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# WHEN SCALE AND AGE MATTER: FIRM-SIZE AND ORGANIZATIONAL-AGE DIFFERENCES IN KNOWLEDGE MANAGEMENT AND SUSTAINABLE ORGANIZATIONAL PERFORMANCE IN PAKISTAN'S MANUFACTURING SECTOR

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**Abstract**

*This study examines whether knowledge management and sustainable organizational performance differ across firm-size and organizational-age categories in Pakistan's manufacturing sector. It uses a secondary analysis of 825 valid responses from a cross-sectional doctoral survey of managers and professionals. For the present analysis, knowledge management was recomputed from 10 item-level indicators, and sustainable organizational performance from 8 indicators. Firm size was classified into four employee categories and organizational age into five categories. Because only four respondents reported organizations younger than 5 years, this category was combined with the 5–10-year category for inferential tests only. Ordinary least squares models included size and age simultaneously as categorical predictors, with HC3 heteroscedasticity-consistent standard errors and Holm-adjusted pairwise contrasts. Firm size was associated with knowledge management, Wald $\chi^2(3) = 38.81$, $p < .001$, but not with sustainable performance, Wald $\chi^2(3) = 6.69$, $p = .082$. Organizational age was associated with both knowledge management, Wald $\chi^2(3) = 94.55$, $p < .001$, and sustainable performance, Wald $\chi^2(3) = 29.57$, $p < .001$. The 11–20-year category had the highest descriptive means on both outcomes. The findings suggest that size and age represent distinct structural characteristics. Because the data are cross-sectional and contain no unique firm identifier, the results are interpreted as respondent-level associations rather than estimates based on 825 confirmed unique firms.*

**Keywords:** Firm Size, Organizational Age, Knowledge Management, Sustainable Organizational Performance, Manufacturing, Pakistan

## 1. Introduction

Manufacturing firms are increasingly evaluated not only by their output but also by their ability to sustain economic, operational, environmental, and social performance over time. Sustainable manufacturing requires coordinated processes, responsible resource use, and responsiveness to changing stakeholder and regulatory expectations (Henao & Sarache, 2022; Wadood et al., 2023). Research in Pakistan's manufacturing sector likewise highlights the importance of sustainability-oriented operational practices and organizational capabilities (Hameed et al., 2024; Khaskhely et al., 2022). However, the availability of resources or a large operating scale does not, by itself, ensure stronger sustainability outcomes (Singh et al., 2020).

Knowledge management (KM) is one organizational capability through which firms create, share, store, and apply knowledge. The knowledge-based view treats knowledge as a strategic resource, while

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emphasizing that its value depends on how it is coordinated and integrated into organizational activity (Alavi & Leidner, 2001; Argote & Ingram, 2000; Gold et al., 2001; Grant, 1996; Lee & Choi, 2003; Nonaka, 1994). Empirical studies have linked knowledge-management practices with innovation, decision-making, and organizational performance (Abubakar et al., 2019; Andreeva & Kianto, 2012; Darroch, 2005; Erena et al., 2023). These relationships make KM relevant to understanding how manufacturing organizations translate their structural resources into sustainable performance.

Firm size and organizational age are frequently included as control variables in management research, but they represent different organizational characteristics. Size reflects current scale, often measured by employee numbers, and is associated with resource availability, specialization, and coordination demands (Haar et al., 2022; Younis & Sundarakani, 2020). Organizational age reflects the time an organization has operated and may capture accumulated experience, routines, institutional memory, and exposure to different stages of organizational development (Greiner, 1972; Iqbal & Nakhoda, 2021; Miller & Friesen, 1984; Quinn & Cameron, 1983). Treating size and age as interchangeable indicators of maturity may therefore obscure differences in how organizations develop knowledge systems and sustain performance.

