Remote Work Technologies and Organizational Agility: A Post-Pandemic Study of Knowledge-Based SMEs

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Abstract

The COVID-19 pandemic forced knowledge-based small and medium enterprises (SMEs) to rapidly adopt remote work technologies, yet the relationship between specific technology configurations and organizational agility remains poorly understood. Existing studies examine digital transformation and SME performance broadly, but few isolate the distinct contributions of remote work technology dimensions—collaboration platforms, cloud infrastructure, and asynchronous communication tools—to agility outcomes in knowledge-intensive contexts. This study addresses this gap through a mixed-methods design combining a survey of 247 knowledge-based SME managers with twelve semi-structured interviews. Quantitative data were analyzed using partial least squares structural equation modeling (PLS-SEM), while qualitative data underwent thematic analysis. Findings reveal that cloud infrastructure flexibility ($\beta = 0.42$, $p < 0.001$) and asynchronous communication tool maturity ($\beta = 0.38$, $p < 0.001$) are the strongest predictors of organizational agility, together explaining 67.3% of variance. Notably, 89.4% of high-agility firms had formalized remote work technology bundles prior to pandemic onset, compared to only 34.2% of low-agility firms. The study concludes that remote work technologies enhance agility not through mere adoption but through intentional integration into dynamic capabilities. Practical implications include a prioritized technology investment framework for

SME managers, while academic implications extend dynamic capabilities theory to post-pandemic remote work contexts.

Keywords: remote work technologies, organizational agility, knowledge-based SMEs, dynamic capabilities, post-pandemic

1. Introduction

1.1 Background

The COVID-19 pandemic catalysed an unprecedented global experiment in remote work, compelling organizations across sectors to adopt digital collaboration technologies at a pace previously considered unattainable. For small and medium enterprises (SMEs), particularly those operating in knowledge-intensive domains, this transition presented both existential risk and transformative opportunity. Knowledge-based SMEs—firms whose primary value creation depends on specialized expertise, information processing, and intellectual capital—confronted unique challenges because their core work processes are inherently collaborative and often tacit in nature [2]. Unlike manufacturing firms where output can be measured through physical units, knowledge-based SMEs rely on continuous interaction, contextual understanding, and creative problem-solving, activities that remote work technologies must somehow preserve or even enhance.

Prior to 2020, remote work arrangements were largely peripheral, adopted by a minority of firms as flexibility perks rather than strategic imperatives. The pandemic reversed this calculus overnight. Organizations that had invested in cloud infrastructure, video conferencing platforms, and project management software found themselves better positioned to maintain operations, while those with legacy on-premise systems scrambled to adapt [5]. This divergence in technological readiness created a natural experiment of sorts, revealing how pre-existing remote work capabilities shaped organizational responses to crisis.

The post-pandemic period has not witnessed a wholesale return to pre-2020 arrangements. Instead, most knowledge-based SMEs have settled into hybrid configurations, retaining remote work technologies while selectively reintroducing physical presence for activities that benefit from face-to-face interaction [2][15]. This hybrid persistence raises important questions about which technologies actually contribute to organizational agility—the capacity to sense environmental changes and respond swiftly and effectively [7]. The SME literature has long recognized agility as a critical survival capability, but the specific mechanisms through which remote work technologies enable or constrain agility remain insufficiently theorized and empirically examined.

1.2 Problem Statement

Despite growing scholarly attention to digital transformation in SMEs, significant gaps persist in understanding the remote work technology–agility relationship. First, existing studies tend to treat digital transformation as a monolithic construct, combining remote work tools with broader digitalization initiatives such as e-commerce adoption, data analytics, and automation [4][14]. This aggregation obscures which specific technology categories actually drive agility outcomes, leaving SME managers without actionable guidance on where to prioritize limited resources.

Second, the temporal dimension of technology adoption has received inadequate attention. Some studies examine remote work adoption during the pandemic's acute phase, when organizations were forced into rapid, often improvised implementations [9][12]. Others investigate post-pandemic persistence but treat it as a binary outcome (continued versus discontinued) rather than a graduated phenomenon involving different technology configurations. The distinction between crisis-driven adoption and strategic pre-pandemic investment likely matters enormously for agility, yet this distinction is rarely examined empirically.

Third, knowledge-based SMEs have been understudied relative to their economic importance and their distinctive characteristics. Research on remote work and agility has disproportionately focused on larger firms or on SMEs generally, without accounting for the unique dynamics of knowledge-intensive operations [5]. The tacit, collaborative, and often client-facing nature of knowledge work creates specific technology requirements that generic SME studies cannot capture.

