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Managing operational alignment complexity: A recommender system approach

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ABSTRACT

Operational alignment, defined as the alignment between business processes (BPs) and information systems (ISs), is essential for ensuring that IS capabilities effectively support organizational operations. Despite extensive efforts, existing approaches to operational alignment remain constrained by a trade-off between simplicity and comprehensiveness. Coarse-grained methods overlook critical details, while fine-grained methods, though more precise, generate overwhelming complexity that impedes practical application. Drawing on complexity theory and systems thinking, this study conceptualizes operational alignment as a complex, nonlinear phenomenon characterized by emergent behaviors and intricate coevolutionary interactions among numerous detailed BP activities and IS tasks. While acknowledging dynamic/process complexity conceptually, this study targets the structural complexity at the BP-IS interface (i.e., the many-to-many mapping between BP activities and IS tasks) and operationalizes it through activity-task matching. To address structural complexity, this research proposes a novel operational alignment technique that balances abstraction and idealization through the logic of recommender systems (RSs). Using the Delphi method, the relationships between BPs and ISs, including the importance and performance of specific BP activities and IS tasks, were identified and used to parameterize an RS-based operational alignment technique. This technique manages structural complexity by defining alignment indicators derived from a fit-as-matching perspective, yielding pairwise BP-IS correspondences. The technique employs collaborative filtering to estimate missing values and prioritize high-impact alignment areas. It was empirically validated at Top Public Universities (TPUs) in the Middle East, where it generated actionable recommendations for aligning ISs with BPs and vice versa. Results from expert evaluations and a practical workshop confirmed the technique's usefulness, usability, and applicability, emphasizing its effectiveness in reducing structural complexity. By translating structural alignment complexity into actionable empirical solutions, this study contributes to design science research by providing a practical, theoretically grounded artifact that addresses operational alignment challenges, preserves alignment accuracy, and supports informed decision-making in dynamic organizational environments.

Introduction

Business-IS alignment has been a primary concern of information technology (IT) leaders since the early 1980s. To achieve business-IS alignment, we must realize alignment at both strategic and operational levels (Coltman et al., 2015; Kappelman et al., 2019, 2022). Strategic alignment refers to aligning information systems (ISs) strategies with business strategies and helps meet the future IS needs of the business. Conversely, operational alignment is the alignment of ISs and business processes (BPs) to ensure adequate support of the business requirements by the ISs (Chan and Reich, 2007; Liang et al., 2017; Zhou et al., 2018; Levstek et al., 2018; Ganji Bidmeshk et al., 2021). While strategic alignment focuses on the "external level" by answering "What should be done?", operational alignment is rooted in the "internal level" and addresses "How to perform activities?" (Henderson and Venkatraman, 1993; Chan and Reich, 2007; Gerow et al., 2016). As such, alignment is not achieved unless it is realized at strategic and operational levels (Henderson and Venkatraman, 1993; Kappelman et al., 2018; Renaud et al., 2016; Ganji Bidmeshk et al., 2022; Amarilli et al., 2023).

Existing approaches to achieving operational alignment typically fall

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into two broad categories: coarse-grained and fine-grained methods. Coarse-grained methods are predominantly abstract, overlooking specific drivers of operational alignment and intricate many-to-many interactions between BPs and ISs (Ciborra, 1997; Ciborra et al., 2000; Vermerris et al., 2014; Gerow et al., 2016; Zhang et al., 2019). Conversely, fine-grained methods offer detailed representations which, despite theoretical comprehensiveness, produce overwhelming complexity that impedes practical application (Gerow et al., 2016; Kaul et al., 2017). This structural complexity significantly challenges practitioners, obscuring clear and actionable guidance (Kaul et al., 2017; Njanka et al., 2021). Hence, bridging this gap demands an operational alignment approach that considers detailed BP-IS relationships, while simultaneously maintaining a high-level overview to ensure practical feasibility.

Operational alignment constitutes one facet of the broader business-IS alignment literature, which, viewed holistically, involves complex system evolution driven by interacting actors, nonlinear dynamics, emergent behaviors, and feedback loops (Amarilli et al., 2023; Zhang et al., 2021; Pelletier and Raymond, 2024; Taghavy et al., 2025). Although complexity theory highlights these dynamics and coevolutionary processes at strategic and systemic levels (Benbya and McKelvey, 2006; Tanriverdi et al., 2010), operational alignment studies have rarely incorporated such perspectives explicitly. Similarly, open innovation literature emphasizes managing complexity through bounded rationality, collective intelligence, and multi-actor collaboration across diverse contexts (Pyo et al., 2021; Turoń and Kubik, 2022). Within this literature, two complementary complexity lenses are salient. Dynamic/process complexity explains alignment as nonlinear, time-evolving interactions among heterogeneous actors with feedback and adaptation (Benbya and McKelvey, 2006; Haki et al., 2020). Structural complexity concerns the static yet dense configuration of interdependencies that must cohere at a decision point, namely, the many-to-many mapping between BP activities and IS tasks/capabilities (Beese et al., 2023; Xia and Lee, 2005). This study adopts the structural lens and operationalizes it through an activity-task matching perspective with defined alignment indicators, thereby rendering the BP-IS correspondence space tractable and prescriptive, and directly answering the calls articulated by Gerow et al. (2016) and Kaul et al. (2017) for actionable, detailed methodologies at the operational level. Dynamic/process complexity is acknowledged and handled pragmatically through iterative re-elicitation and re-application of the technique as conditions change; it is not explicitly modeled here.

Managing this structural complexity effectively necessitates balancing abstraction and idealization. Abstraction reduces complexity by selectively omitting or aggregating details, representing some aspects clearly while suppressing others (Kaul et al., 2017). However, abstraction alone cannot fully manage complexity. Complementing abstraction, idealization involves intentionally introducing simplifying assumptions, statements known as false, to enhance model practicality and operability (Woods and Rosales, 2010). Thus, abstraction simplifies complexity by omission, whereas idealization simplifies by intentional distortion or assumption (Kaul et al., 2017; Woods and Rosales, 2010). Achieving an optimal balance between abstraction and idealization is both scientifically and practically crucial. An imbalance can result in either overly abstracted or simplistic models lacking critical detail or excessively detailed models that hinder practical implementation. The consequences of failing to maintain this balance include significant implementation challenges, reduced alignment effectiveness, and diminished strategic value realization (Kaul et al., 2017; Wagner et al., 2014; Gerow et al., 2016). Scientifically, an imbalance between abstraction and idealization can either produce overly generalized theoretical frameworks lacking operational depth or overly detailed approaches impractical for real-world applications. Practically, such imbalance results in misalignment, hindering the effective implementation of IS solutions, reducing operational effectiveness, and ultimately limiting strategic value realization (Kaul et al., 2017; Gerow et al., 2016).