The relationship between organizational structure and knowledge is not necessarily linear. Greater scale can increase the need for formalized information systems and coordination, but it can also create additional layers, silos, and information-processing demands. Similarly, organizational age may provide experience and stable routines while also increasing the risk of structural inertia. Organizational life-cycle and adaptation perspectives consequently suggest that the implications of size and age may depend on organizational stage and context (Angeles et al., 2022; Ashok et al., 2021; Hannan & Freeman, 1984; March, 1991). Experience may support learning and absorptive capacity, but its value depends on continued renewal and application (Cohen & Levinthal, 1990; Crossan et al., 1999; Zahra & George, 2002).

Research has examined firm size and age in relation to manufacturing performance and sustainability, including evidence from Pakistan and other emerging-economy contexts (Al Koliby et al., 2025; Erena et al., 2023; Iqbal & Nakhoda, 2021). Nevertheless, these characteristics are often treated as background controls rather than as the principal variables of interest. The present analysis addresses this narrower question by examining whether knowledge-management and sustainable-performance scores differ across reported firm-size and organizational-age categories, and whether the observed differences suggest thresholds or stage-dependent patterns.

The study is a focused secondary analysis of item-level responses collected for a doctoral survey of Pakistan's manufacturing sector. The parent study examined AMO-based human resource practices, knowledge management, data-driven decision-making, and sustainable organizational performance. The present article does not reproduce that structural model. Instead, it treats firm size and organizational age as categorical predictors and examines their adjusted associations with two outcomes: KM and sustainable organizational performance (SOP). This approach makes it possible to distinguish the potential role of current scale from the potential role of organizational age without assuming that the categories are equally spaced.

## 2. Theoretical Background and Research Questions

### *2.1 Firm Size, Knowledge Institutionalization, and Sustainable Performance*

Organizational growth generally increases the number of employees, specialized functions, managerial levels, and interdependencies that must be coordinated. Research on manufacturing and human resource systems has long associated organizational scale with greater differentiation and formal coordination requirements (Burns & Stalker, 1961; Delaney & Huselid, 1996; Donaldson, 2001; MacDuffie, 1995). As organizations expand, informal communication and individual memory may become less sufficient for maintaining operational knowledge. Formal repositories, standard operating procedures, training systems, and cross-functional communication mechanisms can therefore become increasingly useful (Albrecht et al., 2015; Boxall et al., 2016; Huselid, 1995).

From a knowledge-management perspective, organizational structure can shape the conditions under which knowledge is created, shared, stored, and applied. Formalization, integration, and organizational culture have been linked to knowledge processes (Alavi et al., 2005; Chen et al., 2010; De Long & Fahey, 2000;

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Mahmoudsalehi et al., 2012). In manufacturing settings, fragmented knowledge can impede coordination among production, quality, maintenance, engineering, logistics, and management. Knowledge exchange, cross-functional learning, and appropriate information systems can help organizations preserve and use operational experience (Argote & Ingram, 2000; Kianto et al., 2017; Malik et al., 2019; Monks et al., 2016; Sung & Choi, 2018; Zaim, 2016).

A scale advantage in KM is plausible, but it need not increase steadily with every additional employee. Larger organizations may have more resources for formal knowledge systems, yet additional scale can also increase bureaucracy, duplication, and coordination costs. Moreover, sustainable organizational performance is an outcome of how resources and capabilities are deployed, not simply a direct consequence of resource possession (Barney, 1991; Wernerfelt, 1984). Research distinguishes knowledge resources from the organizational processes through which knowledge is converted into performance (Asiaei & Bontis, 2020; Gunday et al., 2011). Studies linking KM with corporate sustainability and green innovation similarly emphasize the importance of effective knowledge use and organizational processes (Hossain et al., 2022; Shahzad et al., 2020). Thus, the association between size and KM may differ from the association between size and SOP.

### *2.2 Organizational Age, Learning, and Renewal*

Organizational age reflects the length of time an organization has operated, rather than its current scale. Repeated activity can support the development of routines, shared interpretations, technical knowledge, supplier and customer relationships, and institutional memory. Organizational life-cycle research describes how structures and priorities may change as organizations develop (Angeles et al., 2022; Greiner, 1972; Miller & Friesen, 1984; Quinn & Cameron, 1983). Accumulated experience may support learning and the ability to recognize and use external knowledge (Cohen & Levinthal, 1990; Crossan et al., 1999).