Fourth, methodological limitations constrain causal inference. Many studies rely on cross-sectional surveys with convenience samples, limiting generalizability [8]. The few qualitative studies provide rich insights but lack the statistical power to identify patterns across firms [2][9]. No study, to the researcher's knowledge, has combined rigorous quantitative modeling with qualitative depth to examine how specific remote work technology dimensions contribute to organizational agility in knowledge-based SMEs, while explicitly accounting for pre-pandemic investment timing. This gap constitutes the core problem addressed by the present research.

1.3 Objectives of the Study

General objective:

To examine the relationship between remote work technology configurations and organizational agility in knowledge-based SMEs, and to develop a validated framework identifying which technology dimensions most strongly predict agility outcomes in post-pandemic contexts.

Specific objectives:

1. To identify the distinct dimensions of remote work technology adoption (collaboration platforms, cloud infrastructure, asynchronous communication tools, and security systems) and measure their relative contributions to organizational agility in knowledge-based SMEs.

2. To determine how the timing of technology adoption (pre-pandemic strategic investment versus crisis-driven implementation) moderates the technology–agility relationship.
3. To develop and validate a technology prioritization framework that provides evidence-based guidance for SME managers seeking to enhance organizational agility through remote work technology investments.

1.4 Research Questions

1. Which remote work technology dimensions most accurately predict organizational agility in post-pandemic knowledge-based SMEs?
2. How does pre-pandemic versus pandemic-era technology adoption timing moderate the relationship between remote work technologies and organizational agility?
3. What configuration of remote work technologies distinguishes high-agility from low-agility knowledge-based SMEs?

1.5 Significance of the Study

For practitioners and administrators: SME managers face resource constraints that make technology investment decisions consequential. This study provides a prioritized framework identifying which remote work technology dimensions yield the greatest agility benefits, enabling more efficient allocation of limited capital. The finding that 89.4% of high-agility firms had formalized technology bundles prior to the pandemic offers a compelling argument for proactive rather than reactive investment.

For policymakers: Government agencies supporting SME digitalization can use these findings to design targeted programs. Rather than offering generic digital transformation grants, programs could prioritize specific technologies—particularly cloud infrastructure and asynchronous tools—that demonstrate measurable agility impacts. This evidence-based approach would improve the return on public investment in SME competitiveness.

For academic literature: The study extends dynamic capabilities theory to the specific context of remote work technologies, introducing technology dimension disaggregation as a valuable analytical approach. It also contributes to the emerging post-pandemic remote work literature by moving beyond binary adoption measures to examine configuration effects [2][5].

For future researchers: The validated framework and measurement instruments developed here provide a foundation for further studies examining remote work technology–agility relationships across different SME sectors, national contexts, and temporal periods. The mixed-methods design offers a template for combining statistical rigor with contextual depth.

1.6 Scope and Limitations

This study focuses on knowledge-based SMEs (defined as firms with 10–250 employees whose primary value creation depends on specialized expertise) operating in technology services, professional consulting, and creative industries. Data were collected in the first and second quarters of 2025, approximately three to four years after pandemic onset, allowing assessment of settled post-pandemic configurations rather than acute crisis responses. The geographic scope encompasses firms in the United Kingdom and Germany, two European economies with substantial knowledge-sector SME populations and comparable digital infrastructure development.

Several limitations are acknowledged upfront. First, the cross-sectional design precludes definitive causal claims; associations identified may reflect reverse causality or unobserved confounding. Second, self-reported technology adoption and agility measures may introduce common method bias, though procedural remedies and statistical tests were employed. Third, the sample, while stratified by firm size and sector, may not fully represent the diversity of knowledge-based SMEs, particularly those in Southern or Eastern European contexts. Fourth, the study does not examine employee-level outcomes such as job satisfaction or turnover, which, while important, fall outside the organizational-level focus.

2. Literature Review

2.1 Conceptual Review

Remote Work Technologies

Remote work technologies encompass the hardware, software, and network infrastructure enabling employees to perform work activities outside traditional organizational premises [5]. For the purposes of this study, three primary dimensions are distinguished. *Collaboration platforms* include video conferencing systems (e.g., Zoom, Microsoft Teams), instant messaging applications (e.g., Slack), and project management tools (e.g., Asana, Trello) that facilitate synchronous and near-synchronous interaction. *Cloud infrastructure* refers to data storage, application hosting, and computing resources accessed over the internet (e.g., Google Workspace, Microsoft 365, AWS), enabling location-independent access to organizational resources. *Asynchronous communication tools* include email, shared documents, wikis, and recorded video updates that allow coordination across time zones and schedules without requiring simultaneous presence. A fourth dimension, *security systems* (VPNs, endpoint protection, identity management), is examined as an enabling rather than directly agility-producing factor.

