact of unobserved differences within the dimensions of dynamic capabilities on firm-level sustainable performance remains unclear. Specifically, in this study, we investigate how unobserved variations in dynamic capabilities influence the sustainable performance of dairy microfirms. Additionally, the study examines the unobserved mediating effects of agility in the relationships between knowledge-sharing sensing capability, managerial cognitive capability, and sustainable performance. Grounded in the Knowledge-Based View (KBV) theory, our study rigorously tests these hypotheses using a unique quantile composite-based path modeling approach. The findings reveal both significant strong and weak unobserved differences in the relationships between knowledge sharing, sensing capability, managerial cognitive capabilities, agility, and the sustainable performance of microfirms. Notably, the results demonstrate that agility significantly mediates the unobserved dimensions of dynamic capabilities in supporting sustainable performance, with the study confirming both full and complementary partial mediation effects. Our findings offer a valuable framework for managers and employees to strategically invest in dynamic capabilities while also discussing the heterogeneous distribution of these capabilities among managers and employees across dairy microfirms.

**Keywords:** agility; dairy microfirm; knowledge sharing; sensing capability; sustainable performance

## 1. Introduction

Sustainable performance has increasingly become a concern for stakeholders of microfirms due to unpredictable disruptions that exacerbate limited resource availability and production costs, thereby jeopardizing firm-level competence [1–6]. To address these challenges, previous research has suggested solutions such as developing a sustainability scorecard [7]. This tool is designed to enhance sustainable performance by enabling individual managers and employees to better control both tangible and intangible resources, thereby maintaining positive dynamism within the firm [8–10]. Consequently, managers and employees play a crucial role in overcoming sustainability challenges by optimizing the use of tangible and intangible inputs to maximize production efficiency. Thus, promoting sustainable performance is essential for improving the overall effectiveness of the firm [9–11].

To address the rapidly growing challenges and enhance firms' sustainable performance, other scholars emphasize the crucial role of individual managers and employees in formulating strategies and leveraging both internal and external resources to adapt to environmental changes [7,11]. Evaluating sustainable performance at the individual level, particularly among managers and employees who develop skills to become either innovators or architects and establish capabilities currency, has some limitations [9]. For example, the microfirm sector has been significantly impacted by disruptions such as rising energy costs and resource constraints [1–3]. Understanding environmental dynamism is essential for firm growth and can be categorized into two facets: 'internal growth' and 'acquisition' [10,11]. Integrating these factors illuminates the foundational aspects of dynamic capabilities, which involve managerial processes that develop the market and manage external factors to significantly enhance sustainable performance [12]. Thus, dynamic capability is defined as a firm's ability to intentionally create, extend, and modify its resource base [13]. Similarly, Jantunen et al. [14] and Fainshmidt et al. [15] describe dynamic capability as a firm's capacity to integrate, build, and reconfigure internal and external resources to tackle environmental challenges.

The definition of dynamic capability enhances the understanding of key components: creating, extending, and modifying resource-based optimization to fundamentally improve sustainable performance [16]. These core elements collectively enhance the efficacy of microfirms in managing their resources, aligning with the Knowledge-Based View (KBV), which extends the Resource-Based View (RBV) [3,17]. According to the KBV, dynamic capability is conceptualized as a composite set of attributes—such as sensing capability, knowledge sharing, managerial cognitive capabilities, and agility—that are essential for modifying and extending resources to support sustainable performance [18,19]. The existing literature highlights ongoing efforts to address these challenges by integrating dynamic capabilities and KBV theories. This combination serves as a tuning mechanism to enhance sustainable performance at the firm level and build the internal resilience and endurance of microfirms [5,8,16].

Nonetheless, studies have illustrated that a firm's degree of heterogeneity is crucial for explaining dynamic capabilities from the perspective of the KBV framework. This perspective acknowledges that dynamic capabilities are unique and specific factors that exhibit direct commonalities influencing sustainable performance through idiosyncratic elements [19–21]. Arguably, there are recognizable patterns of dynamic capabilities across firms that positively impact sustainable performance. At the same time, the KBV framework also highlights that nuanced and hidden interdependencies among dynamic capabilities play a critical role in shaping an organization's strategic capabilities and knowledge-based advantages [22]. Understanding these commonalities and patterns at the firm level is essential for helping informal networks involved in sensing, knowledge sharing, managerial cognitive capabilities, and agility. This gives a sense that networks create a dynamic environment conducive to learning and innovation among managers and employees of microfirms. Furthermore, these hidden dimensions of dynamic capabilities, which cut across individual managers and employees, represent interconnected aspects rather than isolated activities [11]. Leveraging these differences in dynamic capabilities can significantly enhance a firm's knowledge-based advantage by fostering adaptability, innovation, and strategic competitiveness.

Building upon the preceding arguments, addressing the challenges faced by dairy microfirms requires a deeper examination and not only the direct relationship between dynamic capabilities and sustainable performance [1]. For instance, numerous studies have highlighted the direct commonalities between dynamic capability dimensions and sustainable performance [23,24]. However, testing these dimensions for direct similar pattern effects on sustainable performance can be tautological, as it often neglects contingency hypotheses and unobserved differences [25]. Following the seminal works of Fainshmidt et al. [22] and Kurtmollaiev [26], which emphasize that understanding the common patterns and unobserved dynamic capabilities is essential for improving internal structures, processes, and pathways that influence a firm's dynamic capabilities and ultimately its sustainable performance, it becomes evident that a re-evaluation is necessary. To effectively address these issues, it is crucial to reconsider how unobserved differences in dynamic capabilities dimensions and contingency hypotheses impact the nature and growth paths of dairy microfirms [11]. Thus, uncovering hidden differences in these dimensions can help managers and employees identify performance gaps and address resource shortages, which are exacerbated by rapid innovations in the dairy industry [6]. Therefore, revealing variations in the interplay between sensing capability, knowledge sharing, managerial cognitive capabilities, agility, and sustainable performance can offer valuable insights for dairy microfirms to achieve a balance between growth, efficiency, and internal development.

The primary objective of this study is to investigate how unobserved variations in dynamic capabilities influence the sustainable performance of dairy microfirms. Additionally, the study examines the unobserved mediating effects of agility in the relationships of knowledge sharing, sensing capability, and managerial cognitive capability on sustainable performance. To test the hypotheses outlined in the conceptual framework (**Figure 1**), we first employed Partial Least Squares Path Modeling (PLS-PM), which is widely recognized and adheres to global analytical standards [27]. Following this, we applied a sophisticated technique—Quantile Composite-Based Path Modeling (QC-PM)—developed by Davino and Vinzi [28] and refined by Dolce et al. [29]. This advanced methodology enables a detailed analysis by incorporating variations across different quantiles, thereby offering a deeper and more comprehensive understanding of the dynamic capabilities and their impact on sustainable performance.

Our study advances the dynamic capabilities theory and sheds further light on sustainable performance in three significant ways. First, it enhances the empirical literature by conceptualizing the direct relationship between dynamic capability dimensions and sustainable performance specifically within the context of dairy microfirms in Tanzania, highlighting the existence of commonalities [2,30,31]. Second, it extends the theory by examining how individual differences among managers and employees influence the relationship between dynamic capability dimensions and sustainable performance [22]. Third, in this study, we explored the role of agility in mediating the unobserved effects of dynamic capability dimensions on sustainable performance, an area that remains empirically unexamined [32]. Notably, it is the first study to develop a mediation model that utilizes agility to mediate the unobserved effects of dynamic capability dimensions on sustainable performance.

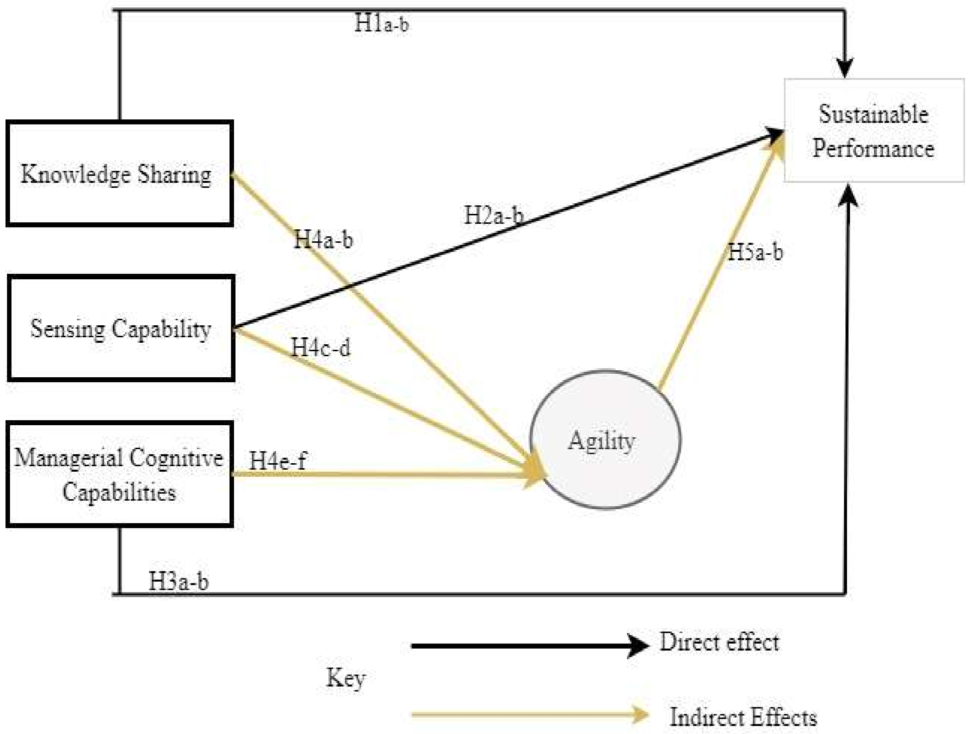


**Figure 1.** Theoretical and conceptual framework

The remainder of the article is structured to critically address the study's objectives. We utilize the KBV as the theoretical framework to formulate hypotheses and develop the proposed conceptual model. The article used theoretical and empirical review to detail the study's materials and methods. Following the empirical testing of the conceptual framework, we present the findings. Then, we established a discussion section that deeply elaborates on the results, including its theoretical and managerial implications, policy recommendations, future research directions, limitations, and concluding remarks.