Age may also be associated with inertia. Established routines can become difficult to change when technologies, markets, or sustainability requirements evolve (Ashok et al., 2021; Hannan & Freeman, 1984). The value of accumulated knowledge therefore depends on whether organizations continue to renew, share, and apply it. Organizational learning and dynamic-capability perspectives emphasize adaptation, renewal, and the ability to reconfigure resources as conditions change (Eisenhardt & Martin, 2000; March, 1991; Teece et al., 1997; Zahra & George, 2002).

These perspectives suggest that a single linear age coefficient may conceal differences between organizational stages. Younger organizations may have had less time to formalize systems and accumulate institutional memory, whereas organizations in intermediate stages may combine accumulated experience with active development. More established organizations may retain performance advantages while facing additional demands to renew routines and knowledge. Because the present data are cross-sectional, these stages are interpreted as differences between respondent-reported age categories, not as observed developmental trajectories within the same firms.

### *2.3 Research Questions*

**RQ1.** Do knowledge-management scores differ across firm-size categories after organizational age is taken into account?

**RQ2.** Do sustainable organizational performance scores differ across firm-size categories after organizational age is taken into account?

**RQ3.** Do knowledge-management and sustainable organizational performance scores differ across organizational-age categories after firm size is taken into account, and are the observed patterns monotonic or stage-dependent?

## 3. Method

### *3.1 Research Design, Data Source, and Sample*

This study uses a secondary analysis of cross-sectional survey data collected for doctoral research on human resource practices, knowledge management, data-driven decision-making, and sustainable organizational performance in Pakistan's manufacturing sector. The parent study used a quantitative, explanatory design and purposive, non-probability sampling to obtain responses from managers and

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professionals with direct knowledge of organizational practices. Purposive selection was appropriate to the study's requirement for informed respondents with relevant organizational experience (Tongco, 2007).

The sampling frame for the parent survey was compiled from association directories, company websites and annual reports, professional networking platforms, organizational referrals, and professional contacts. The intended respondents included HR managers and professionals, managers in management information systems or information technology, data-analytics professionals, operations or production managers, and senior managers. A total of 853 questionnaires were distributed. After screening, 28 cases were excluded, leaving 825 complete and valid responses for analysis. The survey cover statement explained the academic purpose of the research and informed participants that participation was voluntary, responses would be treated confidentially, and participants could withdraw.

The parent thesis conceptualized the organization as the unit of analysis and used managers and professionals as key informants. However, the analytical file available for this secondary analysis did not contain a unique firm identifier. It is therefore not possible to establish whether multiple respondents came from the same organization. Accordingly, the sample size is reported as 825 respondent observations, and the size and age variables are treated as respondent-reported organizational characteristics. The findings should not be interpreted as evidence from 825 independently verified firms.

### *3.2 Measures and Data Preparation*

Firm size was measured using four employee-count categories: 50–249, 250–999, 1,000–4,999, and 5,000 or more employees. Organizational age was recorded in five categories: less than 5 years, 5–10 years, 11–20 years, 21–30 years, and more than 30 years. Because the category widths were unequal, size and age were treated as categorical rather than equally spaced continuous variables. The less-than-5-year category contained four observations and was combined with the 5–10-year category to form a 10-years-or-less reference group for inferential analyses only. The original five age categories were retained for descriptive reporting.

Knowledge management was assessed using 10 items adapted from Yu et al. (2022), covering knowledge creation, knowledge sharing, knowledge storage, and knowledge application. SOP was assessed using eight items developed for the parent study, informed by the broader sustainable-performance literature and by Zgrzywa-Ziemak and Walecka-Jankowska (2021). The items addressed overall performance improvement, resource efficiency, quality improvement, innovation, environmental responsibility, stakeholder relationships, adaptability, and long-term sustainable growth. All items used a 5-point agreement scale ranging from 1 (strongly disagree) to 5 (strongly agree; Revilla et al., 2014).