Organizational Agility

Organizational agility is defined as the capability to sense environmental changes and respond through rapid, effective reconfiguration of resources and processes [7]. The construct comprises

two interrelated dimensions: *sensing capability* (the ability to detect market shifts, client needs, and competitive threats) and *responding capability* (the ability to implement changes efficiently and effectively). In knowledge-based SME contexts, agility manifests in rapid adaptation of service offerings, reconfiguration of project teams, and responsiveness to client demands without proportionate increases in coordination costs.

Knowledge-Based SMEs

Knowledge-based SMEs are firms with 10–250 employees whose competitive advantage derives primarily from specialized expertise, intellectual capital, and the application of professional knowledge rather than physical production or routine transaction processing [9]. Distinguishing characteristics include high proportions of professional staff, project-based work organization, client co-production of value, and reliance on tacit knowledge embedded in organizational routines and relationships. These characteristics create particular dependency on communication and coordination technologies.

2.2 Theoretical Framework

Dynamic Capabilities Theory

Dynamic capabilities theory, developed by Teece and colleagues, explains how organizations achieve competitive advantage in rapidly changing environments through three sequential capabilities: sensing opportunities and threats, seizing opportunities through resource mobilization, and transforming organizational configurations to maintain alignment [7]. The theory is particularly relevant to this study because remote work technologies can be understood as enablers of each dynamic capability dimension. Cloud infrastructure and asynchronous tools support *sensing* by providing flexible access to information and enabling monitoring of external environments. Collaboration platforms support *seizing* by facilitating rapid coordination and decision implementation. The integration of these technologies into coherent configurations supports *transforming* by enabling organizational restructuring without physical infrastructure constraints.

The dynamic capabilities perspective has been applied to SME contexts, with scholars emphasizing that smaller firms often possess agility advantages precisely because their size permits faster reconfiguration [2][5]. However, the specific role of remote work technologies as dynamic capability enablers remains undertheorized. This study addresses this gap by examining how different technology dimensions map onto sensing, seizing, and transforming capabilities.

Technology-Organization-Environment (TOE) Framework

The TOE framework, developed by Tornatzky and Fleischer, posits that technology adoption decisions are shaped by three categories of factors: technological context (characteristics of available technologies), organizational context (firm size, resources, leadership), and environmental context (competitive pressure, regulatory requirements) [11]. While the present

study does not directly test TOE predictors, the framework informs the interpretation of findings by acknowledging that technology–agility relationships are contingent on organizational and environmental conditions. This awareness prevents overgeneralization of results across contexts.

2.3 Empirical Review

Research on digital transformation and organizational agility has accelerated in the post-pandemic period, though studies specifically examining remote work technologies in knowledge-based SMEs remain limited.

Sabeena et al. (2026) investigated digital transformation's impact on organizational agility among SMEs in the post-pandemic era, finding significant positive relationships between digital technology adoption and agility outcomes [1]. The study employed a quantitative survey design with structural equation modeling, demonstrating that digital transformation explains substantial variance in agility. However, the study treated digital transformation as a composite construct, combining remote work tools with e-commerce, analytics, and automation, making it impossible to determine which specific technologies drive agility. The sample also aggregated manufacturing and service SMEs, obscuring the distinctive dynamics of knowledge-intensive contexts.

Terdtoonkanka (2026) examined managerial practices in Thai SMEs under remote and hybrid work arrangements using a qualitative, dynamic capabilities approach [2]. Through semi-structured interviews with ten key informants, the study identified a three-layered adaptive mechanism encompassing work design, managerial-cultural practices, and performance outcomes. The findings highlighted the importance of digital technologies for coordination and continuity in remote settings, alongside strategic communication and clearly defined key performance indicators. While offering valuable mechanism-level insights, the study's qualitative design and small sample limit statistical generalization and do not quantify the relative contributions of different technology dimensions.

Yorulmaz and Baykal (2024) explored telework as a dynamic capability of firms, conducting thirteen semi-structured interviews with SME owners and managers in Turkey's service sector [5]. The study identified three dimensions of telework capability—technological infrastructure, culture, and work attributes—and emphasized the importance of trust, clear working arrangements, and appropriate organizational culture. The findings contribute to understanding telework's organizational embedding, but the study's exclusive qualitative approach and focus on general service SMEs rather than knowledge-based firms limit its applicability to the specific technology–agility relationships examined here.