## 2. Literature review and hypotheses development

### 2.1. Knowledge sharing and sustainable performance

Knowledge sharing involves the process of transmitting or disseminating information, skills, or expertise from one individual or group to another within an organization or community [33]. Likewise, the definition is in line with KBV theory, which asserts that knowledge sharing is crucial to highlighting how managers and employees organize resources to create and replicate new technologies, thereby opening strategic windows for understanding firm capabilities [23,34]. Prior research has suggested that effective knowledge sharing enables managers and employees to foster creativity and protect knowledge, leading to enhanced transformation and sustainability within firms [1,3,35]. Therefore, knowledge sharing encompasses both know-how and know-what [21], which are critical for influencing sustainable performance for microfirms. For example, the dairy industry, recognizing the importance of this process, has called for the development of strategic knowledge-sharing systems between managers and employees. In so doing, it can protect tacit knowledge among employees and managers as the important ingredient for sustainable performance [36]. Thus, knowledge sharing should be emphasized as a critical process for transferring know-how within the firm, particularly between managers and employees.

Furthermore, knowledge sharing between microfirms plays a crucial role in resource integration, utilization, and configuration, all of which are essential for achieving sustainable performance [37]. In that case, it is indispensable for enhancing managers' and employees' learning routines, thereby improving their ordinary capabilities. Importantly, knowledge sharing is not merely about information exchange; it encompasses the sharing of thoughts, experiences, and ideas, which are vital for organizational learning. This learning, in turn, is a significant driver of sustainable performance [38]. While some authors in the dairy industry argue that knowledge sharing can be understood in terms of intensity and knowledge base [37,39,40], the combination of these elements has a substantial impact on dairy microfirms, fostering growth, capabilities, and sustainability. Despite this, few studies have positively correlated knowledge sharing with sustainable performance, particularly when considering variations in dynamic capabilities [1]. The literature review overlooked the effect of knowledge sharing variation among the managers and employees on microfirms sustainable performance. Therefore, we hypothesize that knowledge sharing significantly influences sustainable performance in dairy microfirms, especially when accounting for these quantile changes.

H1a: Knowledge-sharing positively affects sustainable performance.

H1b: Unobserved differences in knowledge sharing positively affect sustainable performance.

## 2.2. Sensing capability and sustainable performance

Sensing capability refers to the ability to identify, interpret, and capitalize on opportunities within the business environment [41]. In the same vein, empirical literature highlights the importance of sensing capabilities, which encompass generating market information, disseminating market intelligence, and responding effectively to market changes [42]. Thus, in the current digital age, the growing complexity of markets has compelled managers and employees to continuously identify new opportunities, adapt to market dynamics, and enhance their firms' flexibility [22]. In that process, it's bringing the fundamental dynamism for both managers and employees of microfirms to integrate sensing capabilities implicitly to knowledge sharing that has become crucial for detecting and leveraging new opportunities, thereby driving sustainable performance.

The KBV theory further emphasizes that a firm's adaptive capability is closely linked to its sensing capability. Thus, the previous studies proposed that flexibility serves as a fundamental mediator between sensing capability and the sustainable performance of dairy microfirms in Tanzania [1]. Therefore, debating a direct and unobserved influence of either sensing or knowledge sharing among managers and employees are vital components of knowledge-based dynamic capabilities in the context of the dairy industry [43], which are critical for sustaining competitive advantage. While most research has focused on sensing capability as a potential mediator as well as the direct effect towards sustainable performance [44], Therefore, there is limited empirical exploration regarding the parallel analysis among the managers and employees of microfirms about the effectiveness of sensing capability on sustainable performance. Based on this reasoning, we posit the following hypothesis

H2a: Sensing capability positively affects sustainable performance.

H2b: Unobserved differences in sensing capability positively affect sustainable performance.

## 2.3. Managerial cognitive capabilities and sustainable performance

Management literature defines managerial cognitive capabilities as the capacity of managers and employees to handle multiple tasks while performing daily mental activities, which are closely tied to cognition [22]. These capabilities assume that managers and employees function as knowledge workers, spending significant time acquiring, organizing, absorbing, processing, and distributing information related to opportunities [45]. In a nutshell, previous research has highlighted the role of managerial cognitive capabilities in linking the mental cognition of managers and employees to actions that directly influence firm performance [14]. This suggests a direct relationship between the mental actions of organizing and acquiring information and a firm's sustainable performance. Consequently, the ability of managers and employees to absorb and process information is crucial for ensuring a firm's sustainability. The KBV theory further supports the importance of managerial cognitive capabilities in enhancing the mental cognitive functions of managers and employees. These cognitive activities encourage accurate information processing and organization, which are vital for improving firm performance [2]. Therefore, the mental cognitive capabilities of managers and employees play a pivotal role in driving the sustainable performance of firms.

Moreover, the mental activities of managers and employees that impact sustainable performance are of particular concern. Factors such as education levels, age, and marital status of managers and employees can significantly influence business performance. It's important to recognize that heterogeneity in how managers and employees mentally organize and process information can affect the dairy industry, leading to spillover effects that play a crucial role in differential sustainable firm performance. Understanding the managerial cognitive capabilities between managers and employees could serve as a pivotal factor in enhancing dynamic managerial capabilities [46,47]. Crucially, managerial cognitive capabilities are closely linked to knowledge sharing between managers and employees [48]. When managers and employees effectively share their experiences and knowledge, it can significantly enhance the sustainable performance of dairy microfirms [1]. This seamless exchange of knowledge and experience is vital for driving improvements in sustainability and overall firm performance.

Moreover, the literature demonstrates that managerial cognitive capabilities play a significant role in promoting sustainable performance, which can favor development within a firm. However, if the firm lacks the ability to modify, integrate, and extend resources effectively among managers and employees, the impact of these capabilities diminishes [49]. This limitation can lead to disorganized resources, making it increasingly difficult for the firm to absorb and process information essential for sustainable performance. Integrating knowledge sharing as an intangible resource can enhance the information-processing capabilities of managers and employees, thereby positively influencing sustainable performance [50]. Therefore, it is crucial to codify hidden managerial cognitive capabilities to facilitate knowledge sharing, which in turn supports sustainable performance [51]. Undoubtedly, previous research has primarily focused on the relationship between managerial cognitive capabilities and innovation, leaving a gap in understanding how these unobserved managerial capabilities influence the sustainable performance of dairy microfirms. Based on this reasoning, the study proposes the following hypothesis.

H3a: Managerial cognitive capabilities positively affect sustainable performance.

H3b: Unobserved differences in managerial cognitive capabilities positively affect sustainable performance.

## 2.4. Agility (mediator)

Agility is defined as a firm's ability to swiftly respond to market opportunities while effectively mitigating threats by leveraging resources such as available assets and human capital. This capability, characterized by the dynamism and mobility of managers and employees, plays a crucial role in enhancing the sustainable performance of microfirms. It is fair to argue that agility among managers and employees can support the sustainable management of customer delivery and the maintenance of strong supplier relationships, which are essential for long-term success in the dairy industry [1]. Certainly, the importance of agility lies in its ability to provide reliable products and services to customers, thereby ensuring sustainable performance. This has been underscored by other scholars who chronicled that "agility" and "flexibility" can be used interchangeably; of course, it underlines the close relationship between agility and sustainable performance toward reducing the business dark side [49,52,53]. However, agility, in particular, is emphasized for its role in creating delivery value and fostering strong supplier relationships by combining dynamic resource capabilities within the firm. As suggested by KBV literature, integrating the dynamic capabilities dimensions—such as sensing capability, managerial cognitive capabilities, and knowledge sharing—with firm agility can significantly enhance sustainable performance [9,50].