Given these considerations, and focusing on the structural complexity at the BP-IS interface, this research seeks to answer the following research question:

RQ. : How can abstraction and idealization be balanced to enable the practical and effective implementation of operational alignment in organizations?

Addressing this gap, we propose a novel operational alignment technique leveraging recommender system (RS) logic to manage information overload, tackle the structural complexity at the BP-IS interface, and systematically balance abstraction and idealization. Our RS-based approach integrates abstraction by selectively reducing unnecessary detail and idealization by intentionally simplifying assumptions, generating clear, actionable alignment recommendations. This provides practitioners with practical, directly implementable guidance to effectively navigate operational alignment complexity through intelligent filtering and prioritization.

To rigorously demonstrate the viability of this technique, empirical validation was conducted through Design Science Research (DSR), including structured Delphi panels and extensive practitioner evaluations within top public universities (TPUs). Results confirmed significant reductions in operational alignment complexity, improved decision-making efficiency, and strong practitioner endorsement of its feasibility. Theoretically, this research advances the alignment literature by empirically demonstrating how abstraction and idealization can be balanced, addressing a critical yet underexplored theoretical gap. Practically, it delivers an easily deployable decision-support tool for rapidly diagnosing and rectifying operational misalignments, explicitly defined by alignment indicators related to IS tasks, BP activities, and their relationships based on Venkatraman's (1989) matching perspective. Accordingly, we adopt the fit-as-matching perspective, supported by task-technology fit (Goodhue and Thompson, 1995) and enterprise-system fit/misfit research (Strong and Volkoff, 2010), as our guiding lens for operational-level alignment, where the core problem is to match specific BP activities with concrete IS tasks. Guided by this lens, a key innovation is repurposing mature RS logic, traditionally employed commercially for recommending products or services based on user preferences, to specifically address the identified alignment challenges.

Detailed methodological descriptions, comprehensive empirical results, and extended discussions are presented in subsequent sections. Specifically, Section 2 reviews the relevant literature and identifies existing research gaps. Section 3 details the structured research methodology and the development of the RS-based operational alignment technique. Section 4 provides extensive empirical findings, and Section 5 elaborates on theoretical contributions, practical implications, and directions for future research.

Related work

The literature on business-IS alignment is extensive, highlighting the critical distinction and relationship between strategic alignment, concerned with high-level integration of business and IS strategies, and operational alignment, focusing on detailed integration of BPs and ISs. To provide clarity and conceptual grounding, we first articulate the theoretical foundations distinguishing these two alignment types, identify the existing theoretical gap in operational alignment, and subsequently discuss practical approaches to achieving operational alignment in practice.

Theoretical foundations and the knowledge gap in alignment

Business-IS alignment literature distinguishes strategic from operational alignment, each differing significantly in theoretical maturity and practical implementation. Strategic alignment is characterized by the congruence of business strategy and IS strategy, ensuring IS supports organizational missions and goals (Chan and Reich, 2007; Broadbent et al., 1999; Henderson and Venkatraman, 1993; Luftman, 2003; Amarilli et al., 2023; Van de Wetering, 2021; Yoshikuni and Albertin, 2018; Pelletier and Raymond, 2024; Taghavy et al., 2025; Yeow et al., 2018). Chan and Reich (2007) define strategic alignment as the degree to which a company's mission, objectives, and plans are shared by its IS strategy. Broadbent et al. (1999) similarly describe it as the extent business strategies are enabled and supported by information strategy. Across definitions, strategic alignment is viewed as consistency among multiple domains, business strategy, IS strategy, organizational structure, and processes, to achieve coherence between business and IS.

Defined by Henderson and Venkatraman (1993), strategic alignment encompasses strategic fit and functional integration across four domains: business strategy, organizational infrastructure, IS strategy, and IS infrastructure, highlighting the need for coherence among them. Luftman (2000), (2003) further operationalized strategic alignment through maturity models and identified key enablers such as communication, governance, and skills, positioning alignment as central to organizational performance (Yoshikuni and Albertin, 2018; Amarilli et al., 2023; Van de Wetering, 2021). Recent studies show organizational performance is closely tied to business-IS alignment strategies tailored to the firm's industry context, enhancing resilience and value creation (Canhoto et al., 2021; Li and Chan, 2019; Sieber et al., 2022).

By contrast, operational alignment addresses detailed, day-to-day integration of BPs with IS functionalities, ensuring practical congruence between workflow requirements and IS capabilities. Operational alignment is achieved when BP requirements are tightly matched by IS capabilities in practice (Tallon et al., 2016; Coltman et al., 2015; Luftman et al., 2017; Wagner et al., 2014; Zhou et al., 2018; Bagheri et al., 2019). Despite its practical significance, operational alignment remains comparatively under-theorized, typically addressed as a managerial or technical implementation issue rather than a distinct conceptual domain. Existing literature often lacks dedicated theoretical frameworks, focusing primarily on managerial integration or methodologies for linking IS solutions to business needs, leaving a notable gap compared to the well-theorized strategic alignment domain (Cataldo et al., 2012; Rahimi et al., 2016; Teo and King, 1997; Őri and Szabó, 2024).

Venkatraman's (1989) typology distinguishes six perspectives of fit (i.e., moderation, mediation, matching, gestalts, profile deviation, and covariation) that have been widely used to conceptualize alignment. In the operational domain, the analytical focus is the pairwise correspondence between BP requirements and IS capabilities. This emphasis aligns with the matching perspective, which defines fit as a theoretically explicit correspondence between two commensurate domains (Cragg et al., 2002; Venkatraman, 1989). This micro-level correspondence view also aligns with established operational IS traditions (e.g., Task-Technology Fit; enterprise-system fit/misfit) (Goodhue and Thompson, 1995; Strong and Volkoff, 2010). Design viewpoints likewise stress aligning a system to its intended context (Chakravarthy, 1987). Framing operational alignment as the pairing of BP and IS functionalities provides a clear implementation criterion at the BP/IS interface, contrasting with the more abstract conceptualizations common in strategic alignment (Chan and Reich, 2007; Coltman et al., 2015).

Recognizing this theoretical distinction, we propose that operational alignment requires an approach explicitly grounded in matching logic, offering conceptual clarity currently underdeveloped within the literature. Such theoretical clarity is essential since strategic alignment models, while providing a broad vision, are not readily transformed into process/task-level tools, which limits their practical applicability (Chan and Reich, 2007; Coltman et al., 2015; Venkatraman, 1989). To clarify scope, we address structural alignment complexity by cohering the many-to-many interdependencies at the BP-IS interface (Beese et al., 2023; Xia and Lee, 2005), while acknowledging, but not modelling, the dynamic/process stream that examines nonlinear, time-evolving interactions (Benbya and McKelvey, 2006; Haki et al., 2020). Similar to operational alignment, open innovation involves intricate interactions among multiple stakeholders, characterized by bounded rationality, multi-actor collaboration, and collective intelligence dynamics (Pyo et al., 2021; Turoń and Kubik, 2022; Yun et al., 2016). This positioning motivates adopting fit as matching as our theoretical lens.