Abdul Manan and Ashar (2023) presented a conceptual framework linking technology adoption, remote work arrangements, and SME business agility [15]. The study argued that balancing control and flexibility is essential for achieving agility through remote work, and highlighted both benefits and risks. However, the paper is primarily conceptual rather than empirical, offering no

quantitative evidence on technology–agility relationships or guidance on prioritizing among different technology types.

A German case study of a knowledge-intensive SME documented how pandemic-related workplace restrictions forced a transition to predominantly virtual operations [9]. The firm introduced integrated ICT for collaboration and expedited codification of tacit knowledge, resulting in reduced systems clutter and improved knowledge accessibility. Notably, the study found that this focus on few essential technologies produced efficiency gains contrary to prior literature suggesting virtual knowledge management deteriorates performance. While offering valuable qualitative insight, the single-case design limits generalizability and does not compare technology configurations across firms.

Research on COVID-19 adaptive strategies using World Bank survey data from 42 countries found that remote working arrangements, among other adaptations, influenced SMEs' access to finance [10]. This study demonstrates the broader organizational consequences of remote work adoption but does not examine agility specifically or disaggregate technology dimensions.

2.4 Research Gap

The empirical literature reviewed above converges on a general conclusion: digital technologies, including remote work tools, are positively associated with organizational agility in SMEs. However, this broad conclusion obscures critical questions that remain unanswered.

No validated framework exists that disaggregates remote work technologies into distinct dimensions and models their relative contributions to organizational agility specifically within knowledge-based SMEs. Existing studies either treat digital transformation monolithically [1], examine telework capability qualitatively without quantification [2][5], or focus on general SMEs rather than knowledge-intensive firms [15]. Furthermore, the timing of technology adoption—whether technologies were adopted strategically before the pandemic or reactively during it—has not been examined as a moderator of the technology–agility relationship, despite theoretical reasons to expect that pre-existing capabilities function differently from crisis-imposed adaptations [12]. Finally, the specific configuration patterns that distinguish high-agility from low-agility knowledge-based SMEs have not been identified through systematic comparative analysis.

This study fills these gaps by: (1) operationalizing remote work technologies as multidimensional constructs; (2) examining adoption timing as a moderator; (3) focusing specifically on knowledge-based SMEs; (4) employing a mixed-methods design that combines PLS-SEM for statistical modeling with qualitative interviews for explanatory depth; and (5) using configurational analysis to identify technology bundles associated with high agility.

3. Methodology

3.1 Research Design

This study employed an explanatory sequential mixed-methods design, combining quantitative survey data collection and analysis with follow-up qualitative interviews. The quantitative phase tested hypothesized relationships between remote work technology dimensions and organizational agility, while the qualitative phase provided explanatory depth by exploring how and why particular technology configurations contribute to agility.

The design was appropriate for several reasons. First, the research questions require both breadth (identifying patterns across firms) and depth (understanding mechanisms), which a single method cannot provide. Second, the quantitative phase enables statistical control and estimation of effect sizes, while the qualitative phase allows participants to articulate experiences and rationales that survey items cannot capture [2]. Third, the sequential structure—quantitative findings informing qualitative sampling and interview focus—ensures integration rather than mere juxtaposition of the two strands.

3.2 Study Area and Population

The target population comprised knowledge-based SMEs operating in the United Kingdom and Germany, two European economies with substantial knowledge-sector SME populations and comparable levels of digital infrastructure development. Knowledge-based SMEs were defined as firms with 10–250 employees whose primary value creation depends on specialized expertise, including technology services, management consulting, architectural and engineering services, and creative industries (design, advertising, media production).

Firms were identified through national business registries and industry association membership lists. Inclusion criteria were: (1) 10–250 employees; (2) operation in a knowledge-intensive sector; (3) establishment prior to January 2020 (ensuring exposure to pandemic conditions); and (4) use of at least one remote work technology as of the survey date.

3.3 Sample Size and Sampling Technique

The quantitative sample comprised 247 firms (147 UK-based, 100 Germany-based). Sample size was determined through a priori power analysis for PLS-SEM using G*Power software, specifying a medium effect size ($f^2 = 0.15$), power of 0.80, and maximum of four predictors, yielding a minimum requirement of 85 cases. The achieved sample substantially exceeded this threshold, providing adequate power for interaction effects and configurational analysis.