There is growing interest in understanding the role of agility in the dairy industry, particularly in light of reducing business disruptions significantly. Agility is seen as a critical factor in reducing production losses across economic, social, and environmental dimensions [5]. In this context, it is important to analyze whether agility can mediate the effects of sensing capability, knowledge sharing, and managerial cognitive capabilities to mitigate these production losses. To explore this, some researchers have measured a firm's agility using sustainability scorecards specifically designed for the dairy industry [8,54]. By contrast, other scholars have argued that assessing an organization's agility, alongside its sensing capability, knowledge sharing, and managerial cognitive capabilities, plays a crucial role in enhancing growth and improving innovation capacity, ultimately supporting the sustainable performance of microfirms [55].

In light of this backdrop, the existing literature demonstrates that only a few researchers have examined the mediating role of agility in the relationships between sensing capability, knowledge sharing, and managerial cognitive capabilities and evaluated its impact on sustainable performance [56]. Consequently, there is growing concern about the sustainability of the dairy industry, which is closely linked to the unobserved role of agility. As noted earlier, microfirms human capital is considered to be an intangible asset that can enhance internal and external firm resource integration, reconfiguration, and extension to support sustainable performance. In this sense, a flexible and resilient system, built upon knowledge sharing, sensing capability, and managerial cognitive capabilities, can significantly influence the individual flexibility of the firm [5]. However, there is a notable shortage of empirical analyses that evaluate the mediation effects of agility following the unobserved effects analysis, particularly in the context of knowledge sharing, sensing capability, and managerial cognitive capabilities. This gap in the literature leads to the formulation of the following hypotheses.

H4a: Agility mediates the effects of knowledge sharing on sustainable performance.

H4b: Agility mediates the unobserved difference effects of knowledge sharing on sustainable performance.

H4c: Agility mediates the effects of sensing capability on sustainable performance.

H4d: Agility mediates the unobserved differences effects of sensing capability on sustainable performance.

H4e: Agility mediates the effects of managerial cognitive capabilities on sustainable performance.

H4f: Agility mediates the effects of unobserved differences in managerial cognitive capabilities on sustainable performance.

## 2.5. Sustainable performance

Sustainable performance in the dairy industry has been examined from various perspectives by different authors [1,57,58]. In this context, managers and employees play a crucial role in developing and improving microfirms dynamic capabilities [19]. However, there is growing concern about integrating dynamic capabilities with sustainable performance to keep pace with both local and global growth. Sustainable performance is defined as "the strategic, transparent integration and achievement of an organization's social, environmental, and economic goals through the systemic coordination of key inter-organizational business processes, aimed at improving the long-term economic performance of the company and its supply chains" [59–61]. In a similar context, KBV theorists postulated that achieving economic sustainability requires the effective deployment of resources to enhance sustainable performance

[62]. In this regard, the dairy microfirm's resources, including the knowledge of managers and employees, industry assets, and various capabilities such as agility and sensing capability, are vital to helping social, environmental, and economic goals.

For example, sustainable performance aligning with dairy microfirms has been presented by different authors from different perspectives [59]. The literature suggested that managers and employees in the dairy industry typically play a key role in developing dynamic capabilities [41]. Nonetheless, there is an emerging concern regarding integrating the industry's capabilities and sustainable performance to keep up with local and global growth. Thus, sustainable performance is defined as "the strategic, transparent integration and achievement of an organization's social, environmental, and economic goals in the systemic coordination of key inter-organizational business processes for improving the long-term economic performance of the individual company and its supply chains" [61,63]. Of course, KBV pieces of literature have suggested that to achieve economic sustainability among the microfirms, the deployment of resources should be adequate to enhance sustainable performance [64]. It is important to note that knowledge of managers and employees is among the important resources within the industry, and managerial learning is a crucial resource to affect sustainable performance.

Several researchers have a growing interest in navigating sustainable performance in the dairy industry [1]. For example, Bourlakis et al. [57] have pointed out the measurement of sustainable performance in the dairy food sectors through efficiency, responsiveness, flexibility, and product quality as potential indicators. However, most of the authors have been focused on measuring these sustainable performance indicators in the supply chain of the dairy industry. For instance, Beske et al. [38] examined the sustainable supply chain and dynamic capabilities in the food industry. The study concluded that dynamic capability in the supply chain is sustainably oriented through knowledge sharing [64]. On the other hand, the empirical literature has less explored relationships between agility and its embedded unobserved variation toward sustainable performance. Based on the above reasons, we hypothesize that.

H5a: Agility positively affects sustainable performance.

H5b: Unobserved differences in agility positively affect sustainable performance.

# 3. Materials and methods

## 3.1. Descriptive analysis

**Table A1** (Appendix) presents the descriptive analysis of the observed indicators and social demographic variables, including occupational levels for managers and employees, sex, size, and educational level. The data reveals a high degree of agreement among managers and employees concerning knowledge sharing, sensing capability, managerial cognitive capability, agility, and sustainable performance. This agreeability is reflected in the mean values for each indicator, which range between 3.62 and 3.02 on a seven-point Likert scale. However, the study also highlights a significant degree of variability within the data sets, as evidenced by the high level of dispersion in the manifest variables associated with these indicators. Additionally, the kurtosis and skewness values indicate both negative (−) and positive (+) values, suggesting that the study sample is normally distributed [65]. Although our study does not rely on the Gaussian principle, this distribution supports the data's validity. Consequently, the observed indicators and social demographic variables exhibit minimal noise.

### 3.2. Measures and data description

The structured questionnaire in this study was developed based on an extensive review of empirical literature related to sensing capability (four items), knowledge sharing (four items), managerial cognitive capabilities (four items), agility (four items), and sustainable performance (four items). We utilized Likert scales ranging from strongly disagree (1) to strongly agree (7) to measure each dimension within the latent constructs, enabling a multidimensional perspective on the dynamic capabilities and sustainable performance of Tanzanian dairy microfirms [65]. In summary, the study designed a survey questionnaire that included both structured and unstructured questions. The initial draft was pretested by collecting responses from one hundred ($n$ = 100) managers and employees across dairy microfirms in three regions: Kilimanjaro, Tanga, and Arusha. The pilot survey helped identify any ambiguities, vagueness, or confusion in the wording of the questions. Feedback from respondents during the pilot phase was invaluable in refining the questionnaire to enhance clarity and ensure consistent interpretation of the questions.

The selection of managers and employees from Tanzanian dairy microfirms as the study population is justified by their significant economic role, particularly in rural development and poverty alleviation. The dairy sector contributes substantially to Tanzania's agricultural GDP and provides essential employment and income for smallholder farmers. Additionally, these dairy microfirms face unique challenges such as market access, financial constraints, and infrastructural deficiencies, making them an ideal focus for examining how dynamic capabilities like agility, knowledge sharing, and sensing capabilities contribute to sustainable performance. Furthermore, studying this sector aligns with broader national development goals related to rural development, food security, and economic empowerment. Addressing this specific context also fills a gap in the existing literature by providing empirical evidence on the application of dynamic capabilities in Tanzanian dairy microfirms, thereby enriching the theoretical understanding of these concepts in a developing country context.

In this study, the selection of three Tanzanian regions for obtaining the sample population is pivotal due to their distinctive characteristics, which collectively provide a comprehensive understanding of the dairy microfirm landscape in Tanzania. First, these regions exhibit varying levels of infrastructural development, market integration, and access to support services, such as veterinary care and financial institutions. By selecting regions with different levels of these critical factors, the study can explore how such variations influence the dynamic capabilities of dairy microenterprises, including their agility, knowledge sharing, and sensing capabilities. Moreover, these regions represent the broader dairy sector in Tanzania, encompassing both well-established and emerging dairy-producing areas. This selection ensures that the findings are generalizable across the country and can provide insights that are relevant to policymakers and stakeholders aiming to support the growth and sustainability of dairy microenterprises in Tanzania.

We tested the conceptual framework (**Figure 1**) using a survey questionnaire on managers and employees of dairy microfirms. The final version of the structured questionnaire was distributed to 400 managers and employees to conduct the empirical analysis. Due to the pandemic, the study employed a drop-and-collect method. Data collection occurred between June 2021 and January 2022 in multiple waves. Notably, collecting data in multiple waves was crucial to mitigating the common method variance (CMV) effect, which is important for enhancing the reliability and validity of the indicators [34]. In the first wave, conducted between April and May 2021, we collected data on the antecedent variables—knowledge sharing and sensing capability. The second wave, between June and July 2021, focused on gathering data about agility from managers and employees. In the final wave, between January and February 2022, we completed data collection by focusing on sustainable performance as the consequent variable [66].

Following the data collection, the study tested the hypotheses (**Figure 1**) using the R programming language (version 4.2.2) [67]. The rationale for using R is that it is open-source software with strong reproducible features. The study tested the conceptual framework by deploying the global model using PLS-PM, and our study added QC-PM within the R environment after installing two packages. First, we unpacked the plspm package (version 0.5.0) [68] to assess the global model for direct and indirect effects. Second, we complemented this with the QC-PM package (version 0.2) [67] to carry out the QC-PM analysis. In line with the standard procedure for QC-PM, we set the manifest variables as reflective indicators, enabling the QC-PM algorithm to iterate stepwise and reach convergence. Consequently, the study constructed quantile composite blocks using 20 manifest variables.