Why fit as matching is the right lens for operational alignment

Given this structural delimitation, fit as matching conceptualizes alignment as a direct correspondence between micro-level BP activities and specific IS tasks/capabilities. Among Venkatraman's six conceptualizations (moderation, mediation, matching, gestalts, profile deviation, covariation), matching is a lens that specifies fit without reference to a performance criterion and formalizes it as A↔B correspondence between well-defined constructs. This is the correct ontological level for prescribing which IS capabilities should support which BP activities (Coltman et al., 2015; Venkatraman, 1989).

Our stance is consistent with two influential operational streams. Task-Technology Fit (TTF) theorizes that performance improves when technology functionalities match task requirements, precisely the pair-level logic (task ↔ capability) that mirrors our BP-IS mapping. Likewise, the enterprise-system fit/misfit literature diagnoses functional, data, usability, role, control, and cultural misfits, again assuming pairwise correspondences between processes and system capabilities. Together, these streams provide prior evidence that operational alignment is often theorized and operationalized via matching (Goodhue and Thompson, 1995; Strong and Volkoff, 2010).

By contrast, moderation and mediation conceptualize alignment relative to a dependent variable (e.g., whether alignment conditions explain the IS-performance relationship). They are ideal for testing performance consequences and mechanisms, but provide limited guidance for diagnosing and designing pairwise BP-IS mappings. Likewise, gestalts, profile deviation, and covariation are configurational perspectives that capture multi-dimensional strategic patterns or ideal profiles; they are powerful for strategy-level coalignment but do not yield process/task-level recommendations that practitioners can implement (Bergeron et al., 2001, 2004; Chan and Reich, 2007; Coltman et al., 2015; Cragg et al., 2002; Venkatraman, 1989). Thus, for the prescriptive BP-IS mapping problem, matching serves as an appropriate primary lens (Bergeron et al., 2004; Cragg et al., 2002).

To make this distinction concrete, and following Venkatraman's (1989) fit typology and alignment syntheses (Chan and Reich, 2007; Coltman et al., 2015), Table 1 compares the six perspectives by research question and unit of analysis; representative exemplars are given in the table note.

As Table 1 indicates, the fit-as-matching lens (Venkatraman, 1989) aligns with our pair-level unit of analysis and the study's prescriptive question ("Which IS capabilities should support which BP activities?"). Accordingly, we operationalize this lens through an alignment execution layer that represents BP Activity Importance and IS-Task Capability as indicators, computes pairwise fit/misfit at the activity-task level via a mapping function, and uses an RS-based routine to prioritize BP-IS adjustments, yielding BP-IS matrices and recommendations.

Approaches to operational alignment

Existing approaches to operational alignment can be categorized into three main types: (1) Driver-based, (2) Modeling Language (ML)-based, and (3) BP-based. Each approach implicitly aims at matching BPs and ISs, albeit with varying degrees of abstraction and practicality. The Driver-based approach identifies the organizational drivers of operational alignment (e.g., social and structural factors) and investigates how these drivers influence alignment outcomes such as IS business value and organizational agility. The ML-based approach employs modeling languages (e.g., Unified Modeling Language (UML)) to link ISs and BPs. The BP-based approach focuses on BP dependencies and functions throughout the business management lifecycle as a foundation for alignment.

Table 1
Choosing a fit perspective by research question and unit of analysis.

Fit perspective	Typical research question	Unit of analysis	Common application in the alignment literature	Relevance to this study
Matching	Which A corresponds to which B?	Pair (BP activity, IS task)	Designing BP-IS correspondences; diagnosing misfit	Provides prescriptive, pairwise mappings needed for the artifact.
Moderation	Does alignment condition the IS-performance relationship?	Interaction with outcome	Performance consequences	Complementary; does not generate pairwise mappings.
Mediation	Does alignment explain the IS-performance relationship?	Causal chain with outcome	Mechanism testing	Complementary; does not generate pairwise mappings.
Gestalts	Which configurations cohere?	Organizational archetype	Strategic archetypes	Too coarse for task-level mapping.
Profile deviation	How far from an ideal profile?	Multi-dimensional profile	Benchmarking against ideal profiles	No pairwise guidance
Covariation	Do alignment dimensions co-vary as a latent construct?	Second-order factor	Structural coherence	Descriptive rather than prescriptive for task-level mapping.

Note. This typology is based on Venkatraman's (1989) perspectives of fit and draws on alignment syntheses by Chan and Reich (2007) and Coltman et al. (2015). The matching perspective reflects operational traditions that conceptualize alignment as a pairwise correspondence, for example, task-technology fit (Goodhue and Thompson, 1995) and enterprise-system fit/misfit (Strong and Volkoff, 2010). By contrast, the moderation perspective treats alignment as a contingency that conditions the IS-performance relationship (Cragg et al., 2002), whereas the mediation perspective treats alignment as an intervening mechanism linking IS capabilities to performance (Bergeron et al., 2001). The profile-deviation perspective evaluates distance from an ideal alignment profile (Bergeron et al., 2004), and gestalts and covariation capture configurational coherence at a higher level (Venkatraman, 1989).

Table 2 presents this categorization, highlighting each approach's level of abstraction, reliance on idealization, primary focus, and major limitations. This classification establishes a conceptual basis for identifying the gap this study aims to address.

Driver-based approach

The Driver-based approach identifies the key enablers of operational alignment and analyzes how they influence alignment outcomes, specifically, how social and structural drivers (e.g., communication, shared understanding, and collaboration) contribute to improved coordination between BPs and ISs, ultimately enhancing IS-enabled business agility and performance (Zhou et al., 2018; Wagner et al., 2014; Bagheri et al., 2019; Santa et al., 2020). Its level of abstraction is social and structural, focusing on communication, language, and competence between IS and business units. In terms of idealization, this approach assumes that the technical details of how ISs meet business requirements (BRs) can be overlooked if social and structural conditions are favorable. However, this assumption makes the Driver-based approach unrealistic and limited in practice, as it does not ensure that ISs can perform in accordance with business needs (Njanka et al., 2021). While this approach offers a high-level perspective that is easy to understand and implement, it lacks the operational depth needed for robust alignment. Appendix A summarizes three studies that exemplify this approach.