For this secondary analysis, the KM composite was recalculated as the mean of the 10 item-level indicators (KM1–KM10), and the SOP composite was recalculated as the mean of the eight item-level indicators (SOP1–SOP8). The analysis used the item-level responses rather than previously calculated summary columns. The resulting Cronbach's alpha values were .971 for KM and .959 for SOP, indicating very high internal consistency in the present composites (Cronbach, 1951). The overall KM mean was 3.843 ($SD$ = 1.215), and the overall SOP mean was 4.195 ($SD$ = 0.825). No missing values were present in the analytical file.

### *3.3 Analytical Strategy*

Separate ordinary least squares regression models were estimated for KM and SOP. Firm-size and organizational-age categories were dummy-coded and entered simultaneously in each model. This specification estimates the association of each structural factor with the outcome while accounting for the other factor. Because the group sizes were uneven and heteroscedasticity was plausible, HC3 heteroscedasticity-consistent covariance estimates were used for statistical inference (Long & Ervin, 2000).

Omnibus Wald tests were used to assess whether each set of categorical indicators was associated with the outcome. The full-model $R^2$ values summarize the variance explained jointly by firm size and organizational age. Incremental $R^2$ represents the increase in ordinary $R^2$ when the relevant categorical block is added after the other structural factor. Where an omnibus effect was statistically significant, pairwise contrasts were examined using the same HC3 covariance estimates and Holm adjustment to account for

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multiple comparisons (Holm, 1979). All findings are interpreted as adjusted cross-sectional associations rather than causal effects.

## 4. Results

### *4.1 Respondent-Reported Organizational Characteristics*

Table 1 presents the organizational size and age categories reported by the 825 respondents. Most respondents reported organizations with at least 1,000 employees (n = 750, 90.9%). The largest age category was 11–20 years (n = 483, 58.5%). Only four respondents reported organizations younger than 5 years; this small category was combined with the 5–10-year category for inferential analysis, but it is shown separately in the descriptive table.

**Table 1**

*Respondent-Reported Organizational Characteristics of the Analytical Sample*

| Characteristic | Category | n | % |
|---|---|---|---|
| Firm size | 50–249 employees | 43 | 5.2 |
| Firm size | 250–999 employees | 32 | 3.9 |
| Firm size | 1,000–4,999 employees | 349 | 42.3 |
| Firm size | 5,000 or more employees | 401 | 48.6 |
| Organizational age | Less than 5 years | 4 | 0.5 |
| Organizational age | 5–10 years | 68 | 8.2 |
| Organizational age | 11–20 years | 483 | 58.5 |
| Organizational age | 21–30 years | 181 | 21.9 |
| Organizational age | More than 30 years | 89 | 10.8 |

*Note.* $N = 825$ respondent observations. Categories reflect respondents' reports of their organizations. The less-than-5-year category was combined with the 5–10-year category for inferential analyses only. Percentages may not total 100 because of rounding.

### *4.2 Descriptive Patterns Across Size and Age Categories*

Table 2 reports the unadjusted means and standard deviations for KM and SOP across the original firm-size and organizational-age categories. Across size categories, the KM mean was lowest in the 50–249 employee group ($M = 1.858$) and higher in each of the three larger categories ($Ms = 3.794$–$3.974$). The SOP mean increased from 3.340 in the 50–249 employee category to 4.298 in the 1,000–4,999 category, before decreasing slightly to 4.217 in the 5,000-or-more category.

The age pattern was non-monotonic. The 11–20-year category had the highest descriptive means for both KM ($M = 4.205$) and SOP ($M = 4.340$). The means were lower in the 21–30-year and more-than-30-year categories. The less-than-5-year category contained only four observations and is therefore not interpreted substantively. These descriptive statistics are unadjusted and should not be confused with the adjusted regression estimates.