Validation of the QC-PM and PLS-PM was conducted through the outer and inner models. Certainly, loadings and path coefficients were estimated using quantile regressions. The study then applied a bootstrapping procedure to both the outer and inner models. Additionally, the underlying global model's inner and outer structures were estimated with 5000 bootstraps to detail standard errors and the lower and upper percentiles at a 95% confidence interval (CI). Finally, we compared the path coefficients of the global model with those of the QC-PM to address the study's first and second objectives. Furthermore, the study conducted a model quality assessment for both the global model and the QC-PM, following the suggestions by Davino et al. [28]. The internal consistency of the two models was first examined using Cronbach's Alpha, Goldstein's Rho, and Dijkstra-Henseler's Rho. For the QC-PM specifically, the study assessed its quality through pseudo-$R^2$ and redundancy measurements. Together, these standard metrics provided a comprehensive internal quality assessment of both the global model and the QC-PM [69].

**Table A2** (Appendix) above presents the block unidimensionality and composite reliability for both the global model and QC-PM. For the global model, we used three indexes: Cronbach's Alpha, Dillon-Goldstein's Rho (DG.rho), eigenvalue, and Average Variance Extracted (AVE). The findings indicate that both Cronbach's Alpha and Dillon-Goldstein's rho are above 0.7, while AVE exceeds 0.5, meaning the indicator variance meets the necessary thresholds [70]. For the quantile model, four index measurements were used, including Dijkstra-Henseler's Rho, to evaluate internal consistency in quantile-composite path modeling. The results show that Cronbach's Alpha, Dillon-Goldstein's Rho, and Dijkstra-Henseler's Rho are all above 0.7, confirming acceptable internal consistency and the reliability of the measurement model in both the global model and QC-PM. Additionally, the Dijkstra-Henseler Rho, with values above 0.7, further supports the reliability of the constructs [70–73]. The study concluded that the latent constructs demonstrate true reliability. Regarding the correlation matrix, the eigenvalue served as the measurement index, as presented in **Table A1** (Appendix), with the first and second eigenvalues falling within the acceptable threshold. It is fair to argue that our study's sampled data fits well with the two constructed models (PLS-PM and QC-PM), meeting the required thresholds of internal consistency.

### 3.3. Quantile composite-based path modelling (QC-PM)

The QC-PM is a composite analysis method that measures network relationships between observed and unobserved variables, initially proposed by Davino and Vinzi [73]. It integrates quantile regression [74] and quantile correlation within a single, unified framework [75]. As an extension of Ordinary Least Squares (OLS) regression [76], QC-PM focuses on the conditional quantiles of response variables. Meanwhile, PLS-PM converges by calculating the outer weight as a linear combination to reveal latent variables through OLS [77]. Notably, QC-PM complements the PLS-PM approach by exploring the entire dependence structure of an observed sample using quantile regression, thereby navigating variations across the full distribution of the response construct. This study employs both QC-PM and PLS-PM as dimension reduction approaches to test hypotheses (H1-H7) and uncover potential unobserved variations between dimensions of dynamic capabilities and sustainable performance. These dual dimension reduction methods are particularly robust when dealing with non-normal data [71]. QC-PM highlights how unobserved variables shift within the quantile of interest [18], while PLS-PM explores the homogeneous relationships within the study's conceptual framework (**Figure 1**). By integrating these two methods into a single, unified framework, this study provides a comprehensive explanation of the alternative relationships between dimensions of dynamic capabilities and sustainable performance.

The QC-PM method is the primary analytical approach used in this study. As outlined, QC-PM mirrors the PLS-PM algorithm (soft modeling) but replaces OLS regression with quantile regression. QC-PM follows a two-step procedure to achieve convergence. First, it computes the outer weights through iterative techniques, and then an algorithm uses these weights to develop the composites. Second, leveraging the composite estimates, the model parameters—such as loadings and path coefficients—are established [70]. The study then analyzed the model using quantile regression [77], while incorporating partial criteria at each step, similar to the PLS-PM method. QC-PM focuses on the model's conditional distribution for all involved response variables, allowing for the estimation of partial conditional quantiles. By following these QC-PM steps, our study combined the two models into a single conceptual framework (**Figure 1**) to unravel the differing relationships between the dimensions of dynamic capabilities and the sustainable performance of dairy microfirms. This approach enabled us to precisely address the study's objectives.

## 4. Findings

### 4.1. Measurement model summary

**Table A3** (Appendix) presents the initial evaluations of the quantile composite model using two indexes: loadings and communality at quantile levels of 0.25, 0.50, and 0.75. The model was constructed with reflective indicators, and the loadings were evaluated using quantile regressions. All loadings across the quantiles are above 0.7, indicating that the constructs explain at least 50% of the indicator's variance. Thus, the study demonstrates that each quantile's measurement model has acceptable reliability [72].

**Figure 2** presents the measurement model summary for the global model, evaluated based on the correlations among latent variables and indicators. The figure shows that the loading scores are above 0.5, exceeding the required thresholds [16]. This indicates that the latent constructs capture at least 50% of the variation in the indicators.

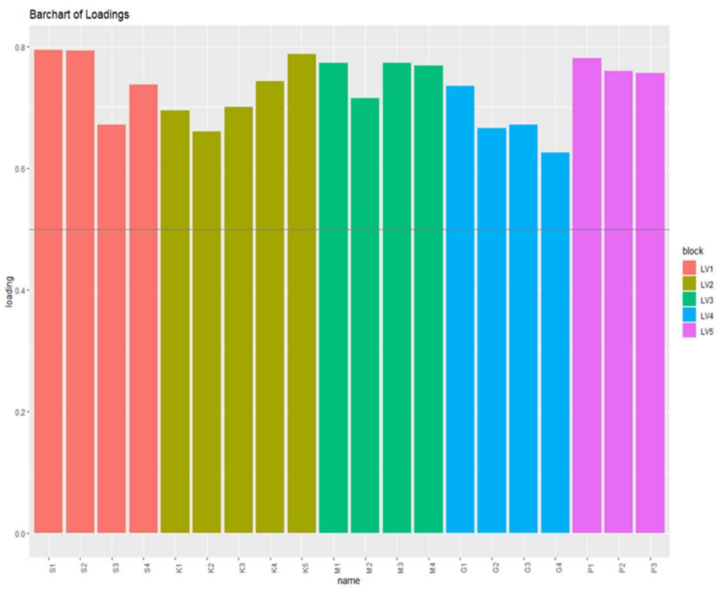


**Figure 2.** Measurement model summary.

### 4.2. Model assessment and validation

**Table A4** (Appendix) presents the internal and external estimation scores assessed at quantile levels of 0.25, 0.50, and 0.75. The internal and external evaluations were conducted separately at each quantile level. To assess and validate the QC-PM model, we used three indexes: block communalities, block redundancy, and Pseudo-$R^2$. The findings indicate that block communalities are above 0.2, suggesting that the dimensions of dynamic capabilities have strong block communality values.

Regarding the measurement model, the study used Pseudo-$R^2$ to assess the variability explained by agility and sustainable performance concerning explanatory variables such as sensing capability, knowledge sharing, and managerial cognitive capabilities. Agility showed Pseudo-$R^2$ values of 0.276 at the 0.25 quantile, 0.108 at the 0.50 quantile, and 0.38 at the 0.75 quantile, indicating satisfactory goodness of fit for each quantile. Similarly, sustainable performance demonstrated strong Pseudo-$R^2$ values of 0.125 at the 0.25 quantile, 0.161 at the 0.50 quantile, and 0.291 at the 0.75 quantile. Overall, the goodness of fit at the quantile level is significant [74]. **Table A5** (Appendix) displays the goodness of fit at the global level, with coefficient determination scores of 0.81 for agility and 0.82 for sustainable performance. Additionally, the calculated effect size (*f*) was 0.7, which is considered strong as it exceeds the threshold of 0.5 [70].

Additionally, we evaluated the endogenous blocks to illustrate the outer part of the model using redundancy measures. **Table A4** (Appendix) presents the redundancy values for agility as follows: 0.065 at the 0.25 quantile, 0.10 at the 0.50 quantile, and 0.128 at the 0.75 quantile. For sustainable performance, the redundancy values are 0.039 at the 0.25 quantile, 0.07 at the 0.50 quantile, and 0.932 at the 0.75 quantile [72]. Redundancy measures the variance explained by the observed variables corresponding to the endogenous blocks, such as agility and sustainable performance. Overall, the reliability assessment, constrained separately for each quantile, shows strong scores for both the inner and outer examinations. Consequently, the values for block communality, redundancy, Pseudo-$R^2$, and block redundancy are significant.