ML-based approach

The ML-based approach uses constructs within modeling languages to represent different elements of the business, including BRs, BPs, and ISs. This approach offers a more detailed level of abstraction as it attempts to capture all relevant operational elements through formal modeling. Because it adheres closely to formal definitions and makes few assumptions, it reflects minimal idealization. Despite its theoretical rigor, the ML-based approach presents significant practical challenges. It is often too complex to provide a broad view of operational alignment and difficult to adapt to dynamic environments (Kawtar et al., 2019). As ISs and BPs evolve rapidly, updating formal models becomes time-consuming and inefficient. For example, organizations must frequently adjust ISs to align with new BRs, or vice versa, to remain competitive (Tallon, 2007; Leonard and Seddon, 2012; Vessey and Ward, 2013). These realities make the ML-based approach less feasible for real-world alignment scenarios. Appendix A summarizes various studies that have used ML-based approaches to align (1) BRs and BPs, (2) BRs and ISs, (3) BPs and ISs, and (4) BRs, BPs, and ISs.

BP-based approach

The BP-based approach focuses on BP dependencies, such as physical and informational links, or BP functions across various stages of the development cycle. This method adopts a process-level abstraction, while idealizing that IS-related dependencies, such as system tasks, user roles, and infrastructure capabilities, are either less important or can be overlooked. While this approach is more detailed and actionable than the Driver-based approach, it remains less comprehensive than the ML-based approach. This limitation is well documented in the literature, which highlights that overlooking IS-related dependencies can undermine alignment by creating misfits between redesigned processes and system functionalities (Broadbent et al., 1999; Strong and Volkoff, 2010). As a result, BP-based approaches may lead to operational misalignment when process changes are not fully supported by the underlying IS environment. Broadbent et al. (1999) demonstrate that organizations lacking sufficient IS infrastructure capability often encounter execution barriers or partial alignment during process redesign efforts. Similarly, Heinrich (2014), Millet et al. (2009), and Jonathan et al. (2021) emphasize that omitting IS dependencies in process-oriented alignment can limit the sustainability and completeness of transformation initiatives. Appendix A outlines representative studies using this approach.

Research gap

The analysis above identifies two distinct yet interconnected knowledge gaps in business-IS alignment: one theoretical and one practical. At the theoretical level, a substantial gap remains in the clear conceptualization and detailed understanding of operational alignment, especially compared with the extensively theorized strategic domain (Henderson and Venkatraman, 1993; Chan and Reich, 2007; Luftman, 2000, 2003). While strategic alignment is supported by mature models, operational alignment often remains ambiguously defined and is frequently subsumed within broader strategic discussions. There is, therefore, a shortage of coherent frameworks that specify what constitutes operational alignment and how and why business processes should integrate with information systems. What remains missing is a prescriptive execution logic at the activity-task level that translates strategic intent into prioritized, implementable BP-IS adjustments.

Specifically, Venkatraman's (1989) matching perspective, despite its suitability for operational alignment, has been rarely and inadequately applied. Most alignment studies overlook this detailed lens, leaving the articulation of how operational-level BP activities align precisely with IS capabilities underspecified. This theoretical gap deprives practitioners

Table 2
Literature on operational alignment.

Approach	Abstraction	Idealization	Focus of Selected Studies	Limitation
Driver-based	Social and structural drivers of operational alignment (e.g., communication) between the IS and business departments.	Details of how ISs meet business requirements (BRs) are not considered. Operational alignment is assumed to be achieved if the social and structural drivers and their effect on operational alignment are identified.	Driver: Social and structural alignment Outcome: Organizational agility (Zhou et al., 2018) Driver: Social capital Outcome: IS business value (Wagner et al., 2014) Driver: User-related requirements elicitation problems Outcome: Shared understanding between the business and IS (Bagheri et al., 2019) Driver: Alignment between operational and information systems strategies Outcome: Enhanced firm performance (Santa et al., 2020)	The approach is unrealistic and impractical because it does not ensure ISs perform based on the BRs (Njanka et al., 2021).
ML-based	Constructs in the modeling languages (MLs) represent different aspects of the business (e.g., business requirements (BRs), BPs, and ISs).	No significant assumptions are made, as they reflect the exact definition of operational alignment.	Aligning BRs and BPs (Li et al., 2015; Kraiem et al., 2014; Sousa, do Prado Leite, 2014; Frankova et al., 2011) Aligning BRs and ISs (Han et al., 2009; Gehlert et al., 2008; Wan-Kadir and Loucopoulos, 2004) Aligning BPs and ISs (Aversano et al., 2016; De Castro et al., 2011; Elvesater et al., 2010; Cibran, 2009) Aligning BRs, BPs and ISs (Vasconcelos et al., 2001; Doumi et al., 2013)	The resulting model is complex and cannot provide a broad view of operational alignment because MLs include details of basic operational alignment elements. It is not feasible because adapting to the frequent changes in BPs and ISs is difficult and time-consuming to develop (Kawtar et al., 2019).
BP-based	BP dependencies (e.g., physical and informational) or BP functions are considered.	IS dependencies (e.g., IS tasks, capabilities, roles) are assumed unimportant. Operational alignment is achievable if BP dependencies and BP functions are considered.	BP dependencies in the Supply Chain Operation Reference (SCOR)-based alignment reference model (Millet et al., 2009) BP dependencies in Business Process Management (BPM) life cycle (Weske et al., 2004) BP functions in the Architecture of Integrated Information Systems (ARIS) (Tbaishat, 2018) BP dependencies and IS roles in digital transformation (Jonathan et al., 2021) BP functions and IS alignment in dynamic enterprise architecture capabilities (Van de Wetering, 2021)	It is more realistic and practical than the Driver-based approach because it considers BP dependencies and BP functions. However, it is still less comprehensive than the ML-based approach as it overlooks critical IS dependencies, such as system tasks, user roles, and infrastructure capabilities. As a result, this approach may lead to operational misalignment or "misfits" when redesigned processes are not adequately supported by the underlying enterprise systems (Broadbent et al., 1999; Strong and Volkoff, 2010; Heinrich, 2014; Millet et al., 2009; Jonathan et al., 2021).

of guidance for establishing a well-aligned BP-IS pair.

At the practical level, the execution gap is equally evident. Existing operational alignment methodologies, driver-based, ML-based, and BP-based, exhibit notable shortcomings. Driver-based approaches provide abstract strategic guidance yet lack specificity; ML-based methods rely on idealized assumptions and complex models that limit applicability; BP-based approaches, though detailed, often presume static conditions. This combination of abstraction without actionable detail or rigid idealization hinders effective operational alignment.

