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A Process-Level Digital Maturity and Roadmapping Artifact for Purchasing: Development and Utility Demonstration of DEMA

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Abstract

Digital maturity models are widely used to support transformation; however, many remain organization-level, lack transparency, and are only weakly linked to implementation prioritization. These limitations are especially consequential in purchasing, where maturity may vary substantially across activities and sub-processes. This study develops a process-level digital maturity assessment-and-roadmapping (DEMA) artifact for purchasing. Within the broader DEMA architecture, this study develops and evaluates only the Smart Business Processes component, while retaining Digital Strategy and Infrastructure as a contextual architectural layer. Drawing on design science research and maturity model development guidance, DEMA was developed through literature synthesis, iterative expert involvement over approximately 18 months, and structured refinement conducted in approximately 20 sessions. The artifact was refined through three anonymized pilot applications in electronics manufacturing SMEs and then demonstrated through a focal case application in an electronics SME that used an ERP system but lacked a purchasing-specific digital transformation roadmap. Evaluation was utility-oriented rather than psychometric, focusing on whether the artifact could (i) generate differentiated capability profiles across purchasing subprocesses, (ii) improve item clarity, stage interpretation, and scoring logic through pilot-based refinement, and (iii) translate assessment results into feasible targets, priorities, and sequenced roadmap actions under facilitated conditions. To provide bounded but direct validation evidence, the study also included a lightweight two-rater consistency and interpretability check on a representative subset of 24 items, together with a structured diagnosis-to-roadmap traceability review of six representative items. The results showed moderate exact agreement, perfect adjacent agreement, positive weighted inter-rater agreement for ordinal ratings, and favorable interpretability scores. Together, these findings provide bounded empirical support for the artifact's practical consistency and usability within the study's development-oriented scope. Unlike reflective survey scales, the DEMA is evaluated here as a staged, prescriptive maturity grid. Accordingly, the methodological emphasis is on interpretability, traceability, and assessment-to-action usefulness in facilitated use rather than psychometric scale validation. The DEMA integrates a fully disclosed 70-item staged instrument with explicit scoring, dual-target setting, dependency-aware prioritization, and a structured implementation methodology. In the focal case, the artifact revealed uneven maturity profiles across capabilities, distinguished between current and target capability states, and supported the prioritization of concrete intervention areas, such as data-entry automation/RPA, digital tool budgeting, remote-access improvement, and analytics-related training. Rather than pursuing psychometric scale validation, this study presents a transparent, implementation-oriented artifact for purchasing and shows how process-level maturity diagnosis can be translated into roadmap development in guided-application settings. Therefore, the contribution is design-oriented and practice-

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facing rather than a claim of broad theoretical advancement or comparative superiority over existing maturity frameworks.

Keywords: digital maturity; digital transformation; purchasing; procurement; process-level assessment; roadmapping; decision-support artifact; capability gaps; prioritization; design science research

1. Introduction

Digital transformation (DX) is reshaping business models, organizational processes, and value creation through the combined use of digital technologies, analytics, automation, and new forms of coordination [1–12]. In industrial settings, this transformation is often discussed through the lens of Industry 4.0, value chain integration, and digitally enabled resilience [13–16]. Within this broader context, digital maturity is commonly understood not as a static end state but as an evolving organizational capability that requires continuous adaptation in a changing technological environment [17]. Here, DX refers to the broader organizational transformation context, whereas procurement digitalization refers to its implementation within purchasing processes.

Despite the strategic importance of digitalization, progress remains uneven across all business functions. Technologies such as RFID, advanced analytics, and integrated digital platforms have become increasingly visible in production and logistics; however, their diffusion is less consistent in purchasing [18–23]. This is important because purchasing is a boundary-spanning function that connects internal operations with suppliers, compliance requirements, market intelligence, and coordination across organizational interfaces. In such a setting, digitalization cannot be reduced to tool availability. Rather, it depends on the alignment of technologies with process routines, governance structures, data use, decision rights, and human capabilities [24–27]. Recent evidence also suggests that digital maturity and technology adoption do not develop uniformly, especially for more complex technologies, reinforcing that maturity should not be equated with the mere presence of a tool [28].

Digital maturity models (MMs) are widely used to assess current states, structure improvement efforts, and guide transformation pathways [29–32]. In general, maturity refers to the extent to which digital technologies are embedded in ways that support process performance and strategic objectives [33]. However, three limitations remain particularly consequential for purchasing. First, many existing models assess digital maturity at an aggregate organizational level and, therefore, risk obscuring substantial variation across subprocesses and activities. Second, many models provide limited transparency regarding item content, stage logic, and scoring procedures, which reduces their interpretability, replicability, and practical trust. Third, maturity assessment is often only weakly connected to implementation sequencing, leaving organizations with diagnostic outputs but limited guidance on how to prioritize and phase transformation actions [17]. These limitations are especially problematic in purchasing, where activities such as data entry, confirmations, supplier interaction, analytics, and control routines may display markedly different maturity profiles.

For purchasing, this is not merely a matter of descriptive details. A process-level perspective offers greater analytical discrimination because it reveals where maturity differences occur, providing a more credible basis for capability-specific prioritization and roadmap design. This is also where managerial problems become most visible. In practice, procurement leaders do not only ask how mature the function is overall; they also need to decide where transformation should begin, which capabilities should be strengthened

first, and how initiatives should be sequenced under feasibility constraints. Firm-level maturity scores rarely provide sufficient support for these decisions because they do not readily translate into process-specific priorities, feasible targets, or dependency-aware implementation paths [34]. Roadmapping is therefore central to maturity assessment in purchasing, since organizations need not only a diagnosis of their current position but also a structured way to convert that diagnosis into realistic progression paths [17].

These challenges are amplified by the socio-technical characteristics of procurement digitalization. Digital tools create value only when they are embedded in appropriate skills, organizational routines, governance mechanisms, and cross-functional and inter-organizational coordination. The socio-technical view is used as a conceptual framing device rather than a theory to be tested directly. Accordingly, digital maturity in purchasing is approached as process-level capability enactment and alignment rather than technology possession alone. This framing is particularly relevant in purchasing-specific contexts characterized by supplier integration, compliance, traceability, and analytics-enabled decision-making, all of which require coordinated change across technical and organizational elements [35,36].

Against this background, the present study addresses a gap at the intersection of digital maturity research, procurement digitalization, and implementation-oriented transformation design. More specifically, the literature indicates a need for a transparent, process-level artifact that can diagnose digital maturity within purchasing activities and translate assessment results into prioritized and feasible transformation actions. To address this need, this study develops a purchasing-specific digital maturity assessment-and-roadmapping artifact (DEMA). In the present study, DEMA was used as a broader architectural label for a purchasing-oriented assessment-to-action design. Within that broader architecture, this study focuses specifically on the Smart Business Processes component, which functions as the focal operational artifact under development and evaluation. This focal component combines a staged process-level assessment instrument with explicit scoring, target-setting, prioritization, and roadmap support. Digital Strategy & Infrastructure is retained only as a higher-level contextual layer and is not developed or empirically evaluated as a focal component in this study. This study aims to provide a conceptually informed, implementation-oriented basis for structured diagnosis and action planning in purchasing, rather than testing a general theory of digital transformation.

This study offers three related contributions. First, it clarifies why process-level diagnosis is more decision-relevant than undifferentiated firm-level maturity scores when the managerial task is capability-specific prioritization and sequencing in purchasing. It does so by making heterogeneous capability gaps visible at the point where intervention priorities and sequencing decisions are made [37,38]. Second, it contributes a transparent, purchasing-specific assessment-and-roadmapping artifact whose item logic, scoring structure, and implementation procedure are fully disclosed, thereby addressing longstanding concerns about opacity and limited replicability in maturity-model research. Third, it contributes a structured assessment-to-action logic that links capability diagnosis to dual targets, dependency-aware prioritization, and sequenced roadmap development, thereby extending maturity assessment from diagnosis to implementation-oriented managerial use. Taken together, these contributions clarify how digital maturity in purchasing can be approached through process-level capability alignment and assessment-to-action reasoning. They should be read as design-oriented and application-oriented contributions, rather than claims of theoretical advancement or explanatory theory testing. For clarity, the core artifact in this study is the Smart Business Processes component of DEMA, implemented as a staged process-level assessment-and-roadmapping artifact rather than as separate maturity-model, assessment-tool, and decision-support constructs.

On this basis, the central research problem is as follows: How can digital maturity be assessed and operationalized at the purchasing process level to support actionable transformation? This problem is addressed through three research questions.

RQ1: What design principles should inform a process-specific digital maturity artifact for purchasing activities?
RQ2: How can digital maturity be assessed at the process and activity levels to capture the alignment between technologies and enabling capabilities across maturity stages?
RQ3: How can assessment results be translated into structured and feasible transformation planning?

In terms of scope, the broader DEMA architecture contains two dimensions; however, this study develops and evaluates only the Smart Business Processes component as the focal operational artifact. Digital Strategy & Infrastructure is retained solely as a higher-level contextual layer for interpreting process-level maturity and is not operationalized or empirically validated in the present study. Accordingly, the present study should be read as an empirical development and evaluation of only one dimension of the broader DEMA architecture, namely, Smart Business Processes.

Methodologically, this study follows design science research and maturity model development guidance [39,40]. The artifact was developed through literature synthesis, expert input, and iterative refinement, and was evaluated through three pilot implementations and one case-based utility demonstration. The remainder of this paper is organized as follows. Section 2 reviews digital maturity models and procurement digitalization and derives the main design requirements for the proposed model. Section 3 presents the research methodology used in this study. Sections 4 and 5 introduce the DEMA and its instrument structure. Section 6 presents the case-based evaluation. Section 7 discusses the study's implications. Section 8 concludes with the limitations and directions for future research.

2. Background, Related Work, and Research Gaps

Maturity models describe staged progress in organizational capability, integration, and performance [41,42]. Originating in software engineering [43], they have been widely used to support benchmarking and improvement by making transformation pathways more visible and actionable [44–47]. In the contexts of Industry 4.0 and digital transformation, such models are frequently used to assess digital readiness and guide improvement. However, prior research remains fragmented because of conceptual ambiguity, inconsistent validation, and substantial variation in scope, analytical level, and methodological rigor [14,30,48–51]. Related work also questions linear and uniform transformation paths, suggesting that digital transformation may follow heterogeneous trajectories rather than a single, universal sequence [28].

This fragmentation is particularly consequential for boundary-spanning functions such as purchasing, where heterogeneous subprocesses require capability development that extends beyond the mere availability of tools. Accordingly, the present review focuses on peer-reviewed digital maturity models and related purchasing digitalization work, with particular attention to the analytical level, transparency of assessment logic, empirical grounding, and support for implementation-oriented action [14,50,51].

To position the present study more clearly, Table 1 compares representative maturity-model streams discussed in the literature along four dimensions that are especially relevant for purchasing: analytical level, transparency of assessment logic, evaluation basis, and linkage to implementation guidance. The comparison is not intended to rank prior studies; rather, it clarifies how existing approaches differ in what they assess, how explicitly they disclose their assessment structure, and to what extent they support the translation of diagnosis into sequenced transformation actions.

Table 1. What recent review and comparison studies suggest about digital maturity models and how DEMA is positioned.

Review-Based Observation from Prior Literature	What the Reviewed Literature Shows	Implication for Maturity-Model Design	How DEMA Responds
The field is rich, but highly heterogeneous	Comparative studies show that digital maturity models differ substantially in terms of dimensions, criteria, key performance indicators (KPIs), maturity structures, and intended use. Therefore, direct comparison is difficult, and some studies have built special frameworks or common comparison spaces to compare models systematically [52,53].	A new study should not merely add another broad maturity framework; it should explicitly clarify its analytical focus and design logic.	DEMA is positioned explicitly as a purchasing-specific, process-level artifact rather than as another generic organization-level model.
Most reviewed models remain broad in analytical level	Recent reviews mainly cover models developed for broad organizational transformation, SMEs, sector selection, smart manufacturing, or Industry 4.0 contexts rather than for one clearly delimited business function [52,54,55].	There is room for more domain-grounded and function-specific maturity artifacts.	DEMA narrows the unit of analysis to purchasing activities and subprocesses, where maturity may differ substantially across operational areas.
Assessment transparency varies considerably	Review and comparison studies indicate substantial variation in model disclosure, terminology, criteria structure, and comparability; some models are difficult to compare directly without reverse engineering or interpretive reconstruction [52,53].	Transparency of item logic, scoring, and assessment structure becomes an important design criterion if a model is intended to be interpretable and reusable.	The DEMA is designed as a fully disclosed instrument with an explicit item structure, stages, scoring logic, prioritization logic, and implementation procedure.
Diagnosis is often stronger than implementation support	Several comparison and critical review studies note that maturity assessments are useful for diagnosis, yet often provide only limited direct support for concrete action planning, roadmap definition, or context-sensitive next-step logic [54,55].	The literature points to the need for maturity artifacts that connect diagnosis to feasible implementation actions.	DEMA is conceived not only as an assessment tool but also as an assessment-and-roadmapping artifact linking maturity diagnosis to targets, prioritization, and sequenced action.
Actionability is increasingly recognized, but unevenly realized	Some newer comparisons explicitly assess "actionability" and show that models differ in the clarity and granularity of the improvement guidance they provide [55].	Novelty may lie not only in the dimensions covered but also in improving the assessment-to-action connection.	The DEMA strengthens actionability through dual targets, dependency-aware prioritization, and sequenced roadmap development.
Many prior contributions are comparison-oriented rather than deployable domain artifacts	Review and comparison papers help map the field and support model selection, but they do not provide a purchasing-focused operational artifact for maturity assessment and implementation planning [52,53,55].	A contribution may lie in moving from meta-comparison to a deployable, domain-grounded artifact.	The DEMA contributes a replicable development and implementation logic for purchasing digital transformation, including assessment, prioritization, and roadmap generation.

Note: The table does not attempt to rank prior studies or provide an exhaustive classification of all maturity models. Rather, it synthesizes what recent review and comparison studies collectively indicate about the current maturity-model landscape and uses these observations as explicit design requirements for positioning DEMA more clearly.

Taken together, these review and comparison studies suggest that the digital maturity literature is rich in models but is still fragmented in ways that matter for implementation. Existing models differ substantially in dimensions, criteria, scoring structures, and analytical scope, and many remain oriented toward broad organizational, SME, sectoral, or Industry 4.0 contexts rather than the detailed logic of a specific business function. The reviewed studies also suggest that diagnostic maturity outputs do not automatically translate into concrete and context-sensitive transformation actions. From this perspective, the key gap is the limited availability of transparent, process-level, and implementation-oriented artifacts in specific domains. DEMA is positioned as a response to that gap. It focuses explicitly on purchasing, operates at the level of activities and subprocesses, discloses its assessment and prioritization logic, and links diagnosis to dual targets, dependency-aware prioritization, and sequenced roadmap development. Accordingly, the study is positioned less as a proposal for a new high-level maturity vocabulary and more as a purchasing-specific assessment-to-action artifact grounded in process-level capability differences and feasible transformation planning.

2.1. Structural Limitations

Three recurring structural limitations have emerged from the literature. First, many models remain technology-centric, emphasizing the presence of tools rather than the capabilities required for their effective, sustained, and organizationally embedded use [56–58]. Second, process granularity and domain logic are often underdeveloped in the models. Maturity stages and dimensions vary substantially across studies, yet they are rarely structured in a way that reflects purchasing-specific activities and subprocesses, while firm-level perspectives may obscure important intra-organizational variation [39,59]. Simultaneously, digital maturity is commonly treated as a multidimensional construct spanning areas such as strategy, operations and processes, culture, and digital skills, which underscores the need for structured capability coverage rather than narrow technology inventories [17]. Third, purchasing remains underrepresented as a distinct assessment domain despite its strategic relevance, external orientation, and exposure to coordination and compliance demands [60,61].

2.2. Methodological Gaps

Methodological limitations further reduce the usefulness of existing literature. Large-scale reviews show substantial heterogeneity across digital maturity models in terms of industrial focus, scope, and covered dimensions, which weakens the transferability of generic firm-level templates [28]. Many models provide limited transparency regarding assessment items, scoring procedures, and prioritization mechanisms, constraining both replication and practical applicability [30,62]. In addition, empirical grounding is often limited, and maturity is frequently treated as a proxy for technology adoption rather than capability development, governance quality, or process integration [63]. Such framing can produce weakly actionable roadmaps and may direct attention toward advanced tools while overlooking foundational enablers such as data governance, integration readiness, and skill development [64,65]. In purchasing settings, these weaknesses are particularly problematic because they blur the relationship between maturity scores, capability deficits, and actionable next steps for managerial decision-making.