## 4.3. Comparison of internal structure between quantile and global levels

**Table A5** (Appendix) presents the structural summary results of the tested theoretical and conceptual framework (see **Figure 1**) concerning the relationship between dimensions of dynamic capabilities and the sustainable performance of dairy microfirms. The table highlights the estimation, standard error, *p*-value (Pr), 95% lower confidence limit, and 95% upper confidence limit of the estimated path coefficients for the QC-PM model. It also includes the lower and upper boundaries obtained through bootstrap analysis at a 95% confidence interval for the classical PLS-PM model.

The summary directs effects; the findings show that knowledge sharing has a small positive coefficient effect on sustainable performance (H1a: $\beta$ = 0.250: BCI 0.025 = 0.072; BCI 0.097 = 0.431). Thus, it supports H1a that knowledge sharing positively affects sustainable performance. Interestingly, the beta values at the quantile levels illustrated strong coefficient variations between lower and higher quantiles; certainly, at the quantile levels, the relationship is insignificant (H1b: $\theta$st0.25: $\beta$ = 0.109; $\theta$nd0.5: $\beta$ = 0.140; $\theta$rd0.75: $\beta$ = 0.014). Thus, H1b has been rejected because unobserved differences in knowledge sharing positively impact sustainable performance. The link between sensing capability and sustainable performance has moderately significant positive beta values of (H2a: $\beta$ = 0.376; BCI 0.025 = 0.257; BCI 0.097 = 0.594). Therefore, it supports H2a that sensing capability positively affects sustainable performance. At the same time, the findings show unobserved positive significant coefficient variations from lower to higher quantiles (H2b: $\theta$st0.25: $\beta$ = 0.369***; $\theta$nd0.5: $\beta$ = 0.435***; $\theta$rd0.75: $\beta$ = 0.412*) between sensing capability and sustainable performance. Thus, it supports H2b that unobserved differences in sensing capability positively impact sustainable performance. Furthermore, the path between managerial cognitive capabilities and sustainable performance has a lower significant coefficient value and is insignificant because it contained zero (H3a: $\beta$ = 0.122: BCI 0.025 = −0.020; BCI 0.097 = 0.290). For that reason, it rejected H3a that managerial cognitive capability is positively associated with sustainable performance. Additionally, the same link has shown a strong, significant beta variation between lower and higher quantiles (H3b: $\theta$st0.25: $\beta$ = −0.252; $\theta$nd0.5: $\beta$ = 0.0.199; $\theta$rd0.75: $\beta$ = −0.040). Thus, H3b has been rejected because unobserved differences in managerial cognitive capabilities positively impact sustainable performance. The link between agility and sustainable performance has significant positive beta values of (H5a: $\beta$ = 0.217; BCI 0.025 = 0.074; BCI 0.097 = 0.370). Therefore, it confirmed H5a that agility is positively associated with sustainable performance. Furthermore, the same link demonstrated strong variations of coefficient score between lower and higher quantiles (H5a: $\theta$st0.25: $\beta$ = 0.393***; $\theta$nd0.5: $\beta$ = 0.350**; $\theta$rd0.75: $\beta$ = 0.433***). Thus, it supports H5b. Unobserved differences in agility positively impact sustainable performance.

Regarding the mediation summary (Indirect effects), agility mediates the relationship between sensing capability, knowledge sharing, and managerial cognitive capabilities on sustainable performance. The findings highlight that agility has a significant mediation effect in the relationship between sensing capability and sustainable performance with beta values of (H4a: $\beta$ = 0.425; BCI 0.025 = 0.257; BCI 0.097 = 0.594). It confirmed H4a that agility mediates the effects of knowledge sharing on sustainable performance. In the same breath, there are strong variations of coefficient values between lower to higher quantiles (H4b: $\theta$st0.25: $\beta$ = 0.293**; $\theta$nd0.5: $\beta$ = 0.407***; $\theta$rd0.75: $\beta$ = 0.303***). Thus, it supported H4b that agility mediates the unobserved difference effects of knowledge sharing on sustainable performance. Moreover, findings showed that agility has significant positive mediation effects in the relationship between knowledge sharing and sustainable performance with a coefficient value of (H4c: $\beta$ = 0.290: BCI 0.025 = 0.128; BCI 0.097 = 0.471) and confirmed H4c agility mediates the effects of sensing capability on sustainable performance. At the same time, the findings show coefficient values changed between lower and higher quantiles (H4d: $\theta$st0.25: $\beta$ = 0.200*; $\theta$nd0.5: $\beta$ = 0.214**; $\theta$rd0.75: $\beta$ = 0.224*). Therefore, it supported H4d that agility mediates the unobserved differences effects of sensing capability on sustainable performance. Agility has also positively mediated the relationship between managerial cognitive capabilities and sustainable performance with small beta values of (H4e: $\beta$ = 0.222: BCI 0.025 = 0.082; BCI 0.097 = 0.630). Therefore, it supported H4e that agility mediates the effects of managerial cognitive capabilities on sustainable performance. At the same time, at the quantile levels, the beta coefficients significantly changed from lower to higher quantiles (H4f: $\theta$st0.25: $\beta$ = 0.232**; $\theta$nd0.5: $\beta$ = 0.214***; $\theta$rd0.75: $\beta$ = 0.180*). Thus, findings supported H4f that agility mediates the effects of unobserved differences in managerial cognitive capabilities on sustainable performance. In summary, the findings confirm a significant unobserved difference in the inner structure of relationships among knowledge sharing, sensing capability, managerial cognitive capabilities, agility, and sustainable performance.

## 4.4. Types and magnitude of unobserved mediation effects

**Figures 3–5** present the mediation analysis and detail the type and magnitude of agility's mediating unobserved differences between knowledge sharing, sensing capability, and managerial cognitive capability on sustainable performance, based on the results from **Table A5** (Appendix). To determine if the mediation paths (a*b) are significant, we bootstrapped the sample. **Table A5** (Appendix) shows that both paths a** and b** are statistically significant across the three quantiles, but the type and magnitude of mediation remain unclear. Therefore, the study examined the mediation effects to clarify the role of agility as a mediator. The direct relationship between knowledge sharing and sustainable performance (C') was found to be non-significant (*t*-value = 1.05; Sobel test: *t* = 2.42**), indicating that the relationship is fully mediated by agility. Thus, agility demonstrates full mediation effects in this context. Conversely, agility exhibited complementary partial mediation effects in the relationship between sensing capability and sustainable performance, as the direct effect (C') is significant and both paths a and b are positively oriented (C': *t* = 7.87**; Sobel test: *t* = 3.05**). Additionally, agility displayed competitive partial mediation effects in the relationship between managerial cognitive capability and sustainable performance. Although paths a and b are significant, the direct effect (C') is not significant and shows a negative direction (C': *t* = −2.89; Sobel test: *t* = 3.29**).