Recognizing these limitations, we adopt the fit-as-matching perspective (Venkatraman, 1989) as our theoretical lens and set the following objective: to specify and instantiate a practicable execution mechanism for operational BP-IS alignment at the activity-task level. To

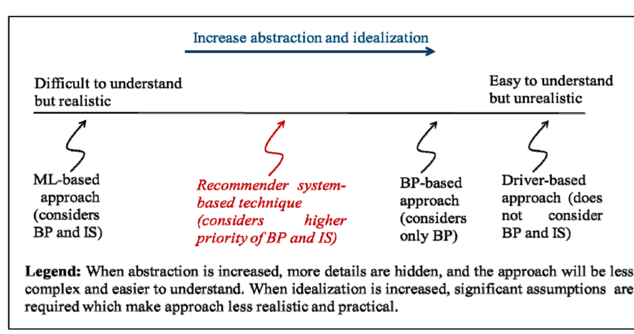


Fig. 1. RS-based technique for practical operational alignment.

address this gap, we design an RS-based technique that operationalizes the lens through an alignment-execution layer that evaluates pairwise correspondences between BP activities and IS tasks and outputs prioritized BP-IS adjustments. Fig. 1 conceptually situates the approach among driver-based, ML-based, and BP-based streams along the abstraction-idealization continuum.

Research methodology

This study employs DSR to develop and evaluate the proposed RS-based operational alignment technique. DSR is an established research paradigm within the ISs discipline, emphasizing the creation and evaluation of innovative artifacts designed to solve identified organizational, complex, and socio-technical problems (Gregor and Hevner, 2013). Given our research question, "How can abstraction and idealization be balanced to enable the practical and effective implementation of operational alignment in organizations?", the study inherently requires an actionable solution rather than mere descriptive theorizing. Accordingly, an RS-based operational alignment technique was developed to facilitate practical implementation. This technique generates a list of ISs for a given BP, ordered by their importance concerning alignment. It produces a list of BPs for a given IS, ordered based on the processes' importance. A decision maker can use these lists to determine how to adjust BPs and ISs to achieve alignment effectively.

The rationale for adopting DSR stems from operational alignment being a complex and socio-technical problem that has been inadequately addressed by traditional approaches. Prior methods typically either oversimplified the alignment challenge through excessive abstraction or produced overly detailed techniques too cumbersome for real-world application. The RS-based operational alignment technique strives specifically to balance abstraction and idealization, managing the many-to-many connections between BPs and ISs and thereby reducing complexity. This balance is essential for two primary reasons. First, increasing abstraction hides more details, making the alignment process less complex and more comprehensible. Conversely, higher idealization introduces specific assumptions, potentially compromising the realism and practicality of the alignment outcomes. Hence, abstraction should increase only enough to reduce complexity without losing interpretability, and idealization should increase only enough to maintain realism and actionability. Second, achieving alignment inherently requires simultaneous consideration of both BPs and ISs. DSR addresses these challenges by providing a structured framework to develop innovative solutions grounded in theoretical rigor and empirical validation, effectively bridging this critical knowledge gap and ensuring practical relevance and theoretical soundness. Within the scope of this study, the artifact addresses structural complexity at the BP-IS interface by computing and prioritizing pairwise activity-task correspondences under a matching perspective. Dynamic/process complexity (nonlinear feedback and temporal evolution) is acknowledged and handled pragmatically through iterative use and periodic re-elicitation of indicators; it is not explicitly modeled in this study.

This research strictly adheres to DSR's core principles, problem relevance, research rigor, artifact design, and thorough evaluation, mapped meticulously onto the following four-phase research process:

Phase 1: problem identification (principle: problem relevance)

This initial phase identified the practical challenge of balancing abstraction and idealization within operational alignment. A comprehensive literature analysis, consultations with industry experts, and empirical analysis of official documentation from TPUs were conducted. This process defined the scope and identified foundational elements, specifically relevant BPs and ISs, creating a robust theoretical and empirical foundation for subsequent analyses.

Phase 2: delphi-based relation mapping (principle: research rigor)

Employing the Delphi method, this phase rigorously collected expert insights to elucidate relationships between BPs and ISs. Experts identified types and importance of BP activities for ISs, types and importance of IS tasks for BPs, and determined the appropriate IS for each BP through iterative consensus. This process ensured the artifact's development was anchored in validated expert knowledge, thus upholding methodological rigor and theoretical precision.

Phase 3: artifact development (principles: design as an artifact, research contribution)

Leveraging insights from Phase 2, the RS-based operational alignment technique was deliberately designed and constructed. This artifact applies Delphi findings by integrating abstraction and idealization to manage complexity. Specifically, abstraction involves concealing details related to (1) the determination of the importance and performance of BP activities and IS tasks, and (2) the relationships between BP activities and IS tasks, which are rooted in the matching perspective of fit, which was introduced by Venkatraman (1989). These decisions were made to avoid overwhelming decision-makers with excessive granularity and to streamline the alignment process, thus enhancing comprehensibility and usability. Idealization is introduced by focusing exclusively on high-priority BPs and ISs, thereby efficiently allocating organizational resources to areas with the greatest potential performance impact. However, acknowledging the significance of social drivers in alignment, the Delphi method facilitated expert consensus and the establishment of a common language. This embeds social aspects implicitly into operational alignment recommendations, maintaining the artifact's practical relevance and robustness. Iterative refinements during this phase ensured theoretical grounding, innovative contribution, and practical utility, directly addressing complexities identified in prior methods.

From an implementation perspective, the RS artifact employs collaborative filtering via matrix factorization algorithms implemented in MATLAB. This method exhibits polynomial computational complexity, specifically $O(n^2m)$, where n represents the number of BPs and m denotes the number of IS tasks. This complexity arises because evaluating alignment recommendations involves examining all possible pairwise interactions among BPs; each of the n BPs is evaluated against every other BP, yielding $n \times n = n^2$ interactions. Subsequently, these pairwise evaluations are computed separately for each IS task, leading to the overall complexity of $O(n^2m)$. Practically, this means the computational resources and processing time scale quadratically as the number of BP activities increases, potentially affecting the usability of the artifact in significantly larger organizational environments. Within our study context of moderate-sized settings, such as TPUs, this complexity was manageable, allowing timely and efficient generation of recommendations. However, future adaptations for larger contexts may require additional optimization approaches, including dimensionality reduction or parallel processing frameworks, to maintain performance.

Phase 4: evaluation (principle: design evaluation)

In the final phase, rigorous evaluation procedures were conducted, involving a structured Delphi follow-up study and a practical workshop with organizational experts. These assessments examined both the artifact's attributes and its practical usability within realistic organizational scenarios, satisfying DSR's rigorous artifact validation requirement. The evaluations combined qualitative and quantitative approaches, robustly confirming the artifact's effectiveness in balancing abstraction and idealization for operational alignment.