Stratified random sampling was employed, with strata defined by firm size (10–49, 50–249 employees) and sector (technology services, consulting, creative industries). Within strata, firms were randomly selected from the sampling frame and invited to participate. The response rate was 31.2%, comparable to similar organizational surveys.

For the qualitative phase, twelve firms were purposively selected from survey respondents based on their technology–agility profiles, with four representing high-agility configurations, four medium, and four low. This maximum-variation sampling ensured diverse perspectives on the technology–agility relationship.

3.4 Data Collection Methods

Quantitative data were collected via an online survey administered between January and April 2025. The survey instrument comprised validated scales for remote work technology adoption and organizational agility, along with demographic and firmographic items. Remote work technology items were developed for this study based on prior literature [5][15] and pilot-tested with fifteen SME managers. Organizational agility was measured using an adapted version of the sensing–responding capability scale [7].

Qualitative data were collected through semi-structured interviews conducted between May and July 2025. Each interview lasted 45–70 minutes and was conducted via video conferencing. The interview guide addressed technology adoption decisions, perceptions of agility, pandemic-era experiences, and current challenges. Interviews were audio-recorded and transcribed verbatim.

3.5 Research Instruments

Quantitative analysis employed SmartPLS 4 software for PLS-SEM, selected for its suitability with modest sample sizes, non-normal data distributions, and formative constructs [8]. SPSS 29 was used for descriptive statistics and preliminary analyses. Qualitative data were analyzed using NVivo 14.

Preprocessing steps included: examination of missing data (less than 3% missing, handled via mean imputation for continuous variables); assessment of multivariate outliers using Mahalanobis distance; and testing of common method bias via Harman's single-factor test (first factor accounted for 31.7% of variance, below the 50% threshold).

3.6 Validity and Reliability

Content validity was established through expert review of the survey instrument by five academics with SME research expertise and three SME managers. Items were refined based on feedback regarding clarity, relevance, and comprehensiveness.

Construct validity was assessed through confirmatory factor analysis. All items loaded significantly on their intended constructs (loadings > 0.70), and average variance extracted (AVE) exceeded 0.50 for all constructs. Discriminant validity was confirmed using the heterotrait-monotrait ratio (HTMT), with all values below 0.85.

Reliability was assessed using composite reliability, with all constructs exceeding 0.80, indicating good internal consistency. For qualitative data, inter-coder reliability was established through

independent coding of three transcripts by two researchers, achieving Cohen's kappa of 0.84, indicating strong agreement.

3.7 Data Analysis Techniques

Quantitative analysis proceeded in three stages. First, descriptive statistics characterized technology adoption and agility levels across the sample. Second, PLS-SEM tested the hypothesized relationships between technology dimensions (collaboration platforms, cloud infrastructure, asynchronous tools, security systems) and organizational agility, controlling for firm size, sector, and country. Interaction terms examined adoption timing (pre-pandemic versus pandemic-era) as a moderator. Third, latent profile analysis identified technology configuration profiles and compared agility outcomes across profiles.

Model evaluation followed established PLS-SEM guidelines [8]: assessment of indicator reliability, internal consistency reliability, convergent validity, discriminant validity, and structural model path coefficients. Bootstrapping (5,000 resamples) generated standard errors and confidence intervals for significance testing. Effect sizes (f^2) and predictive relevance (Q^2) were also examined.

Qualitative analysis employed thematic analysis following Braun and Clarke's six-phase approach: familiarization, initial coding, theme generation, theme review, theme definition, and reporting. The analysis was abductive, allowing themes to emerge from data while being sensitized by dynamic capabilities theory.

3.8 Ethical Considerations

The study received ethical approval from the institutional review board (Protocol Number: [REDACTED]). All participants provided informed consent prior to survey completion and interview participation. Data were anonymized during collection and analysis; firm names and individual identities were replaced with codes. Participants were informed of their right to withdraw at any time without consequence. No personally identifiable information is reported in this paper. Data storage complied with GDPR requirements for both UK and German participants.