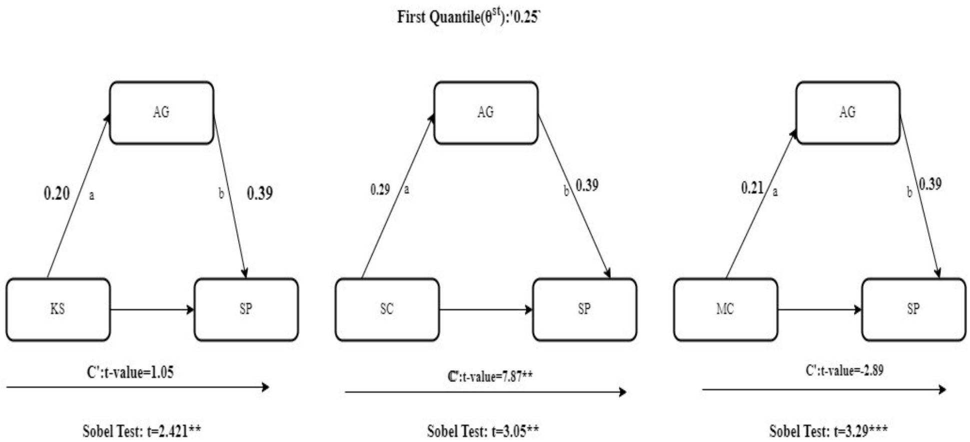


**Figure 3.** Mediation analysis at the first quantile ($\theta^{st}$).

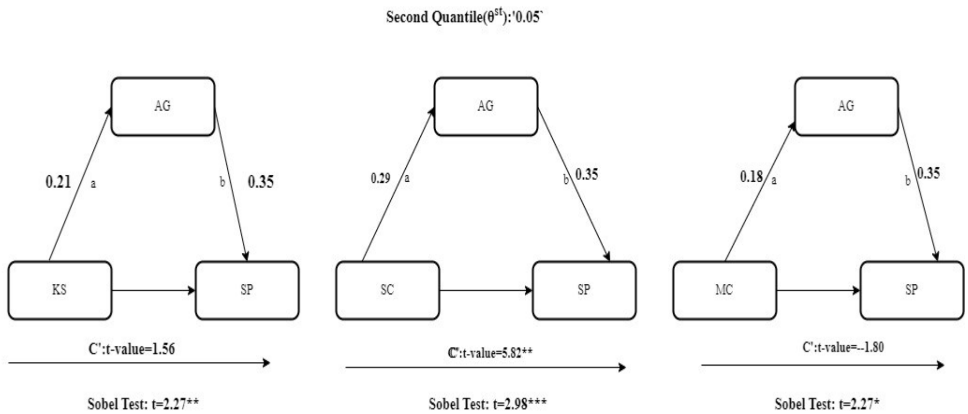


**Figure 4.** Mediation analysis at the second quantile ($\theta^{nd}$).

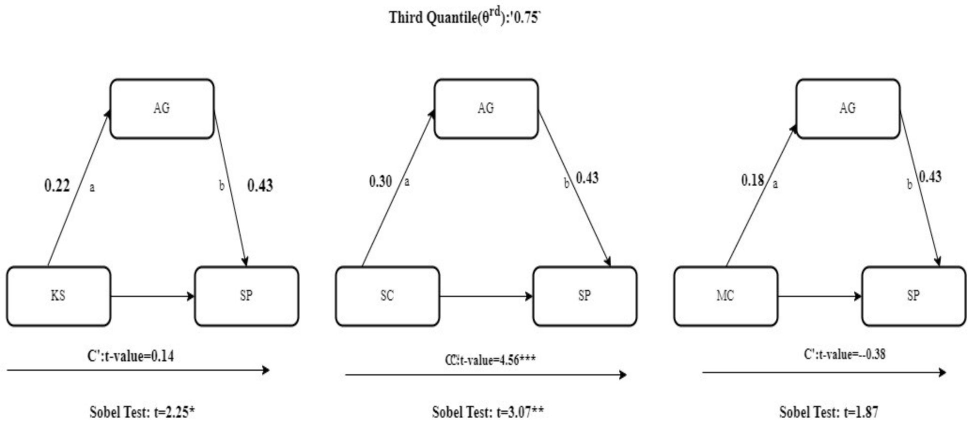


**Figure 5.** Mediation analysis at the third quantile ($\theta^{rd}$).

**Figure 4** illustrates the type and magnitude of mediation at the second quantile. The findings indicate that agility fully mediates the relationship between knowledge sharing and sustainable performance, as the indirect paths (a*b) are statistically significant, although the direct path (C') is not significant (*t*-value = 1.56; Sobel test: *t* = 2.27**). The second path, similar to the results in the first quantile, shows that agility serves as a complementary partial mediator in the relationship between sensing capability and sustainable performance (C': *t*-value = 5.82**; Sobel test: *t* = 2.98**). Additionally, at the second quantile, agility also fully mediates the relationship between managerial cognitive capability and sustainable performance (C': *t*-value = −1.80; Sobel test: *t* = 2.27**), which aligns with the results observed in the first quantile.

**Figure 5** illustrates the mediation analysis at the third quantile, revealing that agility fully mediates the relationship between knowledge sharing and sustainable performance (C': *t*-value = 0.14; Sobel test: *t* = 2.25**, indicating statistical significance). Although the direct path (c') is not significant, the indirect effects (a*b) are statistically significant. Furthermore, the findings confirm that agility has a complementary partial mediation effect on the relationship between sensing capability and sustainable performance (C': *t*-value = 4.56; Sobel test: *t* = 3.07**, also indicating statistical significance). However, the study did not confirm mediation effects for the final link, as the direct effect (c') and Sobel test statistics were not supportive. For additional details, Appendix I (quantile correlations) presents the quantile correlation (QC) estimates, with *P*-values for all loadings being statistically significant according to the BCI at 95% confidence intervals (lower and upper).

## 5. Discussion

The main purpose of the study was to investigate the effects of unobserved variations in dynamic capabilities on the sustainable performance of Tanzanian dairy microfirms. Additionally, our study examined the unobserved mediating effects of agility in the relationship between knowledge sharing, sensing capability, and managerial cognitive capability on sustainable performance. The study draws on the KBV logic, suggesting that there are relationships between dimensions of dynamic capabilities that support the sustainable performance of dairy microfirms. Our study also presents theoretical implications that stem from the tested conceptual framework (**Figure 1**) and thoroughly documents the study's findings.

Our approach is one of the first empirical studies to explicitly test a conceptual framework developed from KBV theory, applying it to the dimensions of dynamic capabilities and providing insights into dairy microfirms. The study not only demonstrates the direct effects of dynamic capabilities on sustainable performance but also highlights the significance of unobserved variations and the role of agility in mediating the relationships between knowledge sharing, sensing capability, and sustainable performance [56]. Specifically, the study found significant direct effects of sensing capability, knowledge sharing, and agility on the sustainable performance of dairy microfirms in Tanzania [1]. These findings suggest that dairy microfirms need to strategically enhance their ability to sense market trends, share knowledge, and remain agile in response to changing conditions [59]. This integrated approach can drive innovation, improve responsiveness to disruptions, and foster a culture of continuous learning, all essential for sustaining long-term performance in a competitive and volatile market [61]. Moreover, the insights provide valuable guidance for managers, employees, and owners in the dairy industry, emphasizing the importance of supporting microfirms through training, market intelligence, and incentives for sustainable practices to position sustainability as a competitive advantage.

Second, the study confirms that the unobserved effects of knowledge sharing, sensing capability, and managerial cognitive capabilities significantly influence the sustainable performance of Tanzanian dairy microfirms. These findings underscore the importance of intangible and often overlooked factors in driving long-term success for microfirms in developing economies like Tanzania. Managers and employees must recognize that both visible actions and underlying cognitive processes and knowledge dynamics are crucial for achieving sustainable performance [16]. This insight suggests that dairy microfirms should invest in developing and nurturing these capabilities within their management teams, fostering an environment that encourages knowledge sharing and enhances the ability to sense and respond to market changes [25]. Additionally, these findings may prompt further research into how these unobserved effects can be better measured and leveraged, opening new avenues for improving the sustainability and performance of microfirms.

Finally, we found that agility among managers and employees fully and partially mediates the unobserved differences between knowledge sharing, sensing capability, and managerial cognitive capability in supporting the sustainable performance of dairy microfirms in Tanzania. This underscores the critical role of agility in effectively translating these capabilities into tangible, sustainable outcomes [22]. Our findings suggest that even if a dairy microfirm has strong knowledge-sharing practices, sensing capabilities, and managerial cognitive skills, these alone may not directly lead to sustainable performance without agility [23]. Therefore, dairy microfirms should prioritize cultivating agility within their employees and management teams, integrating it into their organizational culture and processes to enhance responsiveness and adaptability.

In summary, our study opens the "black box" of dynamic capabilities and highlights the idiosyncratic nature of these capabilities. The results reveal varying degrees of impact from sensing capability, knowledge sharing, managerial cognitive capabilities, and agility on the sustainable performance of dairy microfirms. This suggests that dairy microfirms possess strong, difficult-to-imitate competencies [78]. Systematic changes in resources are crucial, as they enable dairy microfirms to accumulate experience and knowledge in managing heterogeneity, which in turn helps in developing common resources that enhance dynamic capabilities and competitive advantages. Our study posits that the idiosyncratic nature of dynamic capabilities in Tanzanian dairy microfirms stems from multiple sources among managers and employees [26]. We argue that combining differentiation strategies to address heterogeneity is essential for developing evolutionary dynamic capabilities and enhancing managerial competencies. By doing so, dairy microfirms can achieve stability and resilience in the face of environmental changes while potentially reducing costs.

## 6. Conclusion and implication

### 6.1. Conclusion

The study provides significant insights into the dynamics of capabilities within Tanzanian dairy microfirms, particularly focusing on the roles of sensing capability, knowledge sharing, managerial cognitive capabilities, and agility in achieving sustainable performance. By uncovering the unobserved effects and demonstrating how agility mediates the relationships between these capabilities and sustainable performance, the research highlights the complexity and importance of dynamic capabilities in this context.

Key Findings:

1) Unobserved Effects: The study confirms that the unobserved effects of knowledge sharing, sensing capability, and managerial cognitive capabilities significantly influence sustainable performance. These factors, though often intangible and overlooked, are crucial for the long-term success of dairy microfirms.
2) Role of Agility: Agility among managers and employees is found to be a critical mediator. It not only fully but also partially mediates the relationship between knowledge sharing, sensing capability, and managerial cognitive capability with sustainable performance. This emphasizes that agility is essential in translating these capabilities into practical, sustainable outcomes.
3) Strategic Implications: Dairy microfirms must strategically enhance their agility, alongside developing their knowledge-sharing practices, sensing capabilities, and managerial cognitive skills. This integrated approach can drive innovation, improve responsiveness to disruptions, and foster a culture of continuous learning.
4) Competitive Advantage: The study suggests that dairy microfirms possess unique competencies that are difficult to imitate, giving them a competitive edge. Systematic resource changes are vital for accumulating experience and knowledge, which helps in managing heterogeneity and developing common resources that contribute to dynamic capabilities and competitive advantages.