The research was conducted in organizations that met four essential criteria to ensure the reliability and relevance of the findings. These included the extensive use of both BPs and ISs, clearly documented objectives for both BPs and ISs, and the presence of separate, independently functioning BP and IS departments. Additionally, a strong organizational interest in achieving operational alignment at the senior leadership level was required to ensure engagement with and applicability of the proposed technique. These conditions were necessary to minimize confounding factors such as inadequate BP or IS implementation.

The study was carried out within TPUs in a Middle Eastern country, which fulfilled all of the above requirements. Among universities in the region, TPUs are recognized leaders in developing IT and IS capabilities, make extensive use of ISs at multiple organizational levels, and demonstrate effective BP management. BP and IS departments operate independently, each with its own responsibilities and strategic plans. Moreover, operational alignment has long been a key concern for Chief Information Officers (CIOs) at these institutions. Not only do TPUs meet the foundational requirements for operational alignment, but they also have a clear strategic need for their implementation. Therefore, the TPU system provides a suitable and representative context for this empirical study.

In the second phase of the study, the Delphi method was employed. The Delphi method is a structured expert consultation process that facilitates consensus building through iterative feedback (Dalkey, 1969). Its application was essential for identifying and evaluating relationships between BPs and ISs while addressing the complexities inherent in business-IS alignment. In this study, the Delphi method was employed for three main reasons:

First, the Delphi method was used to design the technique by enabling structured expert discussion on: (1) the type of BP activities and their importance for each IS, (2) the type of IS tasks and their importance for each BP, and (3) the appropriateness of each IS for a given BP, based on expert judgment. This was crucial because achieving business-IS alignment requires evaluating both technical and social dimensions, which significantly affect the alignment process (Tanriverdi et al., 2010; Hanson et al., 2011; Vessey and Ward, 2013; Zhang et al., 2021).

Second, the Delphi approach directly supports our research question of balancing abstraction and idealization in operational alignment. By iteratively consulting experts, the Delphi method captured and refined expert knowledge about the relationships between BPs and ISs, identifying high-priority elements essential to the balance targeted by our RS-based operational alignment technique. Delphi grounded our decisions in collective expert insight, providing rigorous guidance on which details to emphasize or abstract away.

Third, employing the Delphi method complemented the DSR framework by reinforcing methodological rigor through validated expert knowledge integrated into artifact development. Delphi's structured rounds and iterative feedback mirrored the iterative nature of DSR, enhancing the credibility, relevance, and practical applicability of our artifact. The anonymity and iterative consensus-building inherent to Delphi reduced individual bias and prevented dominant voices from influencing outcomes excessively (Sackman, 1974; Steurer, 2011), thus ensuring a well-rounded, balanced perspective across business and IS viewpoints.

Consistent with the three reasons outlined above, the Delphi method involved multiple iterative rounds consisting of Likert-scale and open-ended questions initially derived from literature, organizational documents, or reports. Aggregated results from each round were shared with participants for reconsideration, reinforcing methodological rigor and robust collective expert consensus (Dalkey, 1969; Steurer, 2011). The Delphi method's key components, discussed further in subsequent sections, include participant selection, questionnaires, and consensus measurement.

Participants

Participant selection is a critical step for ensuring the validity and reliability of expert-driven research. Experts were identified using a structured hybrid nomination approach involving extensive outreach to academic, professional, and industry networks, alongside relevant institutional affiliations, followed by a non-probability purposive sampling method. Selected individuals were knowledgeable, self-motivated, and experienced specifically in the field of business-IS alignment. To encourage open sharing of opinions, participant anonymity was maintained throughout the study. Most Delphi studies involve between 15 and 20 participants, with the reliability of findings generally improving as the number increases (Dalkey et al., 1972; Ludwig, 1997).

Initially, 31 experts participated, with their involvement confirmed via in-person, phone, or email communication. Active participation slightly decreased from 31 in the first two Delphi rounds to 28 in the final round. The inclusion criteria required substantial professional expertise, defined concretely as having at least 5–7 years of experience across three critical domains: IS development, BP management, and IS operational alignment. Furthermore, all selected experts held senior or executive leadership roles within their organizations, such as CIOs, Chief Executive Officers (CEOs), deans, vice-deans, department heads, senior consultants, and senior faculty members. Among the final 28 participants, 22 held PhDs, with the remaining experts possessing master's or bachelor's degrees, further ensuring robust expert qualifications.

To guarantee comprehensive and practical insights, deliberate attention was given to diversity across professional contexts. The expert panel included representatives from academic and executive groups, with executives encompassing managers and policymakers across sectors such as academia, research and development (R&D), planning and development resources, administrative and financial affairs, education and learning, and cultural and social sectors. This intentional sectoral diversity allowed for capturing varied insights relevant to different organizational contexts, enhancing the robustness of the findings and reducing potential biases. Appendix B (Table B.1) provides detailed demographic information of the expert panel, clearly documenting each expert's sector, specialization, organizational position, academic credentials, and professional experience related to IS, BP, and operational alignment.

Questionnaires

We adopted a hybrid approach to develop the Delphi questionnaires, ensuring that expert questions were grounded in existing knowledge and aligned with identified gaps and the study's objectives. Specifically, the questionnaire items were informed by three primary inputs: (1) insights from relevant literature and established frameworks on business-IS alignment (Aversano et al., 2016; Bagheri et al., 2019; Chan and Reich, 2007; Ganji Bidmeshk et al., 2021, 2022; Wagner et al., 2014; Zhou et al., 2018), providing a theoretical basis for classifying BP activities and IS tasks; (2) identified deficiencies in existing operational alignment methods, particularly the lack of quantitative prioritization and insufficient handling of the complexities inherent in BP-IS relationships (Aversano et al., 2016; Bagheri et al., 2019; Wagner et al., 2014); and (3) the research objective to effectively balance abstraction and idealization.

Four questionnaires were developed for the Delphi rounds, each serving a clear purpose aligned with our research aims:

I. The first questionnaire aimed to classify BP activities and IS tasks. An initial list was derived from prior literature and organizational documentation from TPUs. Experts evaluated the relevance of existing items and suggested additional context-specific ones, directly addressing identified gaps.
II. The second questionnaire structured findings from Round 1, requesting experts to rate the significance of each BP activity for each IS. This step addressed gaps related to quantitative prioritization and complexity management identified in existing approaches.

III. The third questionnaire further assessed the importance of IS tasks for each BP through Likert scale ratings, with additional space for expert justification. This reinforced quantitative prioritization, refining the identification of critical operational alignments.
IV. The final questionnaire synthesized previous rounds by asking experts to assign points indicating the fit of each BP with various ISs. This directly supported our research goal of providing prioritized BP–IS alignment recommendations.