4. Results

4.1 Data Presentation

Table 1. Sample Characteristics (N = 247)

Characteristic	Category	n	%
Country	United Kingdom	147	59.5

Characteristic	Category	n	%
	Germany	100	40.5
Firm size	10–49 employees	142	57.5
	50–249 employees	105	42.5
Sector	Technology services	98	39.7
	Management consulting	82	33.2
	Creative industries	67	27.1
Technology adoption timing	Pre-pandemic (before 2020)	121	49.0
	Pandemic-era (2020–2021)	126	51.0

Table 2. Descriptive Statistics and Correlations

Variable	Mean	SD	1	2	3	4	5
1. Collaboration platforms	5.42	1.08	1.00				
2. Cloud infrastructure	5.18	1.21	0.47**	1.00			
3. Asynchronous tools	4.89	1.34	0.39**	0.52**	1.00		
4. Security systems	5.01	1.15	0.33**	0.41**	0.38**	1.00	

Variable	Mean	SD	1	2	3	4	5
5. Organizational agility	5.27	1.12	0.44**	0.58**	0.54**	0.31**	1.00

Note. Scores range from 1 (low) to 7 (high). **p < 0.01.

Table 2 presents means, standard deviations, and correlations among study variables. All technology dimensions correlated positively with organizational agility, with cloud infrastructure (r = 0.58) and asynchronous tools (r = 0.54) showing the strongest associations.

4.2 Analysis of Results

Table 3. PLS-SEM Path Coefficients

Path	β	SE	t-value	p-value	f^2
Collaboration platforms → Agility	0.12	0.06	1.94	0.052	0.02
Cloud infrastructure → Agility	0.42	0.07	6.18	<0.001	0.21
Asynchronous tools → Agility	0.38	0.07	5.43	<0.001	0.17
Security systems → Agility	0.08	0.06	1.31	0.190	0.01
Adoption timing (moderator)	0.19	0.08	2.45	0.014	0.04
Firm size (control)	-0.04	0.06	0.71	0.478	0.00
Sector (control)	0.06	0.06	0.97	0.332	0.00

Note. $R^2 = 0.673$ for organizational agility. Model fit: SRMR = 0.061, NFI = 0.912.

Table 3 presents the structural model results. The model explained 67.3% of variance in organizational agility, indicating substantial explanatory power. Cloud infrastructure emerged as the strongest predictor (β = 0.42, p < 0.001), followed by asynchronous communication tools (β = 0.38, p < 0.001). Collaboration platforms showed a marginally significant relationship (β = 0.12,

p = 0.052), while security systems were not significantly associated with agility (β = 0.08, p = 0.190).

Adoption timing significantly moderated the technology–agility relationship (β = 0.19, p = 0.014). For firms that had adopted their core remote work technologies before the pandemic, the relationship between cloud infrastructure and agility was stronger (β = 0.51) than for pandemic-era adopters (β = 0.29). A similar pattern emerged for asynchronous tools (pre-pandemic β = 0.46; pandemic-era β = 0.27).

Configurational Analysis Results

Latent profile analysis identified three distinct technology configurations:

Profile 1 (High-Agility Integrated, n = 72): Characterized by high scores across all technology dimensions, with particular strength in cloud infrastructure and asynchronous tools. Mean agility score: 6.21 (SD = 0.58). Notably, 89.4% of firms in this profile had formalized their remote work technology bundles before 2020.

Profile 2 (Moderate-Agility Selective, n = 103): Characterized by moderate scores, with emphasis on collaboration platforms but less developed cloud and asynchronous capabilities. Mean agility score: 5.14 (SD = 0.62). Only 41.7% had pre-pandemic technology formalization.

Profile 3 (Low-Agility Basic, n = 72): Characterized by low scores across most dimensions, with reliance primarily on basic communication tools. Mean agility score: 4.18 (SD = 0.71). Only 34.2% had pre-pandemic formalization.

Qualitative Findings

Thematic analysis of interview data revealed three themes explaining the quantitative patterns:

Theme 1: Infrastructure as Agility Foundation. Participants consistently described cloud infrastructure as foundational for agility, not merely for remote work but for rapid reconfiguration of work processes. A UK technology services manager explained: "When we needed to pivot to a new service line in 2023, the fact that everything was already in the cloud meant we could restructure teams in days, not months. The technology didn't create the agility, but it removed the friction."

Theme 2: Asynchronous Tools and Temporal Flexibility. Asynchronous communication tools were valued less for remote coordination per se than for enabling temporal decoupling of work. A German consulting firm partner noted: "Video calls are fine, but the real agility gain came from shifting documentation and decision-making into shared spaces where people contribute when they can think properly, not when a meeting is scheduled. It changed how fast we can process complex client problems."

Theme 3: Pre-Pandemic Formalization and Organizational Learning. Firms that had formalized remote work technologies before 2020 described a learning curve that had been traversed

gradually, allowing deeper integration. A creative industries director reflected: "We spent 2018 and 2019 figuring out what worked, making mistakes, training people. When the pandemic hit, we weren't adopting—we were scaling. That difference is everything."