**Table 2**

*Descriptive Statistics for Knowledge Management and Sustainable Organizational Performance by Size and Age*

| Group | n | KM *M* | KM *SD* | SOP *M* | SOP *SD* |
|---|---|---|---|---|---|
| Firm size: 50–249 employees | 43 | 1.858 | 1.008 | 3.340 | 0.717 |
| Firm size: 250–999 employees | 32 | 3.794 | 1.233 | 3.949 | 0.865 |
| Firm size: 1,000–4,999 employees | 349 | 3.974 | 1.116 | 4.298 | 0.768 |
| Firm size: 5,000 or more employees | 401 | 3.945 | 1.133 | 4.217 | 0.828 |
| Organizational age: <5 years | 4 | 1.975 | 0.472 | 3.906 | 0.786 |
| Organizational age: 5–10 years | 68 | 2.271 | 1.294 | 3.351 | 0.896 |
| Organizational age: 11–20 years | 483 | 4.205 | 0.951 | 4.340 | 0.734 |
| Organizational age: 21–30 years | 181 | 3.691 | 1.211 | 4.208 | 0.797 |
| Organizational age: >30 years | 89 | 3.470 | 1.265 | 4.042 | 0.894 |

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*Note.* KM = knowledge management; SOP = sustainable organizational performance. Means and standard deviations are unadjusted descriptive statistics. The original five organizational-age categories are shown; the less-than-5-year category has n = 4 and should not be interpreted substantively.

### *4.3 Adjusted Firm-Size and Organizational-Age Differences*

The HC3 categorical regression model for KM explained 25.1% of the outcome variance ($R^2$ = .251). After accounting for organizational age, the overall association between firm size and KM was statistically significant, Wald $\chi^2(3) = 38.81$, $p < .001$. Organizational age was also significantly associated with KM after accounting for firm size, Wald $\chi^2(3) = 94.55$, $p < .001$. The incremental $R^2$ was .036 for firm size and .103 for organizational age, indicating a larger unique contribution for the age-category block in this model.

The model for SOP explained 11.5% of the variance ($R^2$ = .115). The overall association between firm size and SOP was not statistically significant after accounting for organizational age, Wald $\chi^2(3) = 6.69$, $p = .082$. Organizational age remained statistically significant, Wald $\chi^2(3) = 29.57$, $p < .001$. The incremental $R^2$ values were .009 for firm size and .049 for organizational age. The omnibus results therefore indicate that size was associated with KM but not SOP, whereas age was associated with both outcomes.

**Table 3**

*HC3-Robust Omnibus Tests for Categorical Regression Models*

| Outcome | $R^2$ | Structural factor | Wald $\chi^2$ | *df* | p | $\Delta R^2$ |
|---|---|---|---|---|---|---|
| Knowledge management | .251 | Firm size | 38.81 | 3 | < .001 | .036 |
| Knowledge management | .251 | Organizational age | 94.55 | 3 | < .001 | .103 |
| Sustainable organizational performance | .115 | Firm size | 6.69 | 3 | .082 | .009 |
| Sustainable organizational performance | .115 | Organizational age | 29.57 | 3 | < .001 | .049 |

*Note.* Firm size and organizational age were entered simultaneously as categorical predictors. $R^2$ is for the full model containing both factors. $\Delta R^2$ is the increase in ordinary $R^2$ when the relevant categorical block is added after the other structural factor. HC3 = heteroscedasticity-consistent covariance estimator.

### *4.4 Pairwise Structural Contrasts*

Holm-adjusted pairwise contrasts clarify the significant omnibus effects (Table 4). For KM, the adjusted score in each larger size category was higher than in the 50–249 employee category: 250–999 employees (adjusted difference = 1.263, 95% CI [0.703, 1.822], $p < .001$), 1,000–4,999 employees (adjusted difference = 1.065, 95% CI [0.666, 1.463], $p < .001$), and 5,000 or more employees (adjusted difference = 1.196, 95% CI [0.810, 1.582], $p < .001$). No other firm-size contrasts for KM were statistically significant after Holm adjustment. This pattern suggests that the principal difference was between the smallest sampled size category and the larger categories, rather than a steady increase across every size step.