The iterative Delphi process continued until achieving sufficient consensus or when no further insights emerged. At each stage, statistical feedback was provided to ensure consistency and support informed expert responses. Each questionnaire deliberately abstracted low-level details by focusing on categories rather than exhaustive specifics and idealized the alignment challenge by guiding experts to concentrate on high-impact processes and systems. This systematic and theory-informed questionnaire development enhances methodological rigor, ensuring expert feedback is robust and directly informs the RS-based operational alignment technique.

Consensus measurement

We used Kendall's Coefficient of Concordance (W) to assess the level of agreement among experts' opinions. W is a widely used nonparametric statistic in Delphi studies that quantifies consensus among participants when ranking items (Ludwig, 1997; Hsu and Sandford, 2007). Calculated using Equation 1, W reflects the extent to which experts agree on the prioritization of alignment criteria.

$$W = \frac{S}{\frac{1}{12}p_2(n^3 - n)} \quad (1)$$

In Equation 1, p represents the number of experts, n is the number of ranking items or factors, and S is the sum of squared deviations from the mean rank, which is computed using Equation 2.

$$S = \sum \left(R_j - \frac{\sum R_j}{n}\right)^2 \quad (2)$$

In Equation 2, Rj denotes the sum of ranks for each item j, where each rank is assigned by an individual expert.

The value of W ranges between 0 and 1, where 0 indicates no agreement and 1 indicates complete agreement. Interpretive thresholds are commonly applied, with values of 0.1, 0.3, 0.5, 0.7, and 0.9 corresponding to very low, low, moderate, high, and very high agreement, respectively (Zar, 1999).

The Delphi process concluded at the end of the third round. The stopping criterion was defined as the point at which two consecutive rounds produced similar W values, indicating that further iterations would not meaningfully improve consensus. This convergence confirmed that the expert panel had reached a stable level of agreement.

Results

The Results section is structured into sequential phases to reflect the iterative nature of the DSR methodology. Each phase incrementally contributes toward addressing the dimensions of operational alignment, ranging from foundational identification through expert consensus and artifact development to comprehensive evaluation. This structured presentation ensures clarity by linking each phase to the broader research objective, providing coherence throughout the research process.

Phase 1: identification of BPs and ISs

Phase 1 establishes foundational elements required for operational alignment by defining the scope and categorization of BPs and ISs. These critical components were identified using official documentation from the TPUs system. In total, 132 subprocesses were categorized into 45 BPs, while 116 subsystems were grouped into 13 ISs. Ambiguous subsystem categories were classified as mixed ISs. Comprehensive lists of identified BPs and ISs, including examples such as Learning Services Provision and Process Management for BPs, and integrated ESS/DSS and knowledge-based MIS for ISs, are provided in Appendices C and D. This detailed categorization establishes a clear basis for subsequent analyses and technique development. By categorizing essential BPs and ISs, this phase establishes foundational clarity and structured groundwork, ensuring precision critical for subsequent alignment analysis.

Table 3
Types of BP activities and IS tasks at TPUs.

Types of BP Activities	Types of IS Tasks
1- Learning Management	1- Strategic
2- Research Management	2- Management
3- Strategic Management	3- Knowledge-based
4- Quality Management	4- Operational
5- Student Services Management	
6- Social and Cultural Management	
7- Communication Management	
8- Assets Management	
9- Human Resource Management (HRM)	
10- Financial Resource Management	
11- Information and Communication Technology Management (ICT)	

Phase 2: relationships among BPs and ISs based on the delphi method

Phase 2 validates critical BP and IS relationships essential for operational alignment through expert consensus using the Delphi method, involving three iterative rounds. This phase captures detailed expert evaluations of BP activities and IS tasks crucial for operational alignment. Consensus was quantitatively measured using Kendall's W, ensuring the reliability of results. This phase encompasses classification of BP activities and IS tasks, assessment of the importance of BP activities for ISs, evaluation of the importance of IS tasks for BPs, and determination of the most appropriate ISs for each BP. These validated relationships provide essential inputs for developing a practical operational alignment solution. Through structured expert consensus, this phase empirically validates essential BP-IS relationships, providing robust insights vital for targeted operational alignment solutions.

Identifying the type of BP activities and IS tasks

Initially, nine BP activities and three IS tasks were identified. Following iterative rounds, the Delphi panel reached a consensus on eleven BP activities and four IS tasks. The final round incorporated two new BP activities (i.e., Research Management and Assets Management) and one additional IS task (i.e., Management). Consensus improved slightly between the second and third rounds ($W = 0.73$ to $W = 0.75$), indicating strong agreement. The finalized classifications are presented in Table 3, with examples listed in Appendix E.

Importance of BP activities for ISs

Experts assessed the importance of each BP activity across 13 ISs over three rounds. The consensus improved from $W = 0.63$ to $W = 0.77$. In the case of integrated Executive Support System (ESS)[1] and Decision

[1] ESS is used for non-routine issues and problems for which not only information from various sources (internal and external) is used, but also it is necessary to use human inputs, like assumptions and the personal insights of the manager.

Table 4
Importance of BP activities in integrated ESS and DSS (Example).

Type of BP Activity	First Round		Second Round		Third Round	
	Num of experts: 31 W: 0.63		Num of experts: 31 W: 0.72		Num of experts: 28 W: 0.77	
	Avg. Score	Priority	Avg. Score	Priority	Avg. Score	Priority
Learning Management	4.33	4	4.70	3	4.66	3
Research Management	4.28	5	4.61	4	4.57	4
Strategic Management	4.48	2	4.87	1	4.82	1
Quality Management	4.65	1	4.76	2	4.78	2
Student Services Management	3.60	8	4.26	7	4.31	7
Social and Cultural Management	3.32	11	3.22	11	3.27	11
Communication Management	3.48	10	3.63	9	3.72	9
Assets Management	3.54	9	3.47	10	3.54	10
HRM	4.37	3	4.42	6	4.49	6
Financial Resource Management	3.77	7	4.54	5	4.53	5
ICT	3.95	6	3.75	8	3.99	8

Legend: Average score out of 5

Table 5
Importance of IS tasks in learning planning process (Example).

Type of IS Task	First Round		Second Round		Third Round	
	Num of experts: 31 W: 0.61		Num of experts: 31 W: 0.76		Num of experts: 28 W: 0.78	
	Avg. Score	Priority	Avg. Score	Priority	Avg. Score	Priority
Strategic	4.64	1	4.66	3	4.65	3
Management	4.57	2	4.80	1	4.83	1
Knowledge-based	4.41	4	4.70	2	4.76	2
Operational	4.50	3	4.47	4	4.51	4

Legend: Average score out of 5

Support System (DSS),[2] Strategic Management (4.82) and Quality Management (4.78) consistently received the highest importance scores in the final round. These results are illustrated in Table 4.