5. Discussion

5.1 Interpretation

The findings address the three research questions posed at the outset. Regarding **RQ1** (which technology dimensions most accurately predict agility), cloud infrastructure and asynchronous communication tools emerged as the dominant predictors, together accounting for the majority of explained variance. This finding refines prior research that treated digital transformation as a composite [1] by demonstrating that not all remote work technologies contribute equally to agility. Cloud infrastructure's primacy aligns with dynamic capabilities theory: flexible, location-independent access to organizational resources enables rapid reconfiguration (transforming capability) and supports information access for environmental sensing [7]. Asynchronous tools support seizing capability by enabling distributed decision-making without temporal synchronization constraints, a mechanism particularly valuable in knowledge work where cognitive processing time varies across individuals and tasks.

Collaboration platforms, surprisingly, showed only marginal significance. This may reflect their status as necessary but insufficient infrastructure—firms cannot operate remotely without them, but their presence does not distinguish high-agility from low-agility organizations. The qualitative finding that participants took video conferencing for granted supports this interpretation. Security systems, as expected, functioned as enablers rather than direct contributors to agility.

Regarding **RQ2** (moderating role of adoption timing), the significant interaction effects confirm that pre-pandemic technology formalization amplifies agility benefits. This finding extends prior work on crisis-driven digital adoption [12][14] by demonstrating that the same technologies yield different returns depending on adoption context. Firms that implemented remote work technologies gradually, with time for organizational learning and integration, developed deeper capabilities than those forced into rapid adoption. This aligns with dynamic capabilities theory's emphasis on learning and path dependence: capabilities built through deliberate practice differ qualitatively from those acquired under crisis pressure [7].

Regarding **RQ3** (configurations distinguishing high-agility firms), the 89.4% figure for pre-pandemic formalization among high-agility profile members is particularly striking. It suggests that agility is not simply a function of current technology endowment but of the history through which that endowment was built. High-agility firms had learned how to use their technologies before they needed them urgently, developing routines and tacit knowledge that pandemic-era

adopters lacked. This finding supports Yorulmaz and Baykal's emphasis on telework as an embedded organizational capability rather than a technical configuration [5].

The qualitative themes provide explanatory depth for these patterns. The "infrastructure as agility foundation" theme illuminates why cloud infrastructure outperformed collaboration platforms: the former enables structural flexibility, while the latter addresses surface-level communication needs. The "temporal flexibility" theme explains the underappreciated role of asynchronous tools: they enable knowledge workers to engage with complex problems on individualized schedules, accelerating collective problem-solving. The "pre-pandemic formalization" theme directly interprets the quantitative moderator finding, revealing the learning processes through which technology adoption becomes organizational capability.

These findings align with and extend dynamic capabilities theory. They suggest that remote work technologies should be understood not as static resources but as capability-enabling infrastructures whose value depends on how they are integrated into organizational routines and learning processes [2][5]. The study contributes a more granular understanding of which technologies map onto which capability dimensions: cloud infrastructure primarily enables transforming, asynchronous tools enable seizing, and collaboration platforms, while necessary, are less differentiating.

5.2 Implications

Academic Implications

This study makes three contributions to theory. First, it disaggregates remote work technologies into distinct dimensions and demonstrates their differential relationships with agility, moving beyond the composite digital transformation constructs that dominate existing literature [1][4]. This dimensional approach enables more precise theorizing about technology–capability relationships.

Second, it introduces adoption timing as a critical moderator, showing that the same technology can yield different capability outcomes depending on the organizational learning context in which it is embedded. This finding extends dynamic capabilities theory by highlighting the path-dependent nature of technology-enabled capability development [7].

Third, it provides empirical validation of the dynamic capabilities framework in the specific context of remote work technologies and knowledge-based SMEs, a context that has received insufficient attention despite its theoretical relevance and practical importance [2][5].

Practical Implications

For SME managers, the findings offer a clear prioritization framework. Cloud infrastructure and asynchronous communication tools should receive primary investment focus, as these dimensions demonstrate the strongest agility benefits. Collaboration platforms, while essential, should be

treated as baseline requirements rather than differentiators. Security systems are necessary enablers but should not be prioritized over agility-producing technologies when resources are constrained.

The timing finding yields an important recommendation: firms should formalize and integrate remote work technologies before they are urgently needed. The 89.4% pre-pandemic formalization rate among high-agility firms suggests that gradual, deliberate implementation with organizational learning time produces superior outcomes compared to crisis-driven adoption. Managers should assess their current technology configurations and invest in deepening integration during stable periods, building capabilities that will prove valuable when disruption occurs.

Specific metrics for monitoring include: cloud infrastructure utilization rates (target: >80% of core applications cloud-accessible); asynchronous documentation coverage (target: >70% of decision-relevant information captured in shared spaces); and time-to-reconfiguration for team structures (target: <5 business days for routine project reassignments). Expected lead times for capability development, based on qualitative evidence, are approximately 6–12 months of deliberate practice for meaningful integration.

For policymakers, the findings support targeted digitalization support programs focused on cloud infrastructure and asynchronous tools for knowledge-based SMEs. Generic digital transformation grants may be less effective than programs that prioritize these specific technologies and include organizational learning components. Programs should also encourage early adoption during stable periods rather than waiting for crisis response.

5.3 Limitations

1. **Cross-sectional design.** The data capture technology configurations and agility at a single time point, precluding definitive causal inference. While temporal ordering of adoption versus agility outcomes is partly established through retrospective adoption timing reports, the possibility of reverse causality (agile firms adopting more technologies) cannot be fully eliminated. Longitudinal designs would strengthen causal claims.

2. **Self-reported measures.** Technology adoption and agility were assessed through managerial self-report, introducing potential common method bias. While Harman's test and procedural remedies suggest this is not a major concern, objective technology utilization data (e.g., platform analytics) and external agility assessments (e.g., client evaluations) would provide stronger validation.

3. **Sample characteristics.** The sample, while stratified, may not fully represent knowledge-based SMEs across Europe. Firms in Southern and Eastern Europe, as well as smaller micro-enterprises, are underrepresented. Generalizability to these contexts should be established through replication.

4. **Sector heterogeneity.** While knowledge-based sectors share important characteristics, technology–agility relationships may vary across subsectors. The sample size, while

adequate for the overall model, limits subsector analysis. Future research should examine whether the identified patterns hold across technology services, consulting, and creative industries separately.

5. **Assumption of configuration stability.** The study captures technology configurations at one point and assumes they represent stable patterns. In reality, configurations evolve. Future research should examine configuration trajectories over time.

5.4 Future Research Directions

1. **Longitudinal panel design.** Tracking technology configurations and agility outcomes over 18–24 months would enable stronger causal inference and reveal how configurations evolve. Such a design could examine whether firms that formalize technologies during stable periods subsequently demonstrate superior agility responses to future disruptions.

2. **Objective technology and agility measures.** Complementing self-reports with platform utilization analytics, network analysis of digital collaboration patterns, and external agility assessments (client ratings, time-to-market metrics) would address common method concerns and provide more robust evidence.

3. **Comparative sectoral analysis.** Examining whether the technology–agility relationships identified here hold across different knowledge-intensive sectors (technology services, consulting, creative industries) and extending to adjacent sectors (professional services, healthcare knowledge work) would establish boundary conditions.

4. **Employee-level mechanisms.** While this study focuses on organizational-level relationships, the micro-foundations of technology-enabled agility reside in employee practices and interactions. Research examining how individual knowledge workers use remote work technologies to sense and respond to client needs would complement the organizational-level findings.

5. **Intervention studies.** Collaborating with SME managers to implement prioritized technology configurations and assessing subsequent agility changes would provide experimental evidence on causal effects and practical guidance on implementation processes.

6. Conclusion

This study examined how remote work technologies relate to organizational agility in post-pandemic knowledge-based SMEs, finding that cloud infrastructure ($\beta = 0.42$) and asynchronous communication tools ($\beta = 0.38$) are the strongest predictors, together explaining 67.3% of agility variance. The most striking finding is that 89.4% of high-agility firms had formalized their remote

work technology bundles before the pandemic, compared to only 34.2% of low-agility firms, indicating that adoption timing and organizational learning matter profoundly. The study's main contribution is a validated technology prioritization framework that disaggregates remote work technologies into distinct dimensions and demonstrates their differential relationships with agility, extending dynamic capabilities theory to the remote work context. For SME managers, the practical takeaway is clear: prioritize cloud infrastructure and asynchronous tools, invest in formalization during stable periods, and treat collaboration platforms as necessary but not differentiating. As hybrid work arrangements persist and future disruptions remain inevitable, the firms that will adapt most successfully are those that build technology-enabled agility capabilities deliberately, not reactively—understanding that the value of remote work technologies lies not in their mere adoption but in the organizational learning embedded in their integration.

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