5) Practical Recommendations: Managers and employees should focus on cultivating agility within their teams and integrating it into the organizational culture and processes. This will enhance their ability to respond to environmental changes effectively and improve overall performance.

Conclusively, our study underscores the importance of both visible and intangible factors in driving sustainable performance. It suggests that a holistic approach, combining strong dynamic capabilities with high agility, is essential for dairy microfirms to thrive in a competitive and volatile market.

## 6.2. Study implication, limitation, and future research directions

Besides the theoretical contributions mentioned above, the study also highlights managerial, practical, and policy implications. From a managerial perspective, our study provides valuable insights for managers, employees, and owners of dairy microfirms in Tanzania on how to effectively manage differences in dynamic capabilities to enhance sustainable performance. For instance, to improve dynamic capabilities, dairy microfirms should leverage unique resources accumulated through knowledge sharing, sensing capabilities, managerial cognitive skills, and agility to address underlying differences that impact sustainable performance. In terms of practical contributions, the findings indicate that differences in dynamic capabilities can enhance sustainable performance, with agility partially mediating these differences. Therefore, owners of dairy microfirms should streamline resources while considering individual capabilities to effectively implement sensing capabilities, knowledge sharing, and managerial cognitive skills. This approach can help balance growth and maintain a sustainable competitive advantage. Furthermore, the study's empirical results reveal both strong and weak direct and indirect effects. Managers and owners of dairy microfirms can use these insights to enhance agility and strengthen their organizational structure, thereby better supporting dynamic capabilities and improving sustainable performance.

Our study findings offer two key policy insights regarding the dimensions of dynamic capabilities and their impact on the sustainable performance of Tanzanian dairy microfirms. First, resource allocation should be tailored to manage each aspect of sensing capability, knowledge sharing, managerial cognitive capabilities, and agility to enhance sustainable performance. Policymakers can assist owners in optimizing the extension and reconfiguration of physical, natural, human, financial, and intellectual assets to minimize the differential effects of dynamic capability dimensions on sustainable performance. Second, the allocation of resources between managers and employees should align with quantile structural variations to improve sustainable performance. Both internal and external resources can create significant spillover effects, fostering better communication and collaboration. Establishing a robust communication infrastructure is crucial for effectively developing dynamic capabilities and enhancing sustainable performance.

This study has several limitations. While the findings confirm that differences in dimensions of dynamic capabilities significantly influence the sustainable performance of Tanzanian dairy microfirms, the study's conceptual framework utilized a single mediator and tested hypotheses at the individual level. This approach makes it challenging to establish causality with cross-sectional data analysis. To enhance the understanding of dynamic capabilities in dairy microfirms, future research should explore causality between dynamic capability dimensions and sustainable performance at the business unit level and consider antecedents such as alliance transformation. Additionally, the study's conceptual framework is limited to the firm level; future research could extend this framework beyond firm boundaries to verify the validity and reliability of the hypotheses. Furthermore, this study faces a major drawback due to the ripple effects of the COVID-19 pandemic. Data collection occurred at a peak of the pandemic, during which local governments imposed strict restrictions to curb the virus's spread. Consequently, this led to significant delays in both data collection and analysis. Additionally, the pandemic impacted the manuscript development, as the writing and revisions were conducted remotely among the authors.

Future research areas have been built following the findings of this study. First, conducting longitudinal studies would help establish causality between dynamic capabilities and sustainable performance by tracking changes over time. Therefore, expanding the research to the business unit level could provide more detailed insights into how these dimensions of dynamic capabilities impact sustainable performance across different operational contexts. Additionally, investigating antecedents such as alliance transformation could offer a broader perspective on the factors influencing dynamic capabilities and sustainability. Likewise, extending the conceptual framework to include cross-border and multi-firm studies would validate the findings in diverse contexts and assess their generalizability. Last, addressing the specific impacts of the COVID-19 pandemic on dynamic capabilities and performance is also crucial, as it would shed light on how firms adapted and the long-term effects of these adaptations. In summary, combining quantitative methods with qualitative approaches could provide deeper insights into the nuances of dynamic capabilities for sustainable performance.

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# Appendix

**Table A1.** Descriptive analysis.

| Indicators | Mean | Sd | Median | Trimmed | Skew | Kurtosis | Se |
|---|---|---|---|---|---|---|---|
| S1 | 3.11 | 1.79 | 3 | 2.95 | 0.61 | −0.67 | 0.08 |
| S2 | 3.39 | 1.72 | 3 | 3.31 | 0.30 | −0.91 | 0.08 |
| S3 | 3.24 | 1.78 | 3 | 3.10 | 0.50 | −0.69 | 0.08 |
| S4 | 3.19 | 1.62 | 3 | 3.06 | 0.47 | −0.42 | 0.07 |
| K1 | 3.24 | 1.76 | 3 | 3.12 | 0.47 | −0.78 | 0.08 |
| K2 | 3.42 | 1.74 | 3 | 3.33 | 0.35 | −0.82 | 0.08 |
| K3 | 3.28 | 1.68 | 3 | 3.17 | 0.37 | −0.69 | 0.08 |
| K4 | 3.75 | 1.93 | 4 | 3.69 | 0.12 | −1.16 | 0.09 |
| K5 | 3.42 | 1.72 | 3 | 3.32 | 0.41 | −0.67 | 0.08 |
| M1 | 3.41 | 1.76 | 3 | 3.29 | 0.46 | −0.71 | 0.08 |
| M2 | 3.19 | 1.72 | 3 | 3.06 | 0.44 | −0.74 | 0.08 |
| M3 | 3.48 | 1.84 | 3 | 3.38 | 0.36 | −0.90 | 0.08 |
| M4 | 3.62 | 1.85 | 4 | 3.53 | 0.27 | −0.87 | 0.08 |
| G1 | 3.51 | 1.92 | 3 | 3.39 | 0.36 | −1.02 | 0.09 |
| G2 | 3.28 | 1.85 | 3 | 3.14 | 0.38 | −0.91 | 0.08 |
| G3 | 3.04 | 1.75 | 3 | 2.86 | 0.66 | −0.52 | 0.08 |
| P1 | 3.13 | 1.72 | 3 | 2.98 | 0.53 | −0.63 | 0.08 |
| P2 | 3.18 | 1.76 | 3 | 3.03 | 0.46 | −0.72 | 0.08 |
| P3 | 3.14 | 1.77 | 3 | 2.99 | 0.45 | −0.86 | 0.08 |

Note: Ind = indicators, sd = standard deviation, trimm = trimmed mean, se = standard error of mean, skew = skewness.

**Table A2.** Internal consistency of the global model and QC-PM.

| **Global model** | | | | | | **Quantile composite-based path modeling** | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Constructs | C.alpha | DG.rho | Eig.1st | Eig.2nd | AVE | C. alpha | DG. rho | Rho. A | Eig. 1st | Eig. 2nd |
| Sensing | 0.846 | 0.897 | 2.74 | 0.617 | 0.564 | 0.745 | 0.790 | 0.746 | 2.121 | 0.021 |
| Knowledge | 0.785 | 0.812 | 2.17 | 0.943 | 0.517 | 0.846 | 0.896 | 0.844 | 2.740 | 0.616 |
| Managerial | 0.867 | 0.802 | 2.13 | 0.965 | 0.574 | 0.902 | 0.931 | 0.945 | 3.096 | 0.437 |
| Agility | 0.794 | 0.816 | 2.18 | 0.927 | 0.500 | 0.880 | 0.716 | 0.791 | 1.570 | 0.388 |
| Sustainable | 0.720 | 0.832 | 2.34 | 0.969 | 0.587 | 0.798 | 0.822 | 0.804 | 2.321 | 0.989 |

Note: C. alpha=Cronbach's alpha, DG. rho=Dillon-Goldstein's rho, rho. A=Dijkstra-Henseler rho, E. 1st = first eigenvalue value, E. 2nd = second eigenvalue value, AVE = Average Variance Extracted.