Importance of IS tasks for BPs

The importance of each IS task across 45 BPs was similarly evaluated, and consensus improved from W = 0.61 to W = 0.78. For example, in the Learning Planning process, Management (4.83) and Knowledge-based tasks (4.76) were identified as the most critical. Table 5 presents these results.

Appropriate IS for each BP

Experts also evaluated the appropriateness of each IS in supporting specific BPs. The level of consensus increased significantly, from W = 0.63 to W = 0.79. For instance, Integrated ESS and DSS (4.87) and ESS (4.79) were found to be the most suitable for the Learning Planning process. Table 6 displays the top-rated ISs for this process.

The insights from Phase 2 logically inform the artifact development detailed in Phase 3.

[2] DSS is aimed at monitoring, controlling, and making unstructured and ad-hoc decisions.

Table 6
Most appropriate iss for learning planning process (Example).

TPUs' IS	First Round		Second Round		Third Round	
	Num of experts: 31 W: 0.63		Num of experts: 31 W: 0.76		Num of experts: 28 W: 0.79	
	Avg. Score	Priority	Avg. Score	Priority	Avg. Score	Priority
1- Expert System (ES)	4.53	6	4.48	5	4.45	5
2- ESS	4.82	1	4.79	2	4.79	2
3- Integrated ESS and DSS	4.76	2	4.82	1	4.87	1
4- DSS	4.57	5	4.60	4	4.58	4
5- Integrated DSS and MIS	4.66	4	4.27	6	4.34	6
6- MIS	4.70	3	4.62	3	4.65	3
7- Knowledge-based MIS	3.64	7	3.47	8	3.51	8
8- Knowledge Work System (KWS)	3.41	8	3.57	7	3.62	7
9- Group Collaboration System (GCS)	3.25	10	3.28	10	3.39	10
10- Office System (OS)	3.30	9	3.41	9	3.43	9
11- Office Automation System (OAS)	3.09	12	3.20	12	3.25	12
12- Integrated OAS and Transaction Processing System (TPS)	3.18	11	3.24	11	3.31	11
13- TPS	2.99	13	3.17	13	3.12	13

Legend: Average score out of 5

Phase 3: development of the RS-based operational alignment technique

Phase 3 develops a practical artifact based on Delphi-validated relationships and priorities identified in Phase 2. Leveraging these expert-validated insights, the RS-based operational alignment technique employs collaborative filtering methods to manage alignment complexity through controlled abstraction and idealization. This phase introduces a practical, empirically-informed RS-based artifact, effectively bridging identified knowledge gaps. By precisely balancing abstraction and idealization, the innovative approach directly addresses the complexities inherent in operational alignment, optimizing alignment decisions.

Based on the Delphi results, the RS-based operational alignment technique was developed using MATLAB. This technique employs collaborative filtering to estimate missing performance data and optimize alignment between BPs and ISs. RS algorithms typically follow either content-based or collaborative filtering logic. Content-based filtering uses vector multiplication between user and item matrices to compute similarities based on criteria (Shani and Gunawardana, 2011; Lops et al., 2011). However, these methods are often constrained by incomplete item profiles. In contrast, collaborative filtering infers recommendations from patterns in user behavior and can estimate missing values where direct criteria are unavailable (Koren et al., 2009; Chen et al., 2018), making it more appropriate for this study.

While importance data for BPs and ISs were derived from the Delphi process, performance data were incomplete. Collaborative filtering was applied to infer these missing values, using three matrices:

1. **IS-Act Matrix:** representing the importance of each BP activity for each IS
2. **BP-IS Matrix:** based on Delphi scores indicating the appropriateness of each IS for each BP
3. **BP-Act Matrix:** constructed by solving a system of linear equations (Equation 3), representing the performance of BP activities

Equation 3 defines how these values were computed:

$$[\text{IS-Act1}] \bullet T[\text{BP-Act1}] = E \tag{3}$$

$$[\text{IS-Act}_2] \bullet T[\text{BP-Act}_1] = G$$

$$[\text{IS-Act}_Z] \bullet T[\text{BP-Act}_1] = H$$

Legend

[IS-Act1]: First vector in the Information System-Activity matrix

T[BP-Act1]: Transposed performance vector [y1 y2 … yn] for BP1

E, G, H: Scores assigned by the Delphi panel for BP1 across IS1 to ISZ

Solving this system for each BP yielded a complete BP-Act matrix. We then applied content-based filtering to multiply the BP activity performance vectors by IS activity importance vectors to identify the most suitable ISs for each BP and vice versa. A mirrored process was followed to derive suitable BPs for each IS. MATLAB scripts used for implementation are included in Appendix F.

Table 7 displays sample results showing optimal IS recommendations for specific BPs. For example, strategic, managerial, and planning BPs are best supported by ES, ESS, and integrated ESS-DSS, respectively.

Figure 2 provides a graphical representation of the priority level of ISs (e.g., Integrated ESS and DSS) recommended for planning-related BPs, such as cultural and social planning (CSP), Human Resources (HRs) planning (HRP), ICT planning (ICTP), learning planning (LP), research and technology policy (RTP), resource and financial expenses planning (RFEP), and student services planning (SSPl).

The RS-based operational alignment technique prioritizes and aligns BPs and ISs, effectively translating theoretical insights into actionable recommendations. By achieving a practical balance between simplicity and precision, this tangible artifact sets the foundation for the rigorous empirical evaluation presented in Phase 4.

Table 7
Recommending Appropriate IS for Each BP.

IS	BP
ES	Strategy Compilation
	Strategy Implementation
	Strategy Assessment
ESS	Process Management
	Project Management
	Physical Resources Management
	Goods and Services Management
	Communication and Networks Management
	Information and Data Management
	Information and Communication Security Management
	Software and Systems Management
Integrated ESS and DSS	Learning Planning
	Research and Technology Policy
	Student Services Planning
	Cultural and Social Planning
	HRs Planning
	Resource and Financial Expense Planning
	ICT Planning
Integrated DSS and MIS	Research Achievements Release
	Technology Transfer
	HR Hiring, Supply, and Selection
	HRs Skills Development
	HR Transfer and Retirement
	Financial Credit Collection and Distribution
Knowledge-based MIS	Performance Measurement
	Admission
	Learning Assessment
	Student Services Monitoring and Evaluation
	Cultural and Social Services Monitoring
	Public Relations
	Community Interaction
	International University Interactions
	Financial Monitoring
	Software and Hardware Support
MIS	Learning Services Provision
	Study Termination