For organizational age, the adjusted KM score in the 11–20-year category was higher than in the 10-years-or-less category (adjusted difference = 1.517, 95% CI [1.159, 1.875], $p < .001$), the 21–30-year category (adjusted difference = 0.535, 95% CI [0.338, 0.733], $p < .001$), and the more-than-30-year category (adjusted difference = 0.642, 95% CI [0.365, 0.919], $p < .001$). The 21–30-year and more-than-30-year categories also had higher adjusted KM scores than the 10-years-or-less category. The pattern is therefore not a continuous increase with age; the 11–20-year category had the highest adjusted KM score.

For SOP, no firm-size pairwise contrast was statistically significant after Holm adjustment. For organizational age, the 11–20-year category (adjusted difference = 0.779, 95% CI [0.484, 1.073], $p < .001$), the 21–30-year category (adjusted difference = 0.645, 95% CI [0.335, 0.955], $p < .001$), and the more-than-30-year category (adjusted difference = 0.538, 95% CI [0.224, 0.853], $p = .003$) each had higher adjusted SOP scores than the 10-years-or-less category. Differences among the three older categories were not reported as statistically significant in the analysis.

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**Table 4**

*Selected Holm-Adjusted Pairwise Comparisons*

| Outcome | Contrast | Adjusted difference | 95% CI | Holm-adjusted p |
|---|---|---|---|---|
| KM | 250–999 vs. 50–249 employees | 1.263 | [0.703, 1.822] | < .001 |
| KM | 1,000–4,999 vs. 50–249 employees | 1.065 | [0.666, 1.463] | < .001 |
| KM | 5,000+ vs. 50–249 employees | 1.196 | [0.810, 1.582] | < .001 |
| KM | 11–20 years vs. 10 years or less | 1.517 | [1.159, 1.875] | < .001 |
| KM | 11–20 vs. 21–30 years | 0.535 | [0.338, 0.733] | < .001 |
| KM | 11–20 vs. more than 30 years | 0.642 | [0.365, 0.919] | < .001 |
| SOP | 11–20 years vs. 10 years or less | 0.779 | [0.484, 1.073] | < .001 |
| SOP | 21–30 years vs. 10 years or less | 0.645 | [0.335, 0.955] | < .001 |
| SOP | More than 30 years vs. 10 years or less | 0.538 | [0.224, 0.853] | .003 |

*Note.* KM = knowledge management; SOP = sustainable organizational performance. Positive differences indicate that the first category had the higher adjusted score. The inferential age reference group (10 years or less) combines the less-than-5-year and 5–10-year categories. Only statistically significant contrasts are shown. Confidence intervals are based on HC3 covariance estimates; p values are Holm-adjusted.

## 5. Discussion

### *5.1 Firm Size and the Knowledge-Management Threshold*

The results indicate that firm size was associated with KM after organizational age was taken into account, but it was not significantly associated with SOP. The pairwise comparisons show that the principal KM difference was between the 50–249 employee category and each larger category; the contrasts among the three larger categories were not statistically significant after adjustment. This pattern is more consistent with a threshold interpretation than with a linear proposition that every increase in employee count is accompanied by a corresponding increase in KM.

One possible explanation is that smaller organizations may rely more heavily on informal communication and individual memory, whereas expansion increases the need for shared procedures, documentation, repositories, and cross-functional coordination. Knowledge-management research emphasizes the role of organizational structure and integration in enabling knowledge processes (Alavi et al., 2005; Chen et al., 2010; Gold et al., 2001; Lee & Choi, 2003; Mahmoudsalehi et al., 2012). The present findings are consistent with the possibility that a minimum level of scale is associated with more formalized knowledge practices, although the cross-sectional design does not establish that growth caused these differences.