**Table A3.** Estimation of outer loadings at quantile levels 0.25, 0.50 and 0.75.

| Indicators | 0.25 | 0.5 | 0.75 |
|---|---|---|---|
| Knowledge K1 | 0.7362 | 0.7651 | 0.7666 |
| Knowledge K2 | 0.7414 | 0.7382 | 0.6746 |
| Knowledge-K3 | 0.7509 | 0.8067 | 0.8073 |
| Knowledge-K4 | 0.8843 | 0.7952 | 0.8415 |
| Sensing-S1 | 0.7651 | 0.7884 | 0.8478 |

**Table A3.** (*Continued*).

| **Indicators** | **0.25** | **0.5** | **0.75** |
|---|---|---|---|
| Sensing-S2 | 0.8324 | 0.8136 | 0.8174 |
| Sensing-S3 | 0.5560 | 0.7351 | 0.7732 |
| Sensing-S4 | 0.7500 | 0.7708 | 0.7257 |
| Manager-M1 | 0.8151 | 0.7913 | 0.7737 |
| Manager-M2 | 0.7916 | 0.7245 | 0.7863 |
| Manager-M3 | 0.8238 | 0.8290 | 0.8104 |
| Manager-M4 | 0.7617 | 0.7858 | 0.7456 |
| Agility-G1 | 0.7713 | 0.8323 | 0.9321 |
| Agility-G2 | 0.6280 | 0.7287 | 0.8179 |
| Agility-G3 | 0.5190 | 0.6881 | 0.7480 |
| Sustain-P1 | 0.7805 | 0.7819 | 0.9127 |
| Sustain-P2 | 0.7371 | 0.7628 | 0.7620 |
| Sustain-P3 | 0.7284 | 0.7612 | 0.8434 |

Notes: SC = sensing capability, KS = knowledge sharing, MC = managerial cognitive capabilities, AG = agility, SP = sustainable performance.

**Table A4.** Assessing inner and outer model summary.

| **Communality** | | | | **$pseudo. R2** | | |
|---|---|---|---|---|---|---|
| | **0.25** | **0.5** | **0.75** | **Agility** | | |
| Knowledge-K1 | 0.2836 | 0.3512 | 0.3861 | **0.25** | **0.5** | **0.75** |
| Knowledge-K2 | 0.2597 | 0.3147 | 0.2870 | 0.276 | 0.108 | 0.340 |
| Knowledge-K3 | 0.2523 | 0.3786 | 0.4152 | Sustainable | | |
| Knowledge-K4 | 0.3916 | 0.4168 | 0.4571 | **0.25** | **0.5** | **0.75** |
| Sensing-S1 | 0.3101 | 0.4548 | 0.4779 | 0.125 | 0.161 | 0.291 |
| Sensing-S2 | 0.4234 | 0.4380 | 0.4282 | | | |
| Sensing-S3 | 0.0625 | 0.2839 | 0.3767 | | | |
| Sensing-S4 | 0.3371 | 0.3429 | 0.2930 | | | |
| Managerial-M1 | 0.3209 | 0.4066 | 0.3989 | | | |
| Managerial-M2 | 0.2143 | 0.3381 | 0.4121 | | | |
| Managerial-M3 | 0.3650 | 0.4326 | 0.4130 | | | |
| Managerial-M4 | 0.3585 | 0.3863 | 0.4130 | | | |
| Agility-G1 | 0.4278 | 0.4052 | 0.4271 | | | |
| Agility-G2 | 0.1999 | 0.3388 | 0.3592 | | | |
| Agility-G3 | 0.0529 | 0.2549 | 0.3411 | | | |
| Sustainable-P1 | 0.3392 | 0.4075 | 0.4867 | | | |
| Sustainable-P2 | 0.3155 | 0.4524 | 0.3564 | | | |
| Sustainable-P3 | 0.3001 | 0.4602 | 0.4291 | | | |

**Table A4.** (*Continued*).

| **$Block Communality** | | | | | |
|---|---|---|---|---|---|
| | Knowledge | Sensing | Managerial | Agility | Sustainable |
| **0.25** | 0.2968 | 0.2833 | 0.3147 | 0.2269 | 0.3182 |
| **0.5** | 0.3653 | 0.3799 | 0.3909 | 0.3329 | 0.4401 |
| **0.75** | 0.3864 | 0.3940 | 0.4093 | 0.3758 | 0.4241 |

| **$Redundancy** | | | | **$Block Redundancy** | | |
|---|---|---|---|---|---|---|
| | **0.25** | **0.5** | **0.75** | Agility | | |
| Agility-G1 | 0.1181 | 0.1319 | 0.1455 | **0.25** | **0.5** | **0.75** |
| Agility-G2 | 0.0552 | 0.1103 | 0.1224 | 0.062 | 0.108 | 0.128 |
| Agility-G3 | 0.0146 | 0.0830 | 0.1162 | | | |
| Sustainable-P1 | 0.0426 | 0.0657 | 0.1070 | Sustainable | | |
| Sustainable-P2 | 0.0396 | 0.0729 | 0.0783 | **0.25** | **0.5** | **0.75** |
| Sustainable-P3 | 0.0377 | 0.0741 | 0.0943 | 0.0399 | 0.070 | 0.932 |

**Table A5.** Estimated path coefficients at the quantile levels and global model.

| **$boot. path $\`0.25\` (*θ* st)** | | | | | | |
|---|---|---|---|---|---|---|
| **Indirect** | ***β*** | **Std** | ***t*-value** | **Pr(>\|t\|) \|** | **Low 0.95%** | **Upper 0.95%** |
| Know → Ag | 0.2000 | 0.0870 | 2.2971 | 0.0220* | 0.0289 | 0.3710 |
| Sens → Ag | 0.2938 | 0.0933 | 3.1473 | 0.0018** | 0.1104 | 0.4772 |
| Mana → Ag | 0.2327 | 0.0731 | 3.1836 | 0.0015** | 0.0891 | 0.3763 |
| **Direct** | | | | | | |
| Know → Su | 0.1097 | 0.1081 | 1.0155 | 0.3104 | −0.1026 | 0.3221 |
| Sens → Su | 0.3694 | 0.0733 | 5.0433 | 0.0000*** | 0.2255 | 0.5134 |
| Mana → Su | −0.2523 | 0.0896 | −2.8156 | 0.0051** | −0.4283 | −0.0762 |
| Agil → Su | 0.3935 | 0.0499 | 7.8798 | 0.0000*** | 0.2953 | 0.4916 |
| **Indirect** | $boot. path $\`0.5\` (*θ* nd) | | | | | |
| Know → Ag | 0.2145 | 0.0729 | 2.9441 | 0.0034** | 0.0713 | 0.3576 |
| Sens → Ag | 0.4073 | 0.1016 | 4.0074 | 0.0001*** | 0.2076 | 0.6070 |
| Mana → Ag | 0.2142 | 0.0600 | 3.5673 | 0.0004*** | 0.0962 | 0.3322 |
| **Direct** | | | | | | |
| Know → Su | 0.1402 | 0.0898 | 1.5607 | 0.1193 | −0.0363 | 0.3166 |
| Sens → Su | 0.4359 | 0.0749 | 5.8232 | 0.0000*** | 0.2888 | 0.5830 |
| Mana → Su | −0.1994 | 0.1106 | −1.8039 | 0.0719 | −0.4167 | 0.0178 |
| Agil → Su | 0.3503 | 0.1059 | 3.3089 | 0.0010** | 0.1423 | 0.5583 |
| **Indirect** | $boot. path $\`0.75\` (*θ* nd) | | | | | |
| Know → Ag | 0.2241 | 0.0981 | 2.2839 | 0.0228* | 0.0313 | 0.4169 |
| Sens → Ag | 0.3033 | 0.0875 | 3.4649 | 0.0006*** | 0.1313 | 0.4752 |
| Mana → Ag | 0.1803 | 0.0913 | 1.9752 | 0.0488* | 0.0009 | 0.3597 |

**Table A5.** (*Continued*).

| **$boot. path $`0.25` (*θ* st)** | | | | | | |
|---|---|---|---|---|---|---|
| **Direct** | | | | | | |
| Know → Su | 0.0140 | 0.0997 | 0.1403 | 0.8885 | −0.1819 | 0.2099 |
| Sens → Su | 0.4128 | 0.0905 | 4.5606 | 0.0000*** | 0.2349 | 0.5906 |
| Mana → Su | −0.0409 | 0.1060 | −0.3860 | 0.6997 | −0.2491 | 0.1673 |
| Agil → Su | 0.4333 | 0.0851 | 5.0906 | 0.0000*** | 0.2661 | 0.6006 |
| **Internal structural summary at the global level (95CI)** | | | | | | |
| **Indirect** | **Estimates** | **Std.** | **0.025** | **0.097** | **Predictive scores** | |
| SC → AG | 0.425 | 0.426 | 0.257 | 0.594 | $R^2$ Agile = 0.28 | |
| KS → AG | 0.290 | 0.291 | 0.128 | 0.471 | $R^2$ SP = 0.58 | $f = 0.7$ |
| MC → AG | 0.222 | 0.222 | 0.082 | 0.360 | GoF = 0.46 | |
| **Direct** | | | | | | |
| SC → SP | 0.376 | 0.373 | 0.157 | 0.573 | | |
| KS → SP | 0.250 | 0.247 | 0.072 | 0.431 | | |
| MC → SP | 0.122 | 0.128 | -0.020 | 0.290 | | |
| AG → SP | 0.217 | 0.217 | 0.074 | 0.370 | | |

Note: std. = standard errors, Pr = *P*-values, LCL = lower confidence limit at 95%, *β* = Coefficient, UCL = 95% upper confidence limit, R2 = coefficients determination, GoF = Goodness of the fit improvement index, *, **, &***, implies significance at $p < 0.05$, $p < 0.01$, $p < 0.001$, BCI = bootrap confidence intervals.