2.3. Gap and Motivation

Taken together, the literature suggests that many existing maturity models privilege tool presence, operate at relatively aggregate levels, and provide limited transparency in both the design and application logic. This gap is not only methodological but also conceptual. In particular, the literature provides limited support for treating purchasing maturity

as a process-level socio-technical configuration that links digital tools with enabling routines, skills, and coordination mechanisms for implementation-oriented decision-making. These limitations become more pronounced in purchasing, where maturity may vary substantially across subprocesses such as request handling, RFQ processes, ordering, confirmations and supplier analytics. Under these conditions, aggregate maturity scores offer limited diagnostic precision and weak support for action planning. Although procurement digitalization pathways have been discussed in prior studies, integrated approaches that combine process-level scoring, explicit prioritization, and roadmap generation remain limited, particularly when the aim is to support feasible and sequenced transformation rather than high-level benchmarking alone [66].

2.4. Design Response to the Identified Gaps

To address these gaps, the present study adopts a process-specific design that combines a fully disclosed assessment instrument with explicit scoring, prioritization, and roadmapping logic. The full assessment instrument is provided in Supplementary File S1, while the scoring, prioritization, and implementation logic are further documented in the main text and appendices. By disclosing the assessment items, staged response logic, capability structure, scoring approach, and prioritization procedure, this study seeks to support replication, comparison, and cumulative research beyond isolated case applications, this study seeks to support replication, comparison, and cumulative research beyond isolated case applications. More specifically, the literature review indicates a need for an artifact that is process-level rather than purely aggregate, transparent at the item and scoring level, and explicitly connected to implementation sequencing. These requirements directly inform the design of DEMA and are interpreted through conceptual framing that combines process-level capability alignment with a socio-technical view of purchasing digitalization. Their role is to inform artifact design and problem structuring rather than support theory testing or claims of theory advancement in the present study.

To clarify DEMA's contribution more explicitly in relation to alternative maturity-model approaches, Table 2 compares representative streams from the literature in terms of the analytical level, transparency, implementation support, and relative decision value for purchasing transformation.

Table 2. Comparative positioning of DEMA against representative maturity-model approaches relevant to digital transformation and procurement.

Approach/Study	Primary Scope and Analytical Level	Transparency of Assessment Logic	Implementation/ Roadmap Support	Main Limitation Relative to DEMA	DEMA's Distinguishing Feature in This Study	Key Supporting References
Broad digital maturity models reviewed in recent comparison studies	Mostly organization-level, cross-industry, and frequently broad transformation or Industry 4.0 oriented	Often uneven; comparative reviews report substantial variation in dimensions, criteria, terminology, and disclosure	Usually stronger in diagnosis than in concrete implementation guidance	Limited process-level specificity and weaker translation from diagnosis to sequenced action	DEMA narrows the unit of analysis to purchasing subprocesses and explicitly links diagnosis to targets, prioritization, and sequenced roadmap actions	[52,53,55]
DREAMY framework	Manufacturing-wide maturity assessment combined with roadmap support across operational domains	Relatively transparent; questionnaire, maturity logic, gap identification, and roadmap phase are explicit	Strong; integrates maturity assessment with roadmap generation	Not purchasing-specific; broader manufacturing scope reduces functional diagnostic granularity	DEMA is positioned to provide a similar assessment-to-action logic at a narrower, purchasing/process-specific level	[67]

Table 2. *Cont.*

Approach/Study	Primary Scope and Analytical Level	Transparency of Assessment Logic	Implementation/ Roadmap Support	Main Limitation Relative to DEMA	DEMA's Distinguishing Feature in This Study	Key Supporting References
Procurement digitalization pathways model	Procurement-specific, but oriented toward conceptual maturity pathways rather than a fully disclosed staged assessment instrument	Conceptually clear, but not fully operationalized as an item-level assessment-and-scoring artifact	Provides pathway logic more than explicit scoring and prioritization logic	Lacks a transparent item-level assessment grid, explicit stage scoring, and structured prioritization procedure	DEMA translates procurement-specific maturity thinking into a more explicitly operational assessment-and-roadmapping artifact	[24]
Generic assessment-instrument literature in Industry 4.0	Mixed instrument types: maturity models, frameworks, readiness tools, and roadmaps	Reviews explicitly note conceptual ambiguity between instrument types and uneven actionability	Recognized as important, but unevenly realized across models	Blurred distinctions between model, roadmap, framework, and readiness assessment reduce practical clarity	DEMA defines its role more narrowly as an assessment-and-roadmapping artifact and discloses how scoring connects to action	[53,55]
Critical DMM literature	Field-level critique of digital maturity models	Highlights lack of objective evaluation criteria, limited empirical support, and risks of overclaiming	Questions whether many models demonstrate value beyond diagnosis	Does not itself offer a domain-grounded operational artifact	DEMA responds by keeping claims bounded, disclosing the instrument, and adding lightweight evidence on scoring consistency, interpretability, and traceability	[68]
DEMA (this study)	Purchasing-specific, process-level, capability-based artifact focused on activities and subprocesses	High; full staged item grid, scoring logic, dual targets, prioritization, and implementation logic disclosed	Strong within study scope; diagnosis explicitly linked to target setting, prioritization, sequencing, and traceability checks	Utility-oriented and bounded rather than large-sample psychometric validation	Brings together purchasing specificity, process granularity, transparency, and assessment-to-action logic within a single deployable artifact	This study; Supplementary File S1

Table 2 indicates that DEMA's contribution lies less in proposing another generic maturity vocabulary and more in offering a comparatively narrower but more operational artifact. This positioning is also consistent with broader maturity-model research, which has repeatedly noted substantial variation across models in terms of scope, validation, applicability, and intended use, as well as the need to distinguish the maturity model itself from the assessment method and its prescriptive use in practice [38,69,70]. In the present study, these functions are integrated within a single core artifact: the Smart Business Processes assessment-and-road-mapping component of DEMA. Relative to broad digital maturity models, its main advantage is a greater process-level analytical resolution and a more explicit linkage between diagnosis, target setting, prioritization, and sequenced action. Compared with roadmap-oriented frameworks such as DREAMY, DEMA offers a similar assessment-to-action orientation but with a more tightly delimited functional scope, namely purchasing and its subprocesses. Compared with procurement digitalization pathway models, DEMA adds a fully disclosed staged assessment instrument, explicit item-level scoring logic, and structured translation from capability gaps to roadmap decisions. Thus, the comparative claim made here is not one of universal superiority or empirical outperformance against a directly applied baseline model. At this stage, the comparison is analytical rather than experimental in nature. Therefore, this study positions DEMA as

a more explicit process-level assessment-to-action artifact for purchasing transformation under facilitated conditions. A direct side-by-side application of alternative maturity frameworks remains a task for future research.

3. Research Methodology

This study adopts a design science research (DSR) approach to develop an academically grounded and practically useful artifact [71]. Here, the core artifact is the Smart Business Processes component within the broader DEMA architecture. Although DEMA includes a second architectural dimension, Digital Strategy & Infrastructure, that dimension is retained only as a contextual background and is not developed or evaluated empirically here. This focal artifact is implemented as a staged assessment-and-roadmapping artifact for digital maturity diagnosis and transformation planning in purchasing processes. More specifically, it combines a process-level maturity grid, explicit scoring logic, dual-target setting, prioritization rules, and a structured implementation methodology within a single deployable artifact. This research follows a structured and replicable development procedure that moves from problem identification to iterative design, refinement, evaluation, and case-based utility demonstration.

3.1. Methodological Foundations and Development Logic

The methodological logic combines design science reasoning with maturity model development guidance. More specifically, DEMA draws on capability maturity logic [46,72] and follows the six-phase maturity model development lifecycle proposed by [73], which has been applied across multiple maturity model research contexts [49,74,75]. To strengthen the procedural logic of iterative development, this lifecycle is complemented by system development life cycle (SDLC) principles [76], as detailed in Appendix C (Figure A8).

This combined structure supports a coherent progression from scoping and conceptual design to instrument construction, refinement and application. Problem relevance was established through the documented limitations of existing digital maturity models and the practical need for a process-level, transparent, and implementation-oriented approach to purchasing. Rigor was pursued through literature synthesis, use of established maturity-model development guidance, iterative expert refinement, and full disclosure of the instrument, derivation procedure, prioritization logic, and implementation steps in the appendices and the Supplementary File. Accordingly, the study moves from initial problem framing to a deployable and evaluable artifact while keeping the development logic explicit and open for scrutiny.

3.2. Iterative Development and Expert Involvement

The artifact was developed iteratively through sustained expert involvement over approximately 18 months. A panel of five information systems experts contributed through approximately 20 structured sessions lasting 90–120 min. This collaboration was also informed by a communities-of-practice perspective, which helped integrate academic and practice-oriented knowledge during artifact refinement [77–80].

The expert panel was established through purposive selection to ensure that the artifact was shaped by both practical digital transformation experience and process-level implementation knowledge. To support this aim, experts were included based on predefined criteria. The selected experts were expected to have an engineering or closely related degree, substantial professional experience in manufacturing settings, significant exposure to technology and management consultancy, prior involvement in multiple enterprise system implementations and technology selection projects, project management experience, familiarity with cross-functional business processes, and working knowledge

of contemporary digital technologies. Particular importance was given to ERP-related implementation experience because such projects require a detailed understanding of organizational processes and their digital integration.

Disciplinary diversity was considered during panel formation to reduce the risk of a narrow or single-domain perspective. The final expert group included specialists from industrial, computer, mathematical, mechanical, and electronics engineering backgrounds. While all experts shared an information systems orientation, their combined experience covered enterprise systems and digitalization initiatives, such as ERP, MRP, CRM, SCM, and BI. This composition supported both practical relevance and cross-functional interpretability in refining the model.

Bias mitigation was addressed through explicit selection criteria, diversity in disciplinary and project backgrounds, and iterative refinement through repeated expert discussions. These measures helped reduce the risk that the artifact would reflect the assumptions of a single functional viewpoint or the unchallenged preferences of the individual experts. Instead, expert feedback was used as a structured input to improve the clarity, applicability, and internal consistency of the maturity model.

Across these iterations, the experts reviewed the model step-by-step and provided feedback on the dimensions, capabilities, item wording, stage definitions, and response logic. Their input was consolidated after each round and incorporated into the subsequent revisions. This process helped reduce the ambiguity between maturity stages, improve interpretability, and strengthen consistency during facilitated application. In later iterations, expert discussions also informed adjustments related to pilot use, thereby linking conceptual design with application-oriented refinement. Here, expert involvement is treated as a structured refinement mechanism rather than a substitute for formal statistical validation.

3.3. Evaluation Logic and Application Mode

The evaluation logic of this study is utility-oriented rather than psychometric. DEMA is designed as a staged and prescriptive maturity grid in which each item is linked to a capability and maturity stage from 0 to 4. The central question is not whether the artifact behaves like a reflective measurement scale but whether it can be used in an interpretable, traceable, and decision-relevant manner under facilitated conditions.

Accordingly, the evaluation focused on three issues. First, it examined whether item-level responses produced differentiated and meaningful capability profiles across the purchasing subprocesses. Second, it examined whether the pilot applications helped refine item clarity, stage interpretation, and scoring logic. Third, it examined whether assessment outputs could be translated coherently into target setting, prioritization, and sequenced roadmap actions. On this basis, methodological rigor in the present study is pursued through iterative expert review, pilot-based refinement, and case-based utility demonstration.

This evaluation logic does not seek to establish broad statistical validity, psychometric scale properties, or generalizability to large samples. Rather, the present study is positioned as an artifact-development and utility-demonstration stage that provides a bounded form of initial validation, in which reliability is treated primarily as facilitated interpretability and scoring consistency in application rather than as internal consistency among reflective latent constructs. In addition to iterative expert review, pilot-based refinement, and facilitated case-based utility demonstration, a bounded validation layer was included to provide a form of initial validation through evidence of scoring consistency, interpretability, and diagnosis-to-roadmap traceability. Specifically, a lightweight two-rater consistency exercise was conducted on a representative subset of 24 items selected across the three focal subdimensions (Strategy, People, and Process). The subset preserved the original architecture

of DEMA.v1, in which process-specific items were concentrated primarily in the Process subdimension and included items with varying expected levels of interpretive difficulty.

Two independent assessors rated the same 24 items using the original 0–4 maturity logic scale. Because the maturity categories are ordinal, inter-rater agreement was examined using weighted Cohen's kappa, with quadratic weighting reported as the primary coefficient and linear weighting reported as a conservative supplementary check. Agreement was also summarized through exact agreement, adjacent agreement, and mean absolute score differences. To assess interpretability more systematically, each assessor rated item clarity, clarity of level distinctions, and ease of score justification on a 1–5 scale. Finally, to complement the scoring consistency evidence, six representative items were subjected to a structured diagnosis-to-roadmap traceability check linking the current level, target level, gap, priority rationale, recommended action, and sequencing logic.

This additional validation layer does not constitute comprehensive empirical testing, full psychometric validation, strong reliability testing, or large sample statistical generalization. Instead, it should be read as a bounded form of initial validation, showing that the focal component can be interpreted with workable consistency and used in a traceable assessment-to-action manner under facilitated conditions. This design choice is consistent with the study's purpose of artifact development and utility demonstration. The full instrument is presented in Supplementary File S1.

To make the iterative refinement process more transparent, Table 3 summarizes representative refinement evidence from expert reviews, pilot applications, case-based utility use, and assessment-to-roadmap translation. The entries are organized using analytically derived categories that are consistent with the artifact's development and evaluation logic, including content clarity, interpretive consistency, structural coherence, decision-support usefulness, and practical applicability. The summarized entries were derived from documented expert refinement rounds, pilot-based revision observations, and case-related application materials generated during the development and use of the artifact. The purpose of Table 3 is not to claim full-scale validation but to show more explicitly how iterative feedback informed revisions in item wording, stage definitions, scoring logic, target-setting clarity, prioritization transparency, and roadmap usability in guided-application settings. This refinement logic is broadly consistent with maturity model development studies that emphasize iterative construct refinement, item clarification, and stage-definition improvement during model development [39,73,81].

Table 3. Representative refinement evidence across expert reviews, pilot applications, case-based utility demonstrations, and assessment-to-roadmap logic.

Ref. No	Evaluation Stage	Assessed Element	Issue/Problem Identified	Revision Made	Intended Refinement Contribution
E1	Expert review	Stage definitions	Some maturity stage boundaries appeared conceptually too close, especially where system-supported and integrated/automated practices could be interpreted similarly.	The stage descriptors were revised to sharpen the progression logic from manual to system-supported, integrated, and more advanced execution.	This revision was intended to improve interpretive consistency during facilitated scoring and to reduce ambiguity between adjacent maturity stages.
E2	Expert review	Item wording	Several draft items appeared too generic and were not sufficiently anchored in purchasing practice.	The item wording was revised to more explicitly reflect purchasing-specific routines, decisions, and subprocess realities.	This revision was intended to improve content clarity and strengthen the purchasing-specific interpretability.

Table 3. *Cont.*

Ref. No	Evaluation Stage	Assessed Element	Issue/Problem Identified	Revision Made	Intended Refinement Contribution
E3	Expert review	Capability–item alignment	Some items required clearer alignment with capabilities and sub-dimensions to preserve traceability from constructs to items and from items to actions.	The item-to-capability classification was reviewed and adjusted to strengthen the hierarchical consistency.	This revision was intended to improve structural coherence and clarify traceability from assessment outputs to capability-level diagnoses.
E4	Expert review	Response logic/technology cues	Technology references risk being interpreted as defining maturity rather than illustrating typical stage enablers.	Technology cues were retained as illustrative anchors, but their role was clarified so that maturity would not be reduced to the presence of tools alone.	This revision was intended to improve conceptual consistency and reduce the risk of a technology-deterministic interpretation.
P1	Pilot application	Question clarity	Some questions were not immediately clear to respondents when completed before the facilitated discussion.	The question wording and explanatory phrasing were revised after pilot-based feedback.	These revisions were intended to support a smoother completion flow and reduce the need for clarification in later applications.
P2	Pilot application	Classification structure	Certain items or response sets created uncertainty about whether they reflected standard cross-functional capabilities or process-specific purchasing practices.	The classification and labeling of items were clarified, including a clearer differentiation between standard and process-specific items.	This revision was intended to improve instrument readability and strengthen the transparency of the item structure.
P3	Pilot application	Scoring logic	The transition from item responses to scored maturity outputs was not always sufficiently transparent to the participants.	Scoring explanations and reporting logic were revised to facilitate the translation of responses to capability-level outputs easier to follow.	These revisions were intended to improve the scoring transparency and support more interpretable reporting.
P4	Pilot application	Practical flow of application	Early applications suggested that assessment meetings could lose focus or become inefficient without a clearer process and structure.	A more explicit implementation procedure was incorporated to guide the preparation, assessment, review, and reporting.	This revision was intended to improve usability, meeting focus, and consistency of the facilitated deployment.
C1	Case utility demonstration	Interpretability of outputs	The case needed to show whether the artifact could produce more than one aggregate maturity label.	Capability-level reporting and visual outputs were used to differentiate maturity across the sub-dimensions and capabilities.	This application illustrates the artifact's ability to present heterogeneous maturity profiles across capabilities rather than a single undifferentiated score.
C2	Case utility demonstration	Target-setting usefulness	Without explicit target differentiation, maturity assessment risks defaulting to an unrealistic "maximum maturity" endpoint.	The reporting structure distinguished as-is, Target 1 (incremental), and Target 2 (management-defined aspirational target).	This revision was intended to strengthen managerial interpretability by separating near-term improvement needs from longer-horizon transformation intentions.
C3	Case utility demonstration	Actionability of diagnostics	Diagnostic outputs are needed to support concrete intervention discussions rather than descriptive reporting alone.	Capability gaps were linked to intervention areas such as training, automation/RPA, system integration, and remote-working support.	This application illustrates how diagnostic outputs can be translated into discussions of concrete intervention areas under facilitated conditions.
R1	Prioritization logic	Priority mapping transparency	The prioritization mechanism was conceptually understandable but not sufficiently explicit for replication from the main text.	The rule-based logic was clarified to show how the maturity stage and item criticality are translated into project priority values.	This revision was intended to improve formal transparency and strengthen the replicability of the prioritization step.

Table 3. *Cont.*

Ref. No	Evaluation Stage	Assessed Element	Issue/Problem Identified	Revision Made	Intended Refinement Contribution
R2	Dual-target logic	Decision role of targets	The distinction between an incremental next-stage target and a management-defined aspirational target remains unexplained.	The roles of Target 1 and Target 2 were clarified as different decision functions for near-term versus longer-horizon planning.	This revision was intended to improve decision support usefulness and reduce the tendency to treat maximum maturity as the default target.
R3	Roadmap sequencing	Dependency handling	Advanced initiatives risked being discussed before prerequisite capabilities were sufficiently developed.	Dependency-aware sequencing was emphasized during roadmap consolidation so that enabling conditions preceded more advanced initiatives.	This revision was intended to improve implementation feasibility and strengthen the coherence of sequenced roadmap actions.

Note: The categories in this table represent analytically derived refinement themes aligned with the study's design science, maturity model development, and utility-oriented evaluation logic. The table is not presented as evidence of comprehensive empirical testing or full psychometric validation; rather, it summarizes representative issues identified during expert review, pilot applications, case-based use, and assessment-to-roadmap translation, together with the revisions introduced and their intended contribution to initial validation, interpretability, traceability, and practical applicability under facilitated conditions. Ref. No. The codes indicate the stage from which the refinement evidence was derived: E = expert review, P = pilot application, C = case-based utility demonstration, and R = assessment-to-roadmap logic refinement. The summarized entries were derived from documented iterative expert discussions and refinement rounds in Section 3.2; pilot-based revision observations and expert-led review sessions in Section 4.4; and case-related assessment workshops, review meetings, maturity/roadmap outputs, and follow-up discussions in Section 6 and Appendix D. In addition, the entries were organized using a simple structured coding logic to make recurring refinement themes more explicit; this step was intended to improve the transparency of the refinement process rather than to claim formal qualitative coding validation.

To organize the refinement process more systematically, feedback from expert sessions, pilot applications, case-based utility use, and assessment-to-roadmap discussions were reviewed using a simple thematic coding logic. The observations were grouped under recurring themes such as content clarity, stage-definition ambiguity, structural coherence, scoring transparency, target-setting clarity, prioritization transparency, roadmap usability, practical applicability, and audit-related response issues. This grouping was used to improve the transparency and analytical traceability of the refinement process; it was not intended as a formal qualitative validation procedure or as a substitute for inter-rater reliability testing. Rather, it provided an additional way of organizing representative refinement observations and clarifying how iterative feedback informed revisions to item wording, stage definitions, scoring logic, target-setting interpretation, prioritization transparency, and roadmap usability under facilitated conditions.

Table 4 reports the lightweight inter-rater consistency and interpretability evidence obtained from the representative 24-item subset.

Table 4. Lightweight inter-rater consistency and interpretability evidence for a representative 24-item subset.

Metric	Result	Interpretation
Exact agreement	54.2%	Moderate exact score agreement across the two assessors
Adjacent agreement	100.0%	All disagreements remained within one adjacent maturity level
Mean absolute score difference	0.458	Average score deviation remained below half a maturity level
Quadratic weighted Cohen's kappa	0.607	Moderate weighted inter-rater agreement for ordinal maturity ratings
Linear weighted Cohen's kappa	0.426	More conservative agreement estimate; still indicates bounded disagreement
Rater 1 average interpretability	3.99/5	Generally favorable overall interpretability

Table 4. *Cont.*

Metric	Result	Interpretation
Rater 2 average interpretability	4.29/5	Generally favorable overall interpretability
Mean item clarity	4.54/5	Generally high item clarity
Mean level distinction clarity	3.94/5	Generally positive level differentiation, with some room for future refinement
Mean ease of justification	3.94/5	Scores were generally explainable and defensible

Note: The two-rater exercise was designed as a lightweight and bounded form of initial validation rather than as a comprehensive empirical testing or a full psychometric reliability study. Because the maturity ratings were ordinal (0–4), weighted Cohen's kappa was used to reflect the magnitude of disagreements between adjacent and more distant categories. The item subset was selected to preserve balanced coverage across Strategy, People, and Process, while reflecting the original architecture of DEMA.v1.

3.4. Construct Definition and Traceability

The constructs were derived from the literature and refined through expert input, in line with established maturity model development guidance [39,73,81]. Throughout the development logic, traceability was maintained from constructs to capabilities, from capabilities to staged assessment items, from item-level responses to gap profiles, and from gap profiles to prioritized actions. This traceability is central to the artifact's decision-support role because it enables interpretable outputs and supports action sequencing for purchasing stakeholders. This is further examined through a structured six-item diagnosis-to-roadmap check reported later in Section 6.4.

Figure 1 summarizes the overall DEMA research design and development procedure, showing how the study moves from problem identification and model assessment to refinement, case-based utility demonstration, and evaluation.

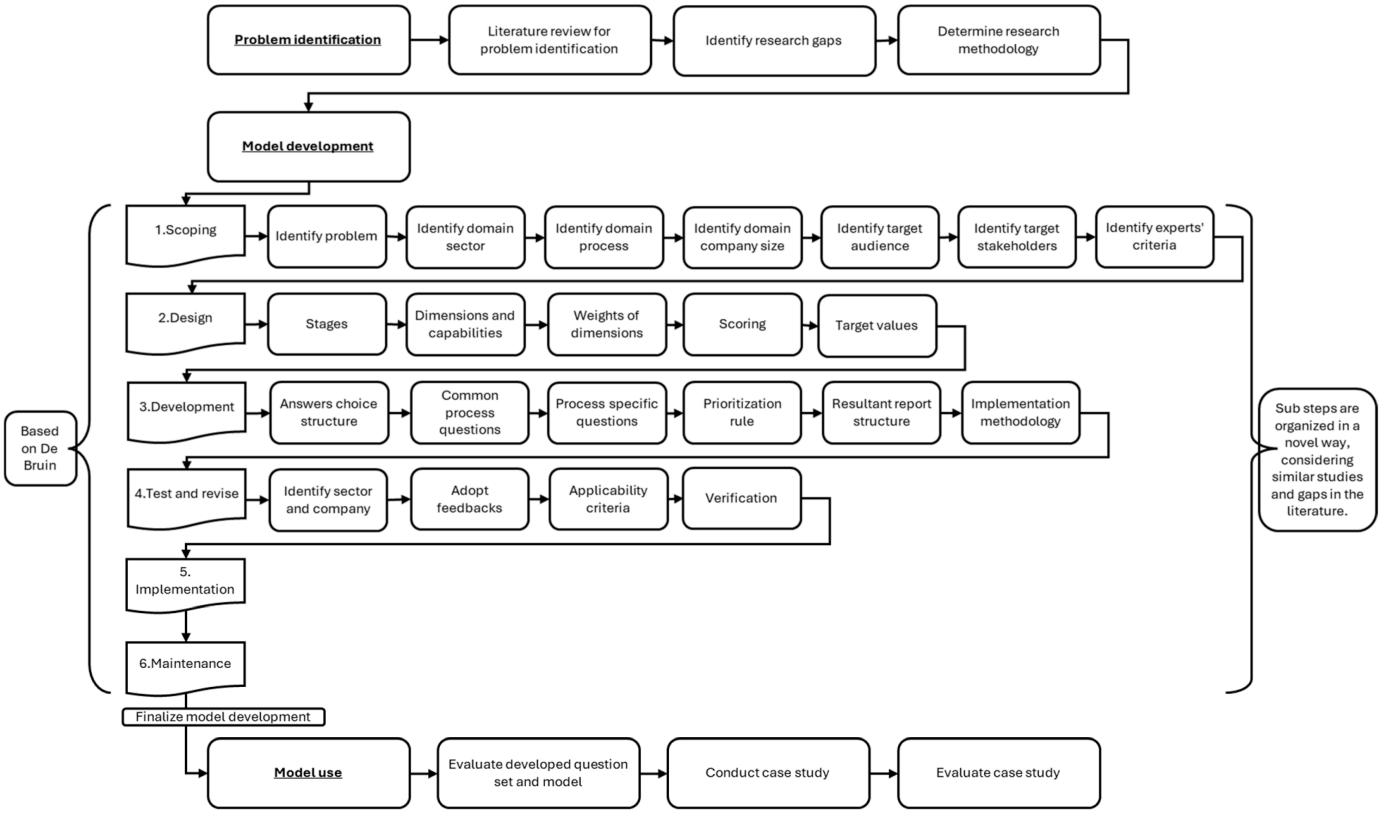


Figure 1. Replicable DEMA research design and development procedure.

4. DEMA Design and Development

In this study, DEMA refers to the broader architectural label, whereas the core artifact evaluated here is the Smart Business Processes component within that architecture. The broader architecture includes a second dimension, Digital Strategy & Infrastructure, but that dimension is retained only as a contextual layer and is not developed or evaluated empirically in this study. The focal artifact comprises a 70-item staged maturity grid, explicit scoring and prioritization logic, dual target setting, and a structured implementation methodology through which assessment results are translated into roadmap outputs. Accordingly, the artifact should be understood as a single assessment-and-roadmapping artifact whose maturity model, assessment, and decision-support functions are integrated rather than treated as separate constructs. Digital Strategy & Infrastructure remains a contextual architectural layer and is not empirically developed or validated in this study.

The DEMA was developed in line with design science research and maturity model development principles [39,71,73]. Throughout the development process, expert sessions repeatedly pointed to two practical barriers: the difficulty of translating abstract digital transformation and Industry 4.0 concepts into actionable purchasing practices [34], and the limited decision value of firm-level and technology-focused maturity scores for guiding concrete transformation priorities in purchasing [22]. In response, the DEMA was designed as a process-level artifact that links diagnosis to implementation-oriented actions.

4.1. Scoping: Domain and Stakeholders

Existing maturity models often provide limited support for purchasing because they operate at an aggregate organizational level and offer insufficient operational depth to heterogeneous subprocesses. Therefore, DEMA focuses on manufacturing settings and treats purchasing as a boundary-spanning and internally differentiated function. The artifact is primarily intended for SMEs, which often operate without fully formalized management systems or integrated digital strategies [82–84] while simultaneously facing substantial digitalization pressure [85]. The main user groups are researchers and purchasing professionals, which define the design boundaries of the artifact.

4.2. Design: Architecture, Stages, and Scoring Logic

The DEMA conceptualizes digital maturity as a staged capability progression [86]. To support interpretability and benchmarking, the artifact uses five maturity levels ranging from 0 to 4 [44,46,73,87–91]. The identification of dimensions began with a literature-derived pool of 307 candidate items, which was subsequently refined through expert input (Appendix A; Figure A1). This process resulted in a DEMA architecture with two dimensions relevant to the present study: (1) Digital Strategy & Infrastructure as an enabling contextual layer, and (2) Smart Business Processes as the focal operational component. The core artifact developed and evaluated in this study is the Smart Business Processes component. Digital Strategy & Infrastructure is retained only as a higher-level contextual layer and is neither operationalized as part of the core artifact nor empirically evaluated in this study. Within Smart Business Processes, three sub-dimensions are defined—Strategy, People, and Process—and each contains a set of capabilities assessed through staged items.

A central design decision was to treat digital maturity as a process-embedded capability rather than as an enterprise-wide average. Within the Smart Business Processes dimension, the sub-dimensions Strategy, People, and Process organize capability coverage at the purchasing-process level. Capabilities are treated as observable expressions of digital maturity and are assessed using items classified as either standard or process specific. In this design, the labels S and P refer only to the assessment item type, not to additional

dimensions or capabilities. Figure 2 presents the hierarchical structure of the Smart Business Processes dimension and distinguishes the sub-dimensions, capabilities, item-type coverage, and staged assessment logic.

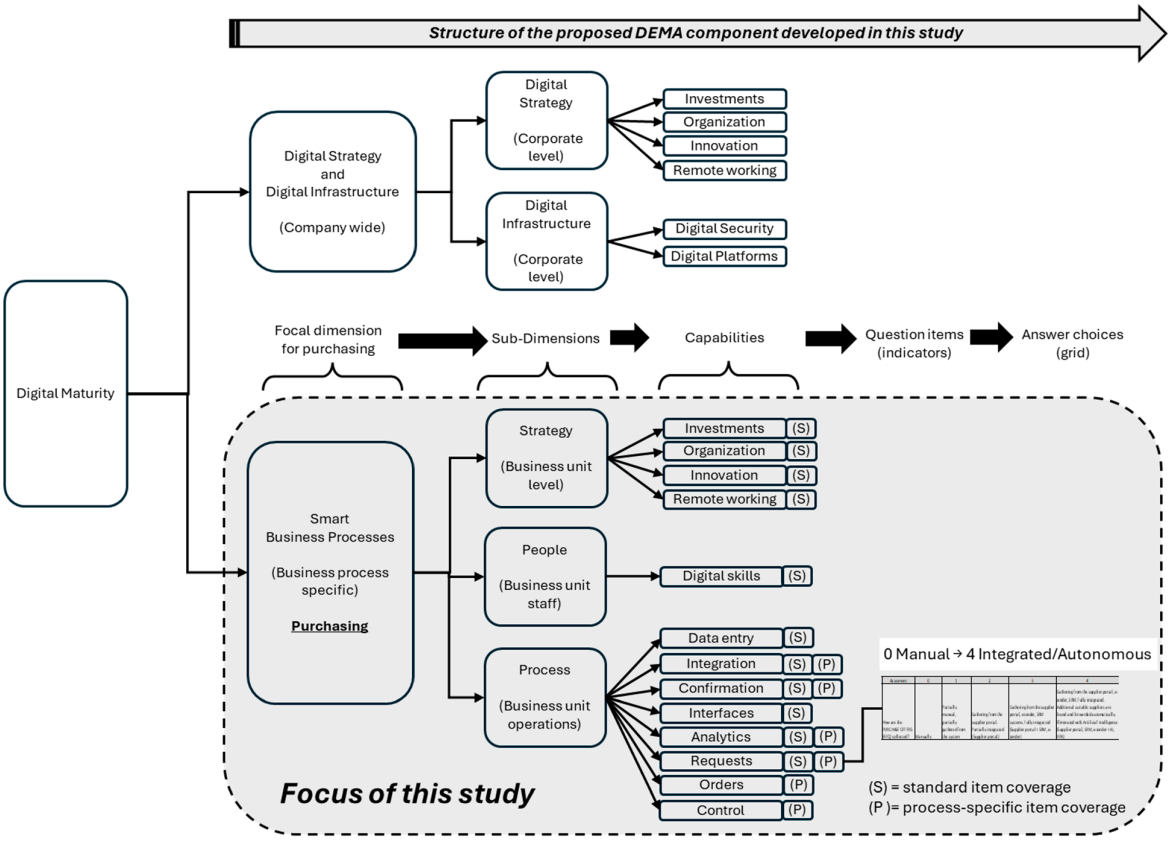


Figure 2. Hierarchical structure of the Smart Business Processes dimension in DEMA, showing sub-dimensions, capabilities, item-type coverage, and staged assessment logic for purchasing.

The broader DEMA architecture can accommodate hierarchical weighting schemes, where needed [46,92–94]. In the focal case application, however, equal weights were intentionally used to preserve the transparency, traceability, and replicability of the reporting logic under facilitated conditions. Therefore, the aim of this study is not to compare alternative weighting configurations but to demonstrate the artifact's assessment-to-action logic in a transparent manner. In addition, DEMA uses dual targets to avoid the implicit assumption that all organizations should immediately aim for the maximum maturity. Target 1 is defined as Current +1, whereas Target 2 is user-defined according to contextual ambition and feasibility [85,95].

The main computational steps underlying the scoring, target-setting, prioritization, and roadmap sequencing logic are summarized in Box 1.

Box 1. Simplified computational logic of DEMA scoring, targeting, and prioritization.

Step 1: Each item is scored on a staged ordinal scale ranging from 0 to 4. Step 2: Item scores are aggregated at the capability level using the predefined capability structure. Step 3: For each capability, the current score is compared with two targets: Target 1 (Current +1) and Target 2 (management-defined aspirational target). Step 4: Capability gaps are calculated as the distance between the current and target states. Step 5: Priority is determined through a rule-based combination of the assessed maturity stage and capability criticality, with dependency considerations incorporated during roadmap consolidation. Step 6: Prioritized capability gaps are translated into intervention areas and then consolidated into sequenced roadmap actions, such that the enabling conditions precede more advanced initiatives.

4.3. Development of the Assessment Instrument and Prioritization Logic

The DEMA applies a questionnaire-based self-assessment approach to support scalability and transparency [50,73]. A maturity-grid response structure was selected because it makes next-stage progression explicit, thereby facilitating translation from assessment outcomes to roadmap actions. The instrument includes optional firm data, digital experience information, and capability-specific staged items (Supplementary File S1). Across development iterations, the answer sets were refined through literature, expert review, and pilot feedback to capture execution patterns ranging from manual to increasingly integrated and automated operations [67,87]. Although informed by prior work [96], all items were redesigned to align with DEMA's assessment-to-action logic.

Technology cues are embedded within staged answer options as cognitive anchors that are intended to stabilize interpretation. Their role is illustrative rather than definitional; they indicate typical enablers associated with a stage, but maturity is not defined solely by the presence of particular tools. This distinction is important because the relationship between maturity and technology adoption may weaken for more complex technologies, cautioning against reducing maturity to tool presence alone [28].

The questions were classified as standard (S) or process-specific (P). These labels denote item types rather than dimensions or capabilities. Standard items capture cross-functional capabilities using purchasing-specific wording, whereas process-specific items provide a finer-grained coverage of purchasing subprocesses. Each question is also linked to one of the three sub-dimensions—Strategy, People, or Process—to support a structured analysis and roadmap generation. Unlike many existing models, DEMA fully discloses its assessment items; even when disclosure exists in prior work, items often remain generic [62,72,97].

Process-specific items were derived from an ERP cycle perspective [98–102] and then refined through expert input. The procedure maps ERP subprocesses to indicators, reformulates these indicators into staged assessment items, and specifies technology-aware response options (Appendix A). Therefore, the stages express maturity through increasing integration and automation rather than through technology presence in isolation.

Each item is linked to a defined capability and maturity stage (Supplementary File S1), which enables a granular gap analysis. The prioritization logic is implemented as a transparent rule-based mapping rather than an optimized mathematical solution. More specifically, two inputs were used as the first-order sequencing basis: (i) the item's assessed maturity stage (Score_stage, 0–4) and (ii) an ex ante item criticality rating defined during artifact development and refined through expert review (Priority, 1–3, where 1 denotes the highest criticality). These two inputs are mapped to a project priority value (Project_Priority, 1–9), such that lower maturity stages and higher criticality produce a higher roadmap priority. In this way, highly critical capabilities at relatively low maturity levels are brought forward in the sequencing logic, whereas less critical or more advanced capabilities receive lower immediate priorities. Dependency constraints are then considered during roadmap consolidation so that advanced initiatives are not scheduled before prerequisite capabilities, such as data governance and integration readiness, are sufficiently developed. For example, an item assessed at Score_stage = 2 and rated as Priority = 1 is mapped to Project_Priority = 1, indicating the highest immediate roadmap priority. Appendix B provides the corresponding priority matrix, rule-based pseudocode, and an illustrative example of the mapping logic. In simplified notation, the sequencing rule can be expressed as Project_Priority = f (Priority, Score_stage), where the mapping follows the rule matrix disclosed in Appendix B, rather than a continuous optimization function. This rule-based formalization is intended to make the prioritization step computationally transparent and replicable across various applications. Figure 3 summarizes the simplified logic from assessment and scoring to maturity gaps, prioritization, and roadmap actions.

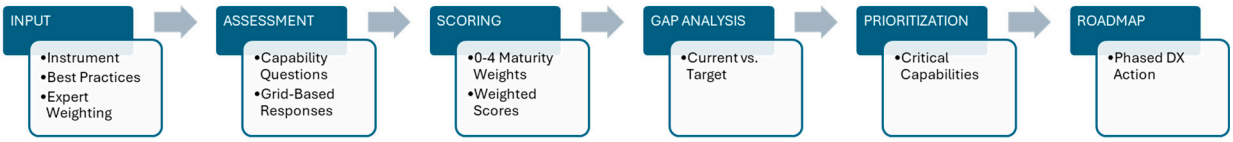


Figure 3. Simplified roadmap view of DEMA, showing the flow from assessment and scoring to maturity gaps, prioritization, and roadmap actions.

4.4. Test and Revision

Before the focal case-based utility demonstration, DEMA was applied to three anonymized electronics SMEs as pilot settings. All three firms were SMEs supplying larger manufacturers, and the applications were conducted with managers responsible for digitalization pilot programs in their respective organizations. The 70-item questionnaire was first shared for completion, after which expert-led sessions were used to review the responses, outputs, and application experience. These pilot applications were primarily used for refinement rather than broad validation. The revisions focused on question clarity, classification, scoring logic, and practical application flow. The findings were subsequently discussed with the firms to gather additional feedback on the structure and usability.

The refinement and review process was informed by the criteria proposed by [103]: completeness, simplicity, flexibility, integration, usability, implementability, and correctness. Given DEMA's prescriptive and decision-support role, the evaluation emphasized expert agreement, applicability, interpretability, and traceability rather than internal consistency metrics [72,97]. A "Consultant Comment" field was used to flag discrepancies between reported and observed practices; however, responses were retained as self-reported inputs for diagnostic purposes.

4.5. Implementation and Maintenance

Following the revision, DEMA.v1 is positioned for guided deployment in individual firms or industry clusters. Its implementation follows the structured methodology described in Appendix C (Figure A8), which is intended to support the consistent application and translation of assessment outputs into roadmap actions. The implementation methodology is treated here as a deployment layer within the broader DEMA architecture, while the roadmap is treated as an output of the focal assessment-and-prioritization process, rather than as a separate artifact category. It structures the application cycle from preparation and coordination to assessment, analysis, target-setting, reporting, and roadmap development. This layer was included because early applications indicated that without a predefined implementation procedure, assessment meetings could become inefficient, lose focus, or drift beyond the intended scope.

Because digital transformation conditions continue to evolve, the DEMA requires periodic updates to its questions, definitions, and scoring logic. Since digital maturity is frequently framed as a continuously evolving and never fully complete condition, periodic instrument revision and reassessment are inherent to the artifact's sustained usefulness [28]. Broader applications will provide further opportunities to refine these approaches.

5. Instrument Structure and Coverage

This section details the structure and coverage of the 70-item DEMA assessment instrument and shows how the hierarchical logic of the Smart Business Processes component is operationalized at the item level. The instrument is organized across three sub-dimensions: Strategy, People, and Process, each of which contains multiple capabilities assessed through staged items. In terms of scope, the instrument is the assessment interface of the focal Smart Business Processes component rather than the entirety of DEMA. Therefore,

the emphasis in this section is on instrument architecture and coverage rather than on organizational outcomes.

The 70-item instrument was not designed as a reflective psychometric scale intended to infer a latent construct through covariance-based item behavior. Instead, it is structured as a prescriptive, process-anchored maturity grid that makes staged capability expectations explicit at the purchasing-process level. The item set was developed through literature synthesis across digital maturity, Industry 4.0, and procurement digitalization research and was subsequently refined through iterative expert input. Full disclosure is used to increase the transparency of item content, staging logic, and capability linkage, thereby supporting scrutiny, reuse, and further development. Within this structure, standard items provide comparability across capability areas, whereas process-specific items provide the granularity required to capture heterogeneity across purchasing activities and sub-processes. Technology examples are embedded as illustrative anchors to reduce interpretive ambiguity rather than as mandatory conditions of maturity.

The instrument comprises 51 standard items and 19 process-specific items (see Figure 4). This distribution reflects a deliberate design trade-off between comparability and granularity. Standard items provide a common assessment backbone across capability areas, whereas process-specific items increase diagnostic sensitivity in subprocesses where purchasing maturity becomes visible in differentiated operational routines. The emphasis on the "Process" sub-dimension is intentional: 46 of the 70 items are linked to "Process" because digital maturity in purchasing is most directly observable in operational execution, while still requiring supporting coverage of strategy- and people-related capabilities. Figure 5 and Supplementary File S1 (Figure S2) summarize the capability-level coverage across the three sub-dimensions, including areas such as digital skills and analytics.

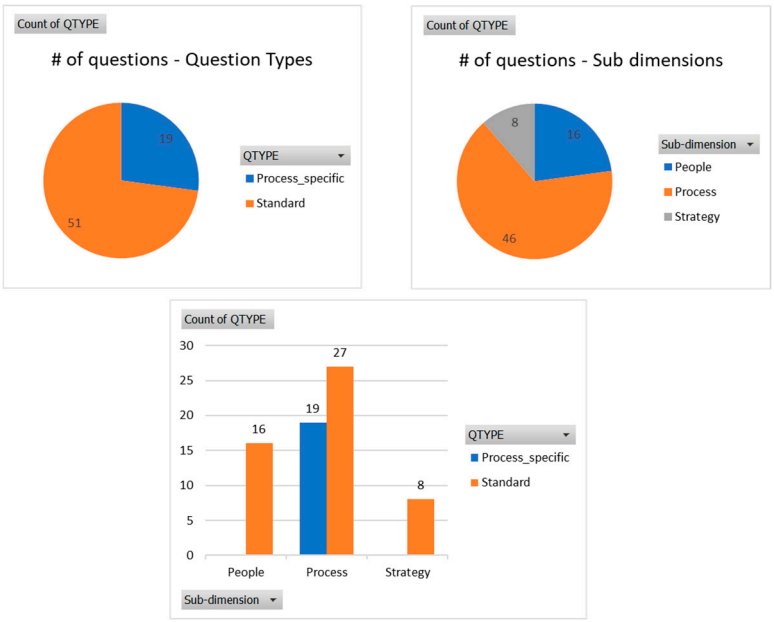


Figure 4. Distribution of assessment items by question type and sub-dimension in the DEMA instrument.

Each item is explicitly linked to a defined capability and maturity stage. This linkage addresses a recurring limitation in maturity model research, where assessment transparency often remains limited at the item and scoring levels. In DEMA, item-stage traceability is explicitly disclosed rather than being left implicit. Technology cues embedded in staged response options function as cognitive anchors that help to stabilize interpretation. References to ERP, automation, and analytics therefore illustrate typical enablers associated with particular maturity stages, but they do not constitute maturity by themselves.

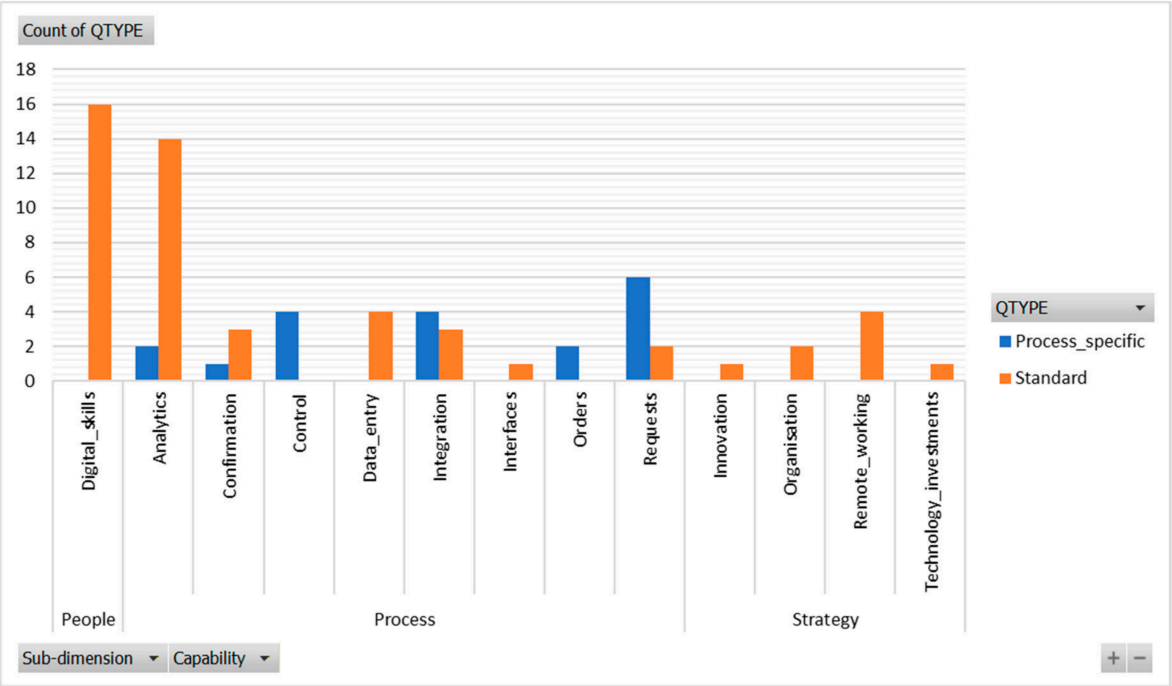


Figure 5. Capability-level coverage of the DEMA instrument across the Strategy, People, and Process sub-dimensions.

Table 5 provides sample item-to-capability mappings from Supplementary File S1 and illustrates how individual questions are connected to the capabilities and item types. This mapping is important because it shows that the instrument functions as a capability-structured assessment grid, in which standard and process-specific items jointly operationalize the Smart Business Processes component.

Table 5. Sample item-to-capability mapping from Supplementary File S1.

Supplementary File S1 Item (Q.)	Capability	Question (Short Form)	Type
Q25	Data Entry	How are incoming material controls and data entry performed?	Process-specific
Q58	Digital Skills	Do the employees in your unit receive sufficient IT training?	Standard
Q33	Analytics	How is supplier evaluation/risk scoring performed?	Process-specific

Overall, the instrument is aligned with DEMA's conceptual logic by providing systematic coverage across strategy-, people-, and process-related capabilities while keeping process execution at the center of the diagnosis. The disclosed structure also provides an analytical basis for the case-based utility demonstration presented in the following section, while a nested coverage view is provided in the Supplementary File (Figure S2).

6. Case Study Evaluation

This section evaluates the utility of DEMA through a case-based application in an electronics manufacturing SME that already used an ERP system but did not have a purchasing-specific digital transformation roadmap [104]. The case was selected purposively because it combined an existing ERP base with the absence of a purchasing-specific digital roadmap, making it suitable for examining DEMA's diagnostic and assessment-to-action utility under realistic SME conditions. The purpose of the case study is not to

establish broad statistical generalizability or claim comparative superiority over alternative maturity models. Rather, it serves as a utility demonstration showing how the artifact can be applied in a real purchasing setting and how assessment outputs can be translated into differentiated capability profiles, targets, priorities, and sequenced actions under favorable conditions. Broader comparative, multi-site, and multi-rater evaluations remain tasks for future research. Accordingly, the present evaluation is best understood as an initial validation within a design-oriented artifact-development context rather than as comprehensive empirical testing. Therefore, this section examines the bounded utility of the focal Smart Business Processes component of DEMA as a design science artifact under facilitated conditions.

6.1. Case Context and Data Collection

The case application was conducted with a cross-functional respondent team, including representatives from planning, IT, management, purchasing, and finance, coordinated by a project lead. Expert facilitation was used throughout the process to support the consistent interpretation of maturity stages and scoring and to align the assessment with both diagnostic consistency and organizational learning objectives [34].

Evidence for the case evaluation was drawn from assessment workshops, review meetings, and the resulting maturity and roadmap outputs. The focal case is not used here as a basis for statistical generalization, causal inference, or comparative superiority claims. Rather, it serves as a structured utility demonstration intended to examine whether the artifact can generate differentiated capability-level diagnoses, support dual-target interpretation, and translate assessment outputs into prioritized and sequenced roadmap actions under facilitated organizational conditions. The case is presented as a utility demonstration within facilitated assessment contexts, with an emphasis on interpretability, traceability from assessment to action, and managerial usefulness. To complement the focal case utility demonstration, this study also includes a bounded validation layer examining whether the same artifact logic yields reasonably consistent scoring and interpretable maturity-stage distinctions when applied independently by two assessors. This step was intended to strengthen the empirical support for facilitated interpretability, scoring consistency, and diagnosis-to-action plausibility without recasting the study as a large-sample validation exercise.

To make the case interpretation more transparent, Table 6 summarizes the main case evidence sources used in the focal application and the associated utility-oriented observations. The table is intended to make explicit how facilitated workshops, review meetings, scoring outputs, target comparisons, roadmap priorities, follow-up discussions, and related case materials inform the interpretation of the artifact's practical usefulness.

Table 6. Case evidence sources and utility-oriented observations.

Evidence Source	What It Was Used for	Utility-Oriented Focus	Utility-Oriented Interpretation
Assessment workshops	To support facilitated scoring, discussion of item meanings, and shared interpretation of maturity stages	Interpretability under facilitated conditions	The workshop format supported a more discussable reading of item-level results rather than treating maturity outputs as isolated numerical scores.
Facilitated assessment setting	To support item interpretation and reduce response ambiguity during application	Interpretive control and limitation awareness	The facilitated setting helped reduce ambiguity in the interpretation of items and scoring discussions. As with other maturity assessments that rely on structured self-reporting, some inaccuracies, incompleteness, or respondent bias may remain in the absence of full independent verification.

Table 6. *Cont.*

Evidence Source	What It Was Used for	Utility-Oriented Focus	Utility-Oriented Interpretation
Review meetings	To examine results after initial scoring and connect them to organizational priorities	Managerial usefulness	Review meetings helped translate diagnostic outputs into issues that managers could discuss concerning investments, skills, and process improvement priorities.
Cross-functional respondent team (planning, IT, management, purchasing, finance)	To bring multiple functional perspectives into the case application	Interpretive breadth	The cross-functional composition supported a broader reading of purchasing maturity beyond a single departmental perspective.
Capability-level scoring outputs	To identify whether maturity varied across capabilities rather than collapsing into one aggregate score	Diagnostic granularity	The case illustrated heterogeneous maturity profiles across capabilities, with stronger areas such as Interfaces and Orders and larger gaps in areas such as Data Entry, Remote Working, and Digital Skills.
Figure 6 (current state + Target 1 + Target 2)	To compare current maturity with incremental and aspirational targets	Target-setting usefulness	The comparison of as-is, Target 1, and Target 2 appears to support more differentiated planning by separating near-term development needs from longer-horizon aspiration levels.
Management-defined Target 2 setting	To avoid assuming maximum maturity as the automatic objective	Realism and feasibility of planning	The case illustrated that DEMA can accommodate realistic target definitions, as Target 2 was set around Levels 3 to 3.5 rather than defaulting to Level 4.
Appendix D, Figure A9/capability diagnostics	To interpret where stronger and weaker capability areas emerged	Capability diagnosis	The diagnostic outputs appear to support a more fine-grained identification of stronger and weaker purchasing capabilities.
Figure 7/priority-based roadmap inputs	To translate gaps into sequenced roadmap inputs	Prioritization usefulness	Priority mapping appears to have helped structure the roadmap discussion by distinguishing more urgent intervention areas from less immediate ones.
Appendix D, Figure A10/item-to-action examples	To show how item-stage responses connect to interventions	Traceability from assessment to action	Item-level examples, such as Q27 and Q59, illustrate how staged responses can be linked to concrete intervention logic, including automation- and training-related actions.
Table 7/capability gaps and priorities	To provide a concise overview of selected gaps and resulting priorities	Actionability of outputs	The summary of gaps and priorities appears to have supported an assessment-to-action reading of the artifact, rather than descriptive maturity reporting alone.
Follow-up discussions	To capture how managers interpreted and intended to use the outputs	Managerial interpretation and learning	Follow-up discussions suggested interest in digital tool budgeting, automation opportunities such as RPA, analytics and digital-literacy training, and stronger attention to data quality and integration issues.
Appendix D, Figure A12/proposed reassessment cycle	To consider how DEMA could be embedded into recurring planning routines	Repeatability and governance usefulness	The proposed reassessment cycle illustrates how artifacts might be integrated into periodic planning and capability-development routines, including possible biannual reassessment.

Because the focal application did not include independent verification of all item-level responses, some inaccuracies, incompleteness, or respondent bias may remain. Therefore, the case should be read as a structured utility demonstration under facilitated conditions. In practice, facilitated assessment use was complemented by review discussions and consultant comment fields to flag possible discrepancies between reported and observed practices.

In line with the evaluation logic introduced in Section 3.3 and the verification perspective discussed in Section 4.4, the case assessment focused on interpretability, traceability from assessment to action, implementation feasibility, and managerial usefulness in guided-application settings.

Although the broader DEMA architecture can accommodate hierarchical weighting schemes, equal weights were used in this study to maintain the transparency, traceability, and replicability of the reporting logic in guided application settings. Strategy, People, and Process were each assigned a weight of 1/3, and each leaf-level criterion was assigned a weight of 1/13. In this case, weighting served only to document aggregation in a transparent manner; it did not alter item-stage assignment, and no sensitivity claims were made about alternative weighting structures or their effect on substantive conclusions.

To complement the case-based evidence, a lightweight inter-rater consistency and interpretability check were also conducted. To provide minimal but direct validation evidence, a lightweight two-rater consistency exercise was conducted on a representative 24-item subset drawn from the focal DEMA.v1 assessment structure. The subset covered Strategy, People, and Process items and preserved the original architecture of the instrument, including the concentration of process-specific items within the Process subdimension.

The exact agreement between the two assessors was 54.2%, whereas the adjacent agreement reached 100%, indicating that all disagreements remained within one maturity level. The mean absolute score difference was 0.458. Because the ratings were ordinal, a weighted Cohen's kappa was also calculated. The quadratic weighted kappa was 0.607 and the linear weighted kappa was 0.426. Taken together, these results suggest bounded disagreement and a reasonably consistent interpretation of the staged maturity logic, rather than fundamentally divergent scoring.

The interpretability was systematically assessed, with generally positive results. Rater 1 and Rater 2's average interpretability scores were 3.99/5 and 4.29/5, respectively. Across both raters, the mean item clarity was 4.54/5, the mean clarity of level distinctions was 3.94/5, and the mean ease of score justification was 3.94/5. These results suggest that the assessment statements were generally understandable and usable, although some maturity stage boundaries may still benefit from further refinement in future multi-rater applications.

6.2. Maturity Results and Target Differentiation

The case results revealed clear heterogeneity in maturity levels across the capabilities. DEMA distinguishes between the current state (as-is) and two target states: Target 1, defined as an incremental improvement of the current +1, and Target 2, defined by management. The dual-target structure serves two different decision-making functions. Target 1 represents an incremental next-stage improvement anchored in the current assessed condition and is used to identify near-term capability-development needs. Target 2 is management-defined and reflects the organization's more ambitious but still context-sensitive aspiration levels. The comparison of as-is, Target 1, and Target 2 helps distinguish immediate improvement priorities from longer-horizon transformation objectives, instead of treating maximum maturity as the default target for all capabilities. Rather than treating maximum maturity as the default objective, the company set Target 2 at approximately Levels 3 to 3.5 based on feasibility and strategic intent. This result is important because it

illustrates that DEMA does not presume Level 4 to be a universal or automatic endpoint for all organizations [85,95]. Figure 6 summarizes the capability-level maturity profiles across sub-dimensions and shows how the current state assessment can be differentiated from incremental and aspirational targets.

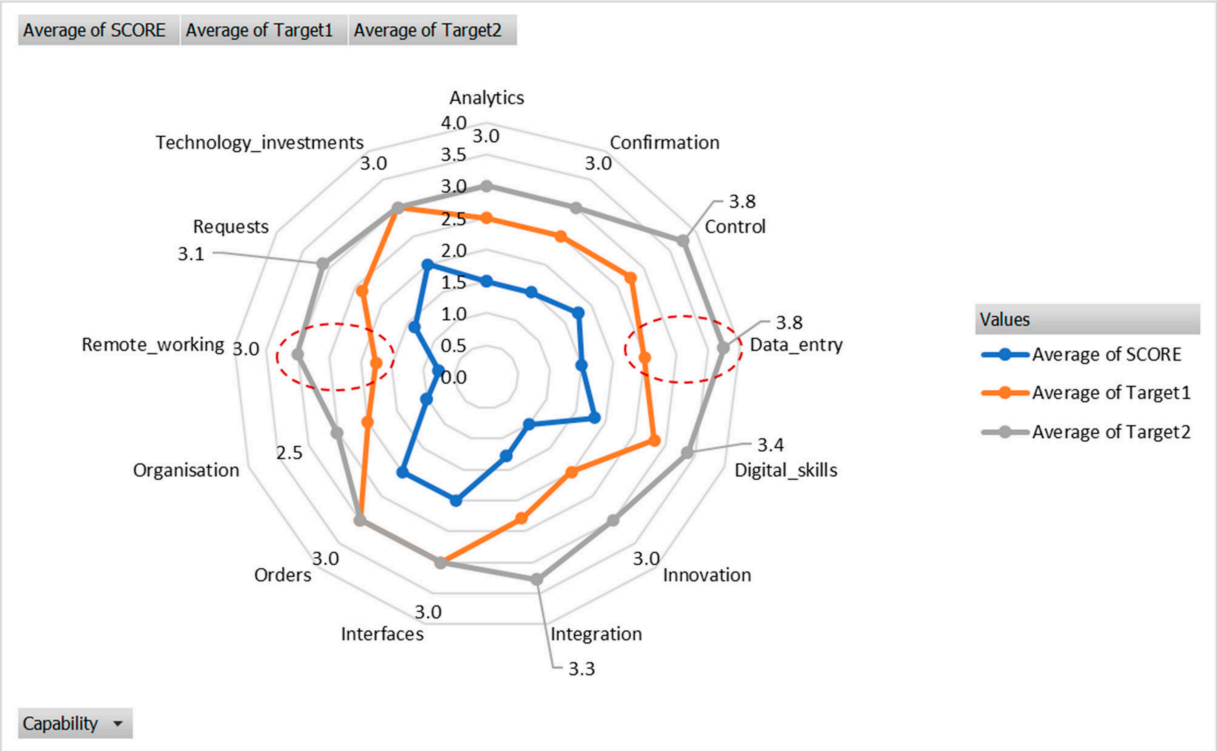


Figure 6. Capability-level maturity profiles for purchasing, comparing current scores with Target 1 and Target 2 across sub-dimensions. The circled areas highlight capabilities where the gap between Target 1 and Target 2 is particularly large, indicating that management's aspirational expectations exceed the incremental next-stage development path. In this case, Remote Working and Data Entry show the most visible Target 1–Target 2 gaps, suggesting areas where accelerated action may be required rather than relying only on gradual maturity progression.

The circled areas in Figure 6 indicate the capabilities with the largest gaps between Target 1 and Target 2, showing where management's aspirational expectations exceed the incremental next-stage improvement path.

6.3. Capability-Level Diagnostics and Gap Analysis

The diagnostic outputs showed substantial variations across capabilities (Appendix D, Figure A9). Relatively stronger areas included Interfaces, Orders, and Technology Investments, whereas more pronounced gaps were identified in Data Entry, Remote Working, and Digital Skills. Comparing the current scores with Target 1 and Target 2 helped distinguish incremental development needs from more substantial capability gaps. In practical terms, this differentiation directs attention toward concrete intervention areas such as training, automation initiatives, including RPA, and systems integration. At this stage, the value of the case lies in showing that the artifact can generate differentiated capability profiles rather than a single aggregated maturity label.

6.4. Prioritization and Roadmapping

The gap magnitude and capability criticality were combined to generate sequenced roadmap inputs (Figure 7). For example, an operational data-handling item (Q27) assessed

at Level 2 triggered an RPA-oriented action intended to support progression to the next stage, whereas a skills-related item (Q59) highlighted targeted training needs related to digital competence. These examples (Appendix D, Figure A10) illustrate traceability from staged item responses to capability gaps and intervention logic (For readability, Table 9 presents a concise summary of the selected capability gaps and resulting priorities that informed the roadmap formulation). In this sense, the contribution of the case is to demonstrate the assessment-to-action logic of the artifact in use rather than to claim a superior roadmap quality relative to alternative approaches.

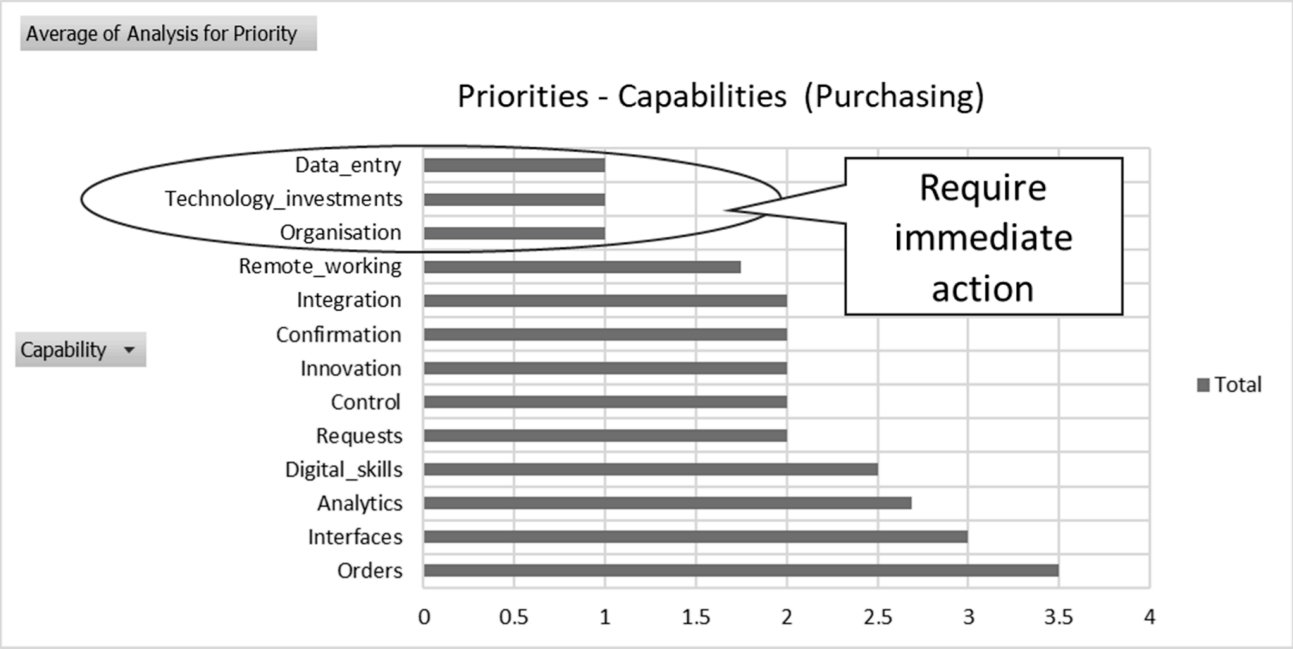


Figure 7. Priority-based roadmap inputs DEMA for purchasing capabilities, combining maturity gaps with criticality ratings, to support sequencing.

6.5. Managerial Interpretation and Use

Managers interpreted the maturity outputs not merely as descriptive scores but as structured inputs for alignment and investment discussions. According to the workshop and follow-up discussions, the staged structure was valued because it translated broad digital transformation ambitions into more concrete and discussable actions. Reported discussion areas included digital tool investment needs and budgeting, awareness of automation opportunities such as RPA, training needs in analytics and digital literacy, and stronger attention to data quality and integration through initiatives such as barcoding and EDI. Follow-up discussions also suggested interest in reapplying DEMA biannually and linking its outputs more closely to planning cycles (Appendix D, Figure A11). These observations should be interpreted as case-based indications of managerial usefulness and interpretive applicability under facilitated conditions, rather than as generalizable evidence of organizational impact or comparative effectiveness. Relative to broader firm-level maturity assessments, the case suggests that DEMA's added value lies in making capability-level differences explicit, linking them to differentiated targets, and structuring intervention sequencing in a way that is directly discussable to managerial decision-making.

Table 7 summarizes the evaluation focus, evidence sources and observed case outcomes. Because Figure 6 captures both capability-level heterogeneity and target differentiation, it serves as the main visual evidence for the diagnostic and planning value of the case application.

Table 7. Case-Based Evaluation Focus, Evidence Sources and Observed Outcomes.

Evaluation Focus	Evidence Source	Outcome Summary
Heterogeneity and target differentiation	Figure 6; Section 6.2	Capability-level comparison supported differentiated and feasible planning rather than a single uniform target
Capability diagnostics	Figure 6; Appendix D, Figure A9	The assessment revealed uneven maturity profiles across purchasing capabilities
Traceability from assessment to action	Appendix D, Figure A10	Item-stage responses could be translated into capability gaps and example actions (e.g., Q27: RPA-oriented intervention)
Roadmap sequencing	Figure 7; Appendix B	Prioritization logic supported sequencing based on gap magnitude and capability criticality
Replicability	Appendix C	Structured and repeatable implementation method
Instrument Transparency	Supplementary File S1	Full disclosure supports replication and interpretability
Process Anchoring	Appendix A	ERP-purchasing logic reinforced process-specific item design
Managerial interpretation under facilitated conditions	Assessment workshops; follow-up discussions; Section 6.5	Results were used as discussion inputs for investment, skills, automation, and data-quality priorities

Table 8 lists the diagnosis-to-roadmap traceability checks for the six DEMA.v1 items.

Compared with broader firm-level maturity assessments, the focal case suggests that DEMA is useful in making capability-level differences explicit, connecting them to differentiated targets, and structuring sequenced managerial interventions rather than leaving the output at the level of aggregate maturity description.

For interpretability, Table 9 presents a concise view of the case outputs in terms of capability gaps and priorities.

Table 8. Representative diagnosis-to-roadmap traceability checks for six DEMA.v1 items.

Item	Short Label	Current Level	Target Level	Gap	Priority Logic	Recommended Action	Sequencing Rationale	Expert Judgment
47	Digital investment budget	2	3	1	Foundational enabler of later digital initiatives.	Define a dedicated annual purchasing digital investment budget linked to roadmap priorities.	Early action supports later analytics, integration, and automation.	Plausible
53	Innovation support	1	2	1	Ad hoc innovation limits the repeatability and scaling.	Establish a simple idea-to-pilot pipeline with ownership and benefit reviews.	Short-term: ideally aligned with budget and governance routines.	Plausible
59	Employee analytics capability	2	3	1	High leverage for reporting, supplier evaluation, and data-driven decisions.	Introduce role-based analytics training and recurring business intelligence-supported decision routines.	Best implemented with reporting and data-quality improvements.	Plausible
1	Master data process	1	2	1	Foundational capability affecting automation, reporting, and integration quality.	Define data ownership, validation rules, workflow-supported maintenance, and periodic quality review.	High early priority is a prerequisite for later process digitization.	Plausible

Table 8. *Cont.*

Item	Short Label	Current Level	Target Level	Gap	Priority Logic	Recommended Action	Sequencing Rationale	Expert Judgment
16	End-to-end trackability	2	3	1	Visibility exists partially, but workflow-integrated tracking is still limited.	Implement workflow-integrated tracking with status visibility, alerts, and response ownership.	It should follow core data and governance improvements.	Plausible
27	Invoice verification	2	3	1	High-value transactional control points with quick efficiency and compliance benefits.	Extend toward workflow-integrated invoice processing with automated ingestion and exception routing to reduce manual work.	Short- to medium-term priorities once matching and workflow rules are clarified.	Plausible

Note: The table is not intended as evidence of a full-scale validation. Its purpose is to provide a structured and transparent examination of assessment-to-action traceability under facilitated case conditions.

Table 9. Capability gaps and priorities (Quick View).

Capability	Current	Target	Priority	Notes
Data Entry	1.2	3.0	High	Requires automation/RPA
Technology Investments	1.4	3.5	High	Digital tools budgeting needed
Remote Working	1.6	3.0	Medium–High	System access updates
Analytics	2.0	3.5	Medium	Data literacy training required

Consistent with maturity model research, the emphasis of the case-based evaluation was placed on decision support, interpretability, and transparency rather than on statistical model fit [39,46,67,72,105].

Relative to broad firm-level maturity assessments, the practical value of DEMA in the focal case lies in making capability differences across subprocesses explicit and therefore discussable in operational terms. Rather than producing a single maturity label, the artifact helped participants distinguish where improvement should begin, which gaps were foundational, which actions were feasible in the near term, and which initiatives depended on prior enabling conditions. In this sense, the case suggests that DEMA contributes less by offering another maturity vocabulary than by improving decision specificity, target realism, sequencing logic, and actionability for purchasing transformation.

7. Discussion

The study's contribution is not to test or extend a general theory of digital transformation but to clarify why maturity in purchasing may be more usefully interpreted at the process level when the managerial objective is capability-specific decision support. In this respect, the findings support an artifact-informed view of digital maturity as a staged process-level capability enactment shaped jointly by technologies, routines, skills, and governance conditions. Therefore, the contribution lies in clarifying the link between subprocess heterogeneity, capability alignment, and implementation-oriented maturity assessment, rather than claiming broad explanatory theory advancement.

The findings address a persistent challenge in digital transformation and Industry 4.0 practice: organizations often struggle to convert technology investments into sustained process-level value, especially in boundary-spanning functions, such as purchasing. The design results and case-based utility demonstration suggest that firm-level, technology-centered, or weakly disclosed maturity models provide limited support in settings where

maturity varies substantially across subprocesses, interfaces and role configurations. Under such conditions, aggregate maturity scores may conceal the operational variation that is most important for prioritization and sequencing.

From this perspective, DEMA treats procurement digitalization as a socio-technical change problem rather than as a technology-adoption problem alone. Digital tools create value only when they are supported by appropriate skills, governance routines, data practices and inter-organizational workflows. Therefore, the artifact is designed to support not only investment discussions but also capability development and coordination across the roles and interfaces that shape whether digital tools become routinized in purchasing practice.

The case-based evaluation indicates that a process-level, capability-based assessment can provide more actionable guidance than undifferentiated firm-level maturity scores in heterogeneous purchasing environments. More specifically, the results illustrate the value of moving from abstract maturity scoring toward an assessment-to-action logic in which diagnosis, target setting, prioritization, and sequenced implementation are explicitly connected. In this respect, DEMA appears most useful when embedded in a reassessment cycle that supports cumulative learning and capability development, rather than being treated as a one-off scoring exercise. The case also suggests that maturity in purchasing depends not only on technology availability but also on the alignment of digital strategy, process execution, and employee capabilities. These observations should be interpreted as artifact-informed and case-based rather than broadly generalizable causal claims.

7.1. Design-Oriented Implications: Digital Maturity as Process-Level Capability Alignment

This study clarifies digital maturity in purchasing as a process-level capability configuration involving three mutually related elements: organizational direction and enabling conditions, process execution, and people-enabled absorption and use of digital tools. In this sense, maturity is more usefully interpreted as staged capability enactment rather than technology possession alone. This reading is consistent with prior work that treats digital transformation as dependent on bundles of organizational capabilities rather than on isolated technology adoption. This interpretation should be read as a design-informed assessment lens for purchasing applications, rather than an empirically established causal proposition.

In boundary-spanning domains such as purchasing, this implies that maturity is unlikely to be represented adequately by a single, aggregate score. Here, subprocess heterogeneity refers to the uneven development of maturity across purchasing activities owing to differences in routines, data quality, integration conditions, digital skill levels, governance support, and contextual priorities. This helps explain why seemingly similar overall maturity positions may still require different improvement paths [28,37]. Subprocesses such as data handling, confirmations, supplier interaction, and analytics may evolve at different speeds and under different enabling conditions. Therefore, a process-level approach offers a higher analytical resolution and a more credible basis for selective managerial intervention. Because prioritization depends on identifying where capability gaps actually reside, this higher analytical resolution may provide a more credible basis for managerial decision-making than undifferentiated firm-level maturity scoring, especially when improvement recommendations must be tailored to strategic goals, core processes and operational constraints [37,38,69]. In this article, that point should be read as a design-oriented clarification derived from artifact design and case application rather than as a fully validated explanatory theory.

On this basis, three design-oriented conceptual implications can be cautiously drawn from the artifact logic and the focal application. First, misalignment between enabling conditions and process-level execution is likely to appear as implementation frictions and

uneven maturity across purchasing capabilities. Second, capability-level diagnostics appear more informative than firm-level scores in contexts characterized by strong subprocess heterogeneity because aggregate maturity assessments can mask variation across activities that are decisive for target setting, intervention sequencing, and tailoring improvement pathways [37,69]. Third, maturity gains are more likely to be sustained when staged targets are reinforced through training, governance routines, and periodic reassessment, rather than being treated as static score improvements. These implications were offered as design-informed interpretations derived from artifact development and application, any may be examined further in future studies.

Compared with broader organization-level maturity approaches, DEMA's contribution in the present study is not established through empirical superiority testing against a baseline model, which remains for future comparative research, but through greater decision specificity in its application. In the focal case, this meant differentiating capability gaps across subprocesses, linking them to explicit targets, and sequencing actions based on feasibility and dependency. Therefore, this comparative value should be interpreted as an application-oriented advantage in transparency and actionability rather than a claim of universal superiority over all alternative maturity frameworks.

7.2. Contributions to Research and Practice

The contributions of this study can be grouped into three related areas: conceptual clarification, artifact design, and implementation support. Table 10 summarizes these contributions to research and practice.

Table 10. Summary of the main contributions across conceptual clarification, artifact design, and practice.

Contribution Cluster	Design-Oriented/Artifact-Level Contribution	Practical Contribution
Conceptual clarification	Reframes digital maturity in purchasing as process-level capability alignment across enabling conditions, process execution, and people-enabled use of digital tools, thereby shifting attention from aggregate firm-level scoring toward implementation-oriented capability diagnosis	Supports diagnosis beyond firm-wide maturity averages by revealing capability differences across purchasing activities
Artifact contribution	Develops a fully disclosed, process-specific maturity instrument with staged capability logic	Provides an interpretable assessment tool for purchasing managers and researchers
Implementation contribution	Links maturity assessment to dual targets, dependency-aware prioritization, and sequenced roadmap development	Supports feasible transformation planning, action prioritization, and reassessment cycles under resource constraints

Taken together, these contributions position DEMA as a transparent assessment-to-action artifact for purchasing transformation, rather than as a scoring framework alone. Its staged responses express capability progression without reducing maturity to technology presence, and the prioritization structure supports a traceable movement from assessment outputs to roadmap actions. The dual-target logic further enables context-sensitive planning by avoiding the assumption that all firms should pursue the same, immediate maturity endpoint.

Therefore, the main contribution of this study lies not in formal theory advancement, but in developing and demonstrating a bounded design-oriented artifact for structuring, assessing, and using purchasing digital maturity in diagnosis-to-action support. Accordingly,

this manuscript should not be read as an empirical validation or extension of a general digital maturity theory. Instead, artifact development and application show the practical value of using a process-level approach when heterogeneous purchasing subprocesses require differentiated diagnosis and prioritization. In this sense, the study contributes a design-oriented assessment perspective in which digital maturity in purchasing is operationalized as a staged process-level capability enactment supported by organizational and technological enablers. Relative to broader and less transparent maturity approaches, DEMA's main comparative advantage in the present study lies in combining purchasing specificity, explicit scoring logic, and assessment-to-action support within a deployable artifact.

Therefore, its contribution is best understood as a transparent and practice-oriented design artifact for purchasing assessment and roadmap support, rather than as a theory-advancing study.

7.3. Boundary Conditions and Transferability

The present study should also be interpreted within clear boundary conditions. DEMA was developed for purchasing and evaluated through a limited set of pilots and one focal case-based utility demonstration. Its structural logic may be adaptable to related domains, but such transfer should be treated as a design proposition rather than an empirically established result.

More broadly, the artifact is informed by perspectives that emphasize the joint importance of technological readiness, organizational capability development, and operational conditions. However, the present study was not designed to test or advance a formal explanatory framework. Its value lies in offering a transparent and implementation-oriented artifact that makes these interdependencies more visible in purchasing assessments and roadmap designs.

8. Conclusions and Future Research

This study introduced DEMA as a process-level digital maturity assessment and roadmapping artifact for purchasing. Rather than treating digital maturity as a single firm-wide score, this study develops an artifact that supports process-specific diagnosis, explicit prioritization, and sequenced transformation planning through a fully disclosed instrument. Across the design logic and case-based utility demonstration, the study suggests that purchasing maturity is more usefully assessed at the level of capabilities, activities, and subprocesses when the aim is to generate actionable guidance for transformation. In this respect, the contribution lies in emphasizing process specificity, methodological transparency, and assessment-to-action linkage in the digital transformation of purchasing.

Several limitations define the scope of this study's conclusions. First, the empirical evaluation is limited to three pilot applications used for refinement and one focal case-based utility demonstration, which constrains transferability across industries, firm sizes, and organizational settings. Second, the study relied on facilitated assessment use and self-reported inputs, although a consultant comment field was used to flag possible discrepancies between reported and observed practices. Third, although the study includes a lightweight two-rater consistency and interpretability check, this evidence should be read as a bounded form of initial validation rather than comprehensive empirical testing, large-sample psychometric validation, formal content-validity indexing, or comparative benchmarking against alternative maturity models. The added evidence strengthens confidence in facilitated interpretability and bounded scoring consistency; however, broader validation claims remain outside the scope of the present artifact development and utility demonstration stage. Fourth, the outputs of DEMA are likely to be more reliable where basic process definitions, data practices, and minimum system traceability are already in place;

in low-standardization settings, results should be interpreted as directional diagnostics rather than as precise benchmarks.

In addition, the study does not provide a side-by-side empirical application against an alternative maturity framework; therefore, any claims about DEMA's distinctive value remain analytical and application-oriented rather than experimentally demonstrated. Moreover, although DEMA is introduced as a broader two-layer architecture, the present study develops and evaluates only the Smart Business Processes component; Digital Strategy and Infrastructure remains a contextual architectural layer for future development rather than an empirically validated dimension in this study. These limitations point to several directions for future research. First, future applications can complement self-assessment with lightweight verification mechanisms, such as document checks, selected transaction reviews, or system-log-based evidence, to strengthen robustness without turning deployment into a full compliance exercise. Second, broader multisite and multirater applications are needed to examine whether the bounded consistency and interpretability evidence reported here remain stable across organizational settings, assessor profiles, and application modes. Third, comparative studies against alternative maturity models would help clarify the distinctive value and boundary conditions of the DEMA. Fourth, longitudinal research could examine how repeated assessments, capability development, and roadmap execution relate to organizational outcomes over time. Finally, the structured adaptation of the artifact to other process domains should be treated as a design proposition requiring separate empirical evaluation rather than as an already established result. Because the empirical application is limited to one facilitated case and no side-by-side baseline comparison was conducted, the findings should be interpreted as bounded evidence of utility rather than broadly generalizable evidence of comparative effectiveness. Therefore, the conceptual interpretation offered in this study should be read as bounded and application-oriented rather than as a formal theory advancement.

Accordingly, the broader DEMA structure should be read as the architectural umbrella of the study, whereas the empirical contribution of the present paper is confined to the Smart Business Processes artifact component, its assessment instrument, its prioritization logic, and its implementation methodology.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/systems14050532/s1, Figure S1: DEMA.v1 maturity levels (0–4) and scoring logic, from manual to integrated and autonomous operations; Table S1: Abbreviations used in S1.8; Table S2: Capability—Definition; Table S3: DEMA.v1 Purchasing Digital Maturity Assessment Grid; Figure S2: Nested view of item coverage across dimensions and capabilities in the DEMA.v1 instrument.

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Data Availability Statement: Data are contained within the article and Supplementary File S1. The full DEMA.v1 assessment instrument is provided as Supplementary File S1; case-related information is reported in anonymized and aggregated form in the manuscript.

Conflicts of Interest: The author declares no conflicts of interest.

Appendix A. Process-Specific Item Derivation Procedure

Appendix A summarizes the instrument design procedure. This appendix documents how process-specific purchasing items were derived from higher-level capability constructs through an ERP-cycle-based decomposition procedure. Its purpose is to make the derivation logic transparent rather than to claim formal validation of item quality.

Figure A1 illustrates the dimension reduction and consolidation procedure used to derive the DEMA.v1 structure from a literature-derived set, supported by expert refinement.

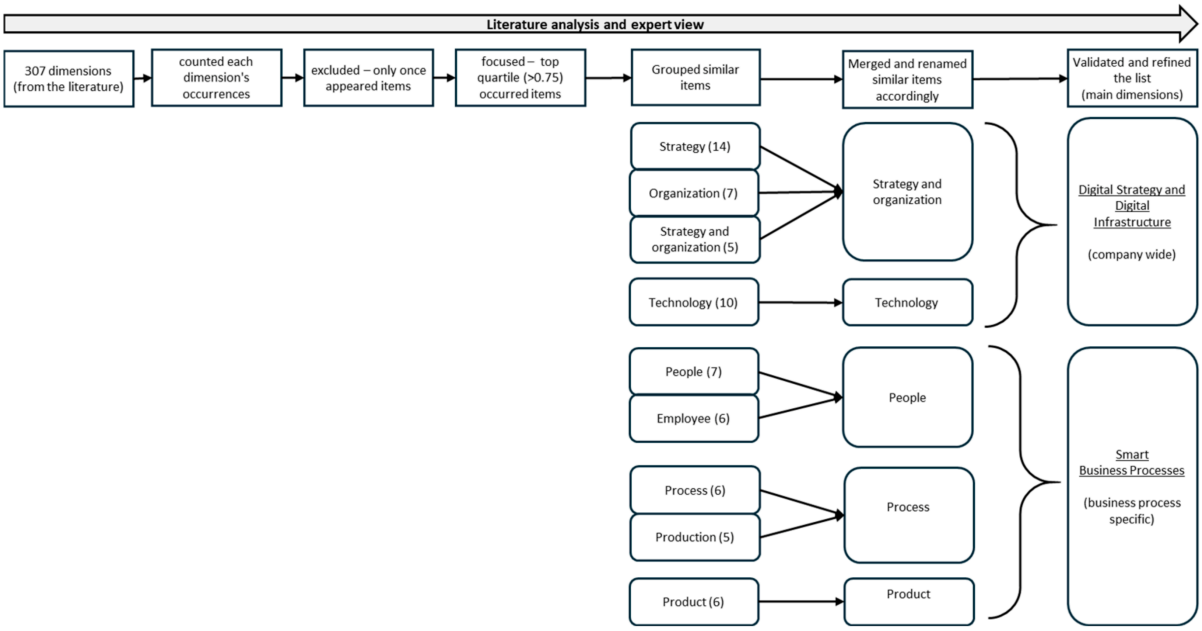


Figure A1. Dimension reduction and consolidation procedure used to derive the DEMA.v1 structure from a literature-derived set, supported by iterative expert refinement.

Figure A2 summarizes the instrument design procedure used to derive process-specific assessment items from business-process logic. The procedure follows four steps: (1) define a generic staged choice structure (0–4), (2) adapt high-level, capability-oriented questions to a focal business process, (3) represent the detailed process as observable activities, and (4) convert best-practice activity requirements into 'process-specific' staged items. This workflow is intentionally designed to be reusable across functions by changing the underlying process map while preserving the choice structure.

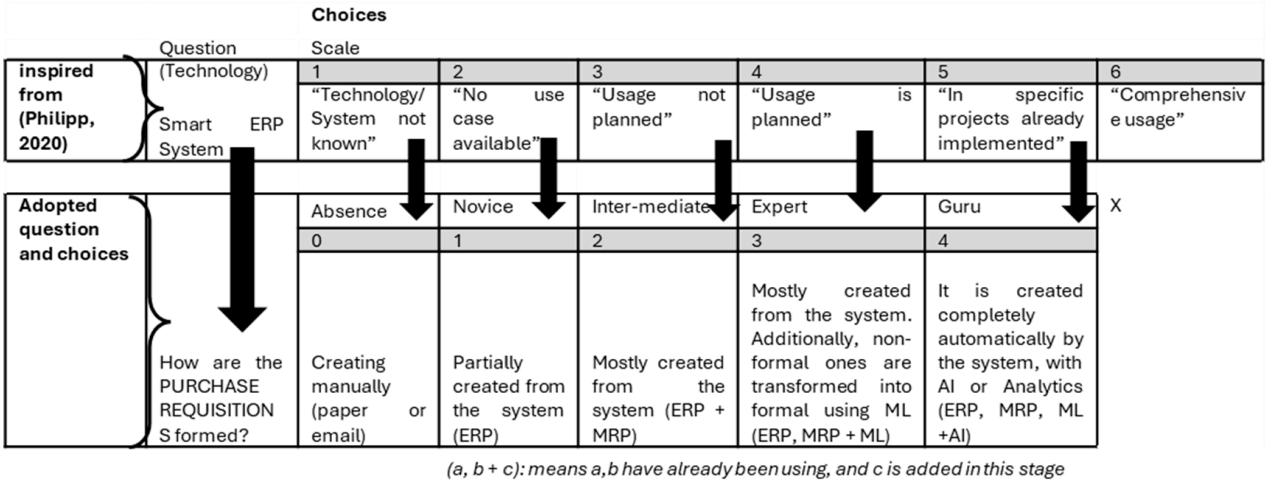


Figure A2. Reusable staged choice structure for converting high-level capabilities into process-specific assessment items.

Figure A3 defines the invariant staged answer logic used across all items and shows how generic capability questions are contextualized to a specific process without changing the staging logic.

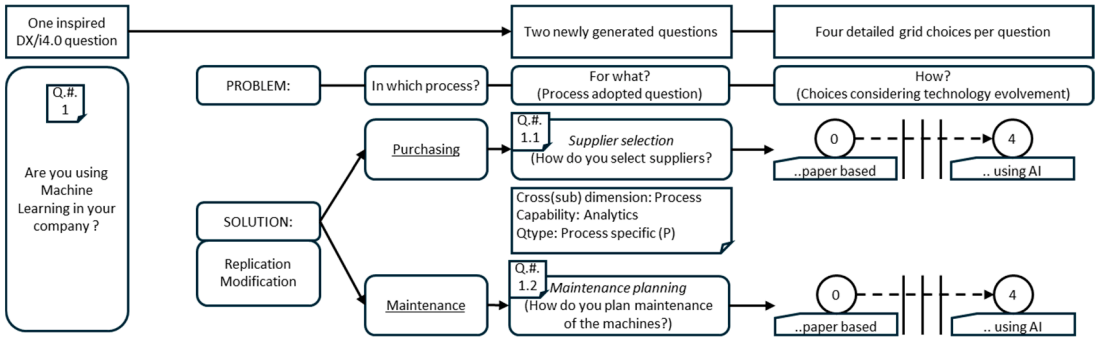


Figure A3. Adapting high-level questions for specific business processes (adoptable for different processes).

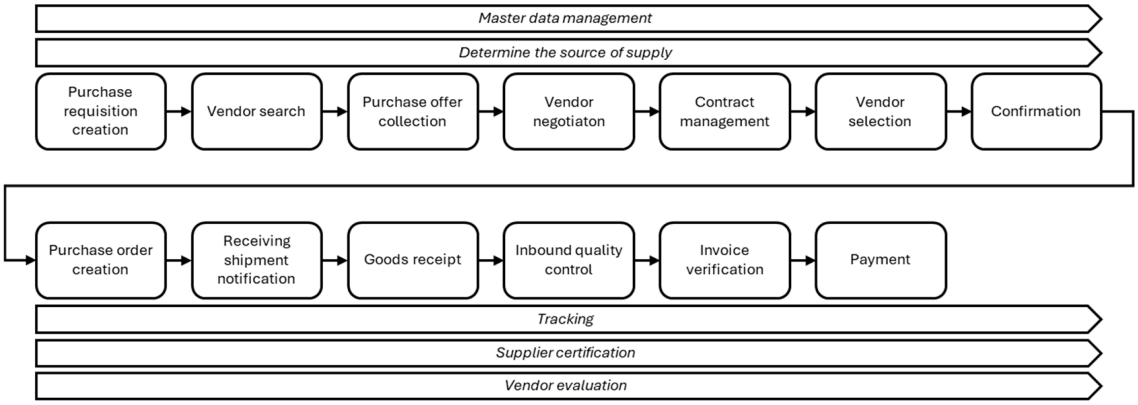


Figure A4. Detailed procurement process decomposition used to anchor observable activities. Adapted from Magal and Word (2011) [102].

Provides the procurement process decomposition used to anchor observable activities.

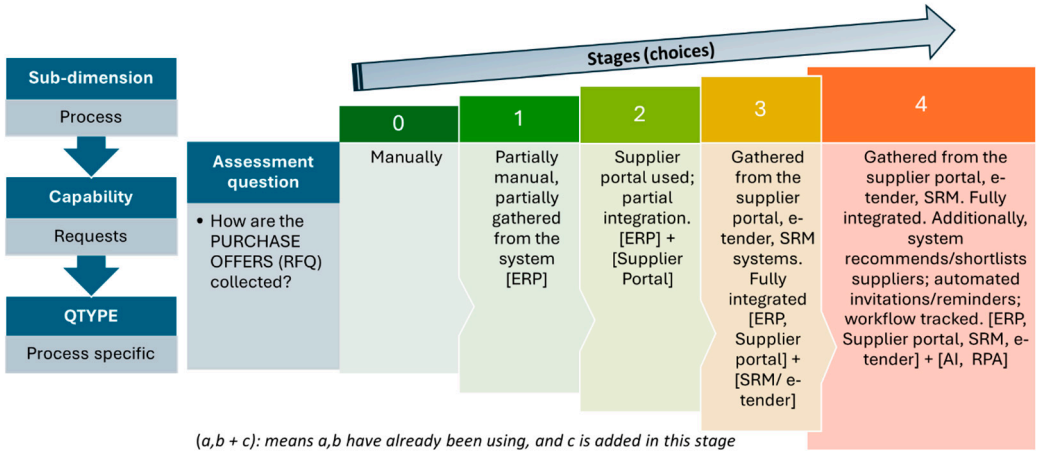


Figure A5. Conversion of best-practice requirements into process-specific staged items for the purchasing process.

Illustrates the conversion of best-practice requirements into process-specific staged items and technology cues.

Appendix B. Prioritization Logic: Priority Mapping for Roadmap Sequencing

This appendix discloses the prioritization mechanism used to translate item-level maturity results into a sequenced roadmap input. The prioritization logic is intended as

a transparent decision-support rule for sequencing action areas; it is not presented as an optimized mathematical solution. The logic combines two inputs: (i) the item score stage (*Score_stage*, 0–4) obtained from the respondent's staged answer option, and (ii) an artifact-level item criticality rating defined during development and refined through expert review (*Priority*, 1–3). These inputs are mapped to a **project priority number** (*Project_Priority*, 1–9) using the priority matrix shown in Figure A6. The resulting project priority number is used as an ordering input for roadmapping: lower maturity stages and higher criticality yield higher roadmap priority.

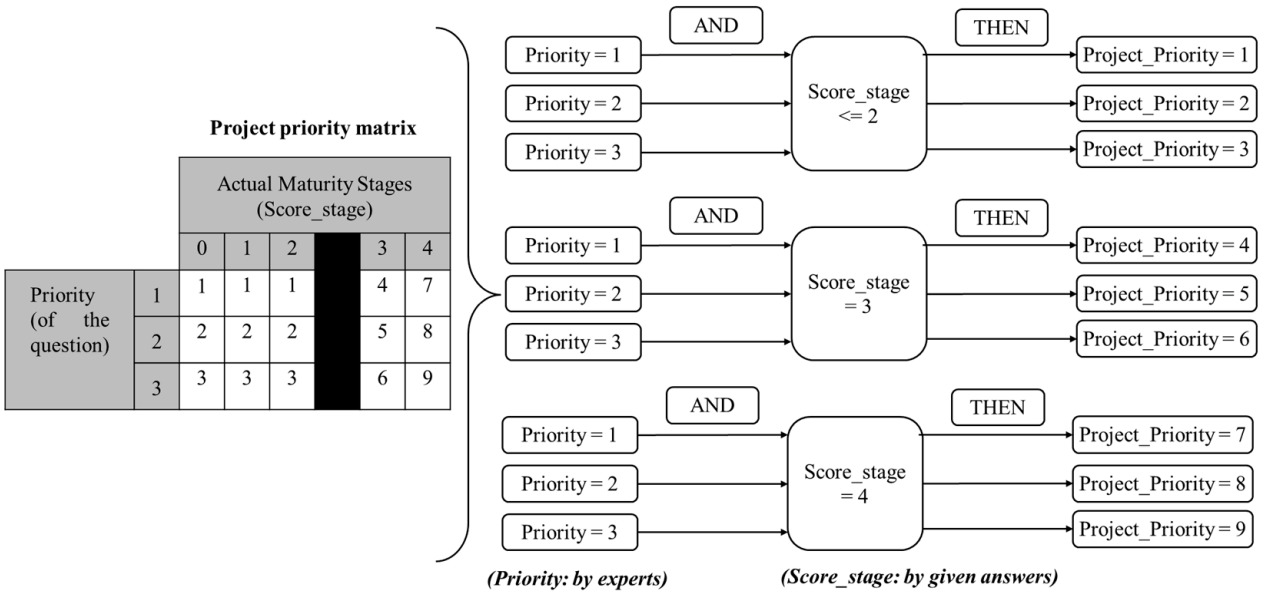


Figure A6. Project priority matrix and rule-based implementation (pseudocode).

Dependency constraints are handled during roadmap consolidation to prevent advanced actions from preceding prerequisites; Figure A6 reports the core priority mapping used as the first-order sequencing input.

Score_stage is the maturity stage assigned by the selected answer option (0–4). *Priority* (*by experts*) is an ex-ante criticality rating (1 = highest criticality; 3 = lowest). The matrix maps (*Priority, Score_stage*) pairs to *Project_Priority* values (1–9), such that lower score stages and higher criticality produce higher roadmap priority. The IF–THEN blocks provide an equivalent rule-based representation for implementation. *Project_Priority* is used for sequencing actions and does not alter the underlying item-stage assessment.

Example: if an item is rated *Priority* = 1 and assessed at *Score_stage* = 2, the mapping assigns *Project_Priority* = 1 (highest roadmap priority).

Appendix C. Implementation Methodology and Cycle (DEMA.v1)

Appendix C.1. Integration of Development and Implementation Logic

To strengthen the procedural logic of DEMA.v1 implementation, Figure A7 summarizes the structured application cycle from preparation and assessment to analysis, target setting, and roadmap development.

Figure A8 summarizes the end-to-end implementation cycle of DEMA.v1, from initial coordination to reporting and roadmap presentation. The cycle is designed to support consistent execution across firms while allowing controlled, documented tailoring only where strictly necessary for scope fit and interpretability. Controlled tailoring is included to preserve comparability while allowing limited adaptation to organizational terminology and process context. The implementation steps and indicative timings presented in this

appendix are illustrative and intended to support consistent deployment of the artifact. They should not be interpreted as a fixed consulting prescription for all settings.

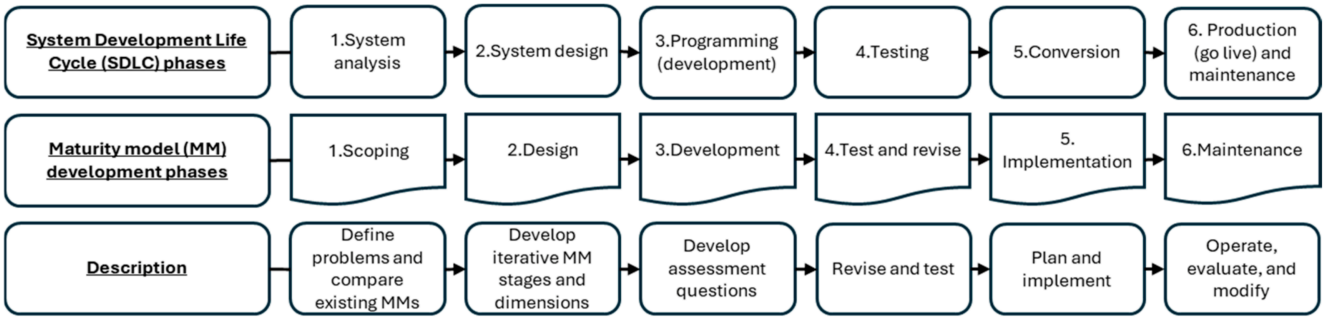


Figure A7. Integration of maturity model development stages [73] and SDLC logic in the DEMA.v1 framework.

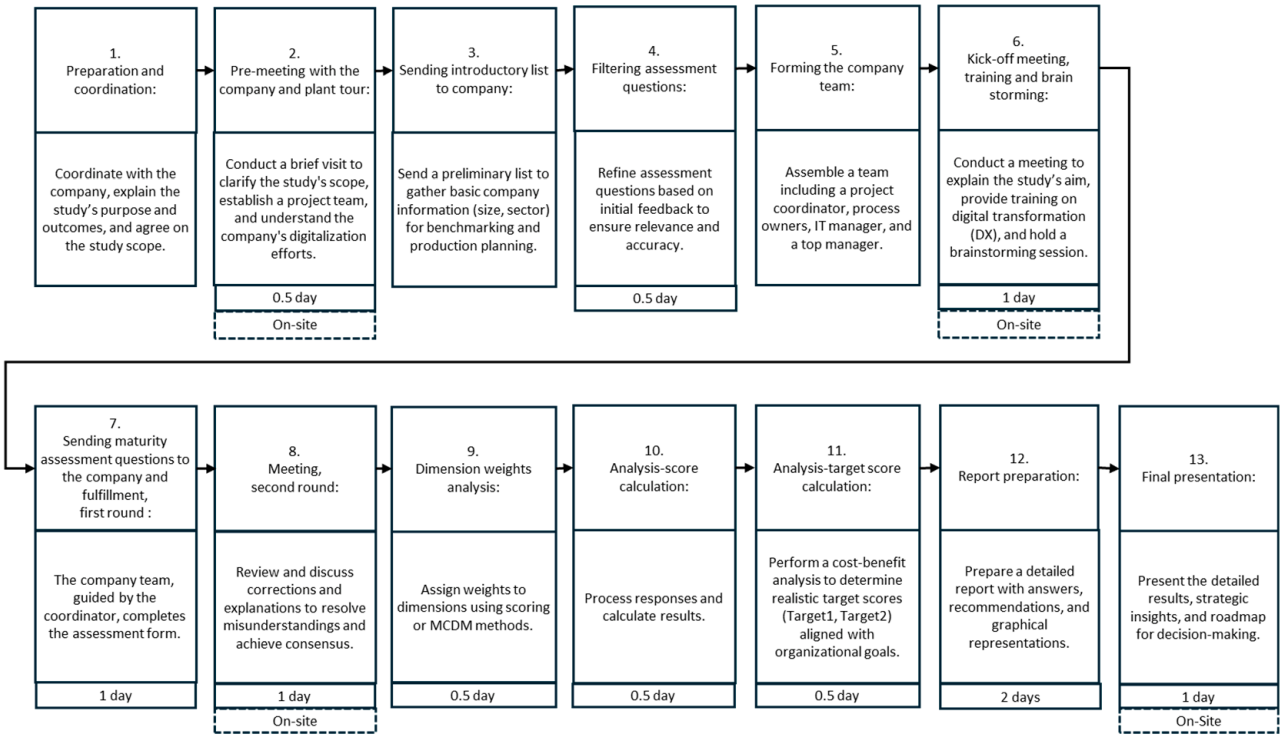


Figure A8. End-to-end implementation methodology for DEMA.v1. with illustrative implementation timings.

Appendix C.2. Implementation Steps

Step 1. Preparation and coordination: Coordinate with the company to clarify objectives, expected outputs, scope boundaries, timing, and responsibilities. Confirm the assessment mode, confidentiality principles, and the internal coordinator role.

Step 2. Pre-meeting and plant tour (on-site, ~0.5 day): Conduct a short on-site visit to validate scope, communicate requirements to management, and request formation of the assessment team and appointment of a project coordinator. Use the plant tour to understand operating realities that may affect interpretation.

Step 3. Send introductory (pre-assessment) list: Send a short introductory list (firm profile variables such as size, sector, workload) to support contextual interpretation and prospective benchmarking. These inputs are collected for context and are not included in maturity scoring.

Step 4. Controlled tailoring of non-applicable items (optional, ~0.5 day): Where necessary, apply a **controlled tailoring** step only to remove clearly non-applicable items. The **standard core set remains fixed** across applications to preserve comparability. Tailoring is limited to: (i) process-specific items that are demonstrably out of scope for a given sector or purchasing setup, and (ii) clearly non-applicable best-practice variants. Any tailoring decision is documented (item ID, rationale, and scope note) to maintain traceability and enable consistent interpretation of results.

Step 5. Form the company team: Form a cross-functional team consisting of the project coordinator, process owners, the IT manager, and a top manager to ensure operational accuracy and managerial alignment.

Step 6. Kick-off meeting: training and calibration (on-site, total ~1 day): Conduct a kick-off session to establish a shared understanding of key concepts and relevant technologies so respondents interpret staged options consistently. This includes short training and a structured calibration discussion to reduce staging ambiguity.

Step 7. First-round completion (typically 1–2 days): Distribute the assessment for completion under the coordination of the project coordinator.

Step 8. Second-round consensus meeting (on-site, ~1 day): Review answers jointly (company team + facilitation team), resolve misunderstandings, and converge on consistent interpretation through discussion and corrections.

Step 9. Dimension weighting (analysis, ~0.5 day): Where weighing is applied, it may be used hierarchically across dimensions, sub-dimensions, capabilities, and items. However, weighting is optional and context-dependent; in the focal case reported in the manuscript, equal weights were used to preserve transparency of aggregation.

Step 10. Score calculation (analysis, ~0.5 day): Process item responses and compute maturity scores for sub-dimension and capability-level views.

Step 11. Target score calculation (analysis, ~0.5 day): Define Target 1 and Target 2 values and compute target profiles. Targets are set to avoid "maximum maturity by default" assumptions and should reflect feasibility and managerial intent, supported by cost–benefit considerations where available.

Step 12. Report preparation (~2 days): Prepare the final report including consolidated responses, maturity results, target comparisons, prioritized recommendations, and graphical representations. Add brief implementation notes where interpretation required calibration.

Step 13. Final presentation and roadmap workshop (on-site, ~1 day): Present results at dimension and item levels to support decision-making and translate priorities into a sequenced roadmap of projects and programs.

Appendix C.3. Outputs (Deliverables)

The implementation cycle produces (as applicable): **(1)** a cross-dimension and capability-level maturity profile (AS-IS), **(2)** target profiles (Target 1 and Target 2) and gap-to-target views, **(3)** an item/capability-level prioritized action list, and **(4)** a phased roadmap translating priorities into sequenced initiatives with brief scope notes and ownership suggestions.

Appendix D. Case Study Supplementary Results

This appendix provides supplementary case outputs related to utility, interpretability, and traceability in the focal application reported in Section 6 (Case Study). Specifically, it presents (1) the capability-level maturity profile used to diagnose heterogeneity, (2) item-level traceability examples linking staged responses to targets and solution cues, and (3) the proposed reassessment cycle discussed as a learning-oriented deployment option.

Appendix D.1. Sub-Dimension Maturity Results

Figure A9 visualizes sub-dimension maturity results for purchasing, comparing current scores with Target 1 and Target 2.

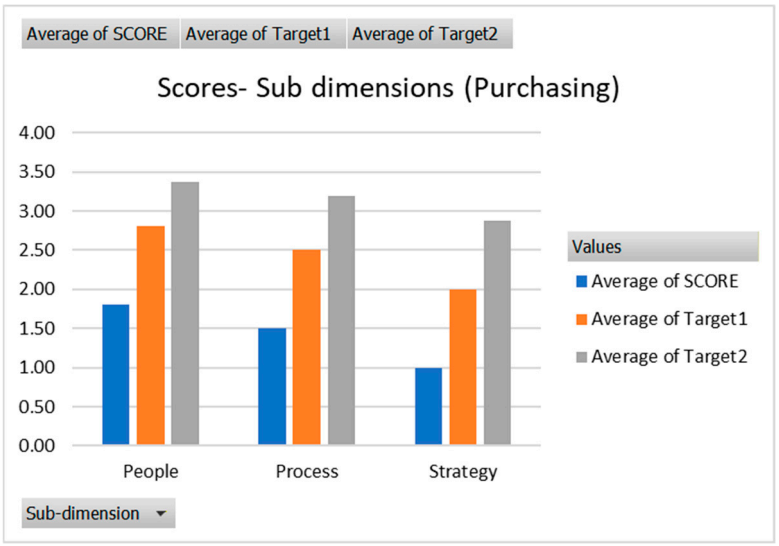


Figure A9. Sub-dimension maturity results for purchasing, comparing current scores with Target 1 and Target 2.

Appendix D.2. Capability-Level Maturity Profile Across Sub-Dimensions

Figure A10 visualizes maturity levels at the **capability level** across the purchasing sub-dimensions, supporting the finding that maturity is **heterogeneous** rather than uniform within a single function. This output complements the "capability-level insights and gap analysis" narrative in Section 6 by providing a consolidated view of capability strengths and gaps used for subsequent target-setting and prioritization.

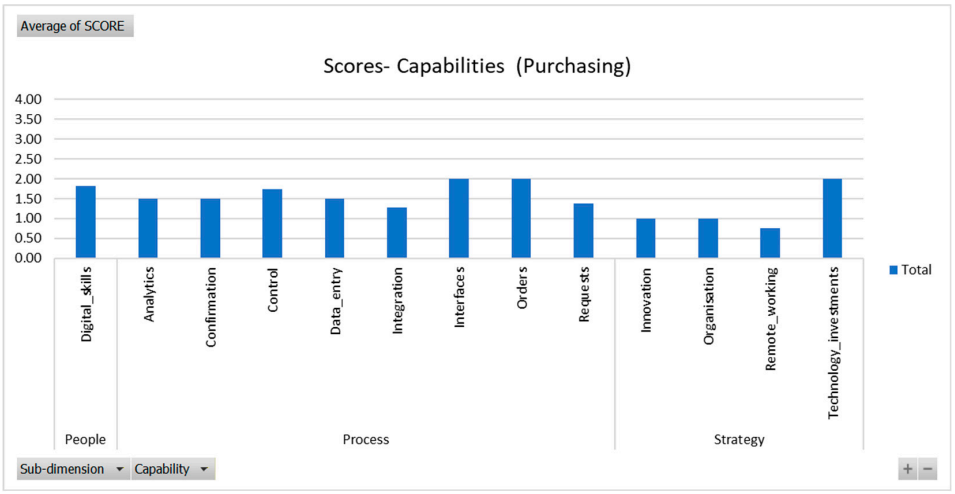


Figure A10. Capability-level maturity profile for purchasing across the Strategy, People, and Process sub-dimensions.

Figure A10 is intended as a diagnostic snapshot to (a) identify capabilities that are relatively advanced and can be leveraged as enablers, and (b) locate capability gaps that constrain process execution and should therefore be considered in the roadmap logic. The profile also supports the rationale for using capability-level diagnostics rather than relying on a single firm-level score.

Appendix D.3. Item-Level Traceability Examples (Staging, Targets, and Solution Cues)

Figure A11 provides exemplary item-level outputs illustrating how DEMA's staged answers are translated into **(1) an AS-IS stage**, **(2) Target 1 and Target 2**, and **(3) solution-oriented cues** that inform roadmap actions. This exhibit operationalizes the "assessment-to-action" logic by showing the traceable linkage from item wording and chosen stage to actionable requirements and intervention options.

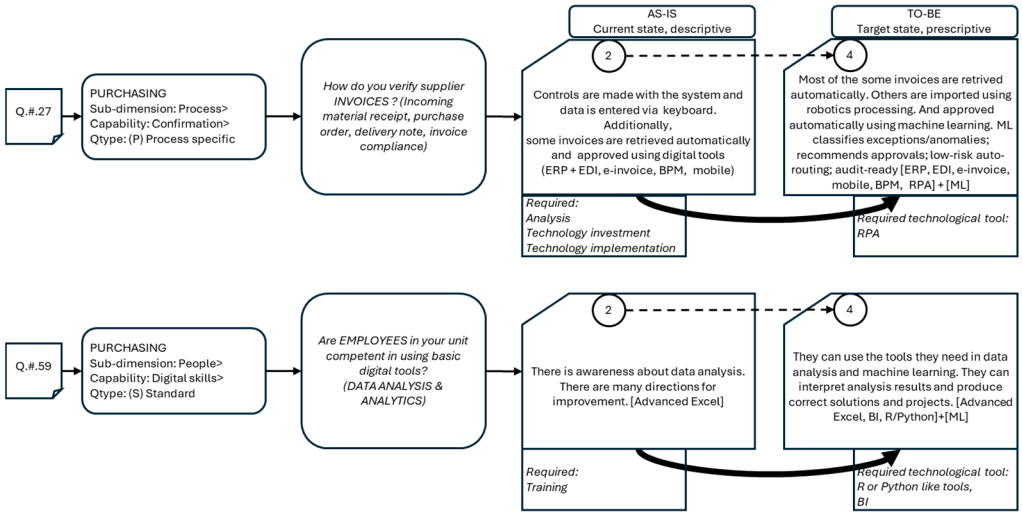


Figure A11. Illustrative example of how selected item-level responses were translated into capability gaps and corresponding action areas in the focal case.

In Figure A11, each example is meant to demonstrate the internal consistency of the staged logic: the selected maturity stage anchors the current capability condition, while the targets formalize the intended progression and enable prioritization and sequencing. The purpose is not to claim statistical measurement properties, but to demonstrate **interpretability and decision-support traceability** at the item level.

Appendix D.4. Proposed Implementation and Reassessment Cycle

Figure A12 outlines a proposed implementation cycle to support repeatable deployment and learning-oriented reassessment. It complements Appendix C's stepwise implementation methodology by emphasizing the role of periodic reassessment as part of capability development and roadmap governance. In the case study, this cycle was discussed as an option for institutionalizing DEMA within planning routines (e.g., biannual reassessment).

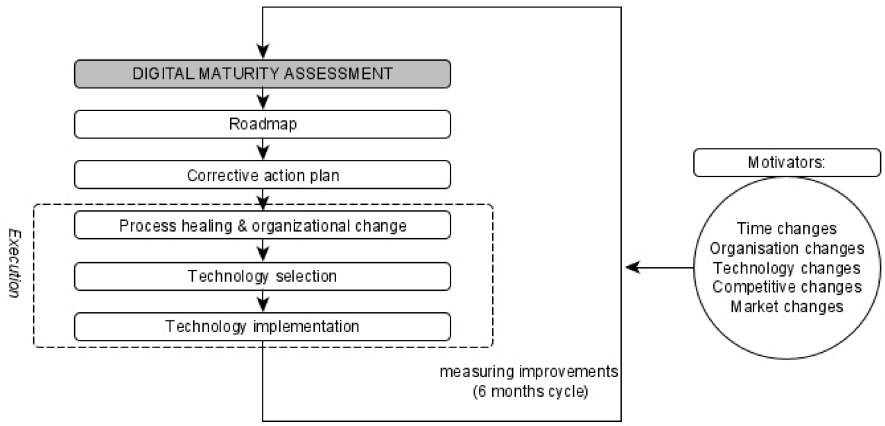


Figure A12. Proposed implementation and reassessment cycle.

In Figure A12 the cycle is intended as a practical governance frame showing how assessment, target-setting, roadmap execution, and reassessment can be integrated into recurring improvement routines.

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