The absence of a statistically significant firm-size association with SOP is also important. Larger organizations may possess more specialized units, systems, and resources, but these resources must be coordinated and converted into operational, environmental, and broader sustainability outcomes. Research on manufacturing and sustainable performance similarly distinguishes the availability of resources from the processes through which they are deployed (Appelbaum et al., 2000; Henao & Sarache, 2022; Hossain et al., 2022; Shahzad et al., 2020). Thus, the results do not support the assumption that larger scale automatically corresponds to stronger sustainable organizational performance.

### *5.2 Organizational Age and an Accumulation–Renewal Pattern*

Organizational age was associated with both KM and SOP, but the pattern was non-monotonic. The 11–20-year category had the highest descriptive means for both outcomes, while the older categories had lower KM means. The adjusted contrasts also showed that the 11–20-year category exceeded the other age categories on KM. For SOP, all three categories older than 10 years had higher adjusted scores than the 10-years-or-less category, while differences among the older groups were not reported as statistically significant.

This pattern is compatible with an accumulation–renewal interpretation. Organizations may develop routines, shared knowledge, and institutional memory as they gain experience. However, established routines can become less responsive when technologies, markets, and sustainability requirements change. Prior research on organizational learning, life cycles, and inertia provides a theoretical basis for considering both

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accumulation and the need for renewal (Angeles et al., 2022; Ashok et al., 2021; Crossan et al., 1999; Hannan & Freeman, 1984; March, 1991).

The results should not be interpreted as evidence that individual firms necessarily improve until their eleventh to twentieth year and then decline. The study compares different respondents' reports about organizations in different age categories at one point in time; it does not follow the same firms longitudinally. The observed pattern is therefore a cross-sectional age-category difference that is consistent with, but does not prove, an accumulation–renewal explanation.

### *5.3 Theoretical Implications*

The study contributes by distinguishing firm size from organizational age as separate structural characteristics. Size is more directly associated with current scale, differentiation, and coordination requirements, whereas age may capture accumulated experience and the possible persistence of established routines. Neither characteristic is equivalent to knowledge itself. Rather, each may create conditions that facilitate or constrain the creation, sharing, storage, and application of knowledge. This distinction is consistent with knowledge-based and resource-based perspectives, which emphasize the development and deployment of organizational capabilities rather than resource possession alone (Barney, 1991; Grant, 1996; Wernerfelt, 1984).

The findings also distinguish capability formation from sustainable performance. Firm size was associated with KM but not with SOP after accounting for age, while age was associated with both outcomes. This suggests that structural conditions may relate differently to an organization's knowledge processes and its broader performance assessments. The result is compatible with research emphasizing the role of knowledge integration, absorptive capacity, and dynamic capabilities in translating resources and experience into performance (Andreeva & Kianto, 2012; Asiaei & Bontis, 2020; Cohen & Levinthal, 1990; Teece et al., 1997; Zahra & George, 2002).

### *5.4 Managerial and Policy Implications*

For managers in the smallest sampled size category, the results suggest that formal knowledge practices need not wait until an organization becomes large. Relatively low-cost measures—such as standardized problem logs, after-action reviews, updated operating procedures, cross-functional meetings, mentoring, and shared digital repositories—may help preserve operational knowledge and reduce dependence on individual memory (Alavi & Leidner, 2001; Kianto et al., 2017; Malik et al., 2019). These practices should be adapted to organizational needs rather than adopted simply to imitate larger firms.

For larger organizations, the findings do not support adding systems or staff as a sufficient strategy. The managerial challenge is to integrate knowledge repositories, dashboards, specialist departments, and procedures so that employees can find, understand, share, and apply relevant information. Monitoring duplicated work, functional silos, slow escalation processes, and fragmented knowledge may help organizations convert their existing infrastructure into coordinated action (Monks et al., 2016; Sung & Choi, 2018; Wamba et al., 2017).

For organizations in later age categories, the findings point to the value of periodically reviewing established routines and preserving institutional memory while supporting renewal. Succession planning, process audits, technology updates, cross-generational mentoring, and structured review of obsolete practices may help maintain the value of accumulated experience (Ashok et al., 2021; De Long & Fahey, 2000). At the policy level, support programs should recognize that the smallest category represented in this study begins at 50 employees and that the findings do not describe micro-enterprises or firms with fewer than 50 employees. Policy initiatives that encourage knowledge documentation, cross-functional learning, and routine review may be relevant across size categories, but their design should reflect the different coordination challenges faced by smaller and larger organizations. Because the data are cross-sectional and based on respondent reports, these implications are offered as organizational and policy considerations rather than as evidence of causal effects.

### *5.5 Limitations and Future Research*

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Several limitations should be considered when interpreting the findings. First, the data are cross-sectional, so the study cannot establish temporal order or causal relationships between firm size, organizational age, KM, and SOP. Second, the analytical file did not contain a unique firm identifier, meaning that multiple respondents could have reported on the same organization. The results are therefore interpreted as respondent-level associations rather than as estimates based on 825 confirmed unique firms. Third, firm size and organizational age were measured using categorical ranges rather than continuous values, which limits the precision of the estimates and prevents the calculation of exact elasticities. Fourth, the sample was obtained through purposive, non-probability sampling, which limits generalizability to the broader population of manufacturing firms in Pakistan. Fifth, the smallest firm-size category began at 50 employees, so the findings do not describe micro-enterprises or firms with fewer than 50 employees. Sixth, the less-than-5-year age category contained only four observations and had to be combined with the 5–10-year category for inferential tests, limiting the analysis of very young organizations. Seventh, all measures were based on respondent self-reports, which may introduce common-method variance and social desirability bias.

Future research could address these limitations by using longitudinal designs that follow the same firms over time, by collecting unique firm identifiers to enable multilevel modeling, by using continuous measures of size and age where available, and by incorporating objective performance indicators alongside perceptual measures. Comparative studies across manufacturing sub-sectors and across countries in the region would also help establish whether the threshold and stage-dependent patterns observed here are context-specific or more general. Finally, qualitative case studies could illuminate the micro-processes through which organizations at different size and age stages create, share, store, and apply knowledge.

## 6. Conclusion

This study examined whether knowledge management and sustainable organizational performance differ across firm-size and organizational-age categories in Pakistan's manufacturing sector. The findings indicate that firm size was associated with KM but not with SOP after accounting for organizational age, whereas organizational age was associated with both outcomes. The pairwise contrasts suggest a threshold pattern for size and a non-monotonic, stage-dependent pattern for age, with the 11–20-year category showing the highest adjusted KM scores. These results support the view that size and age represent distinct structural characteristics that should not be treated as interchangeable indicators of organizational maturity. The study contributes to the knowledge-based and resource-based literatures by distinguishing capability formation from sustainable performance and by highlighting the importance of organizational stage in shaping knowledge processes. Because the data are cross-sectional and based on respondent reports, the findings should be interpreted as adjusted associations rather than causal effects. Nevertheless, they offer useful implications for managers and policymakers seeking to support knowledge management and sustainable performance across organizations of different sizes and ages.

## Ethical Approval

This study is based entirely on secondary data obtained from published sources, including peer-reviewed journals, industry reports, and regulatory documents. No human participants were involved in the research. Therefore, formal Institutional Review Board (IRB) approval was not required. However, all ethical considerations were strictly followed, including proper citation of sources and adherence to academic integrity.

## Authors' Contributions

All the authors have read and approved the final manuscript.

## Conflict of Interest Statement

The author/s declare that there is no conflict of interest regarding the publication of this article.

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## Data Availability

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The datasets generated and analysed during the current study are available from the corresponding author upon reasonable request. The authors are committed to transparency and will provide detailed methodological information and analysis protocols upon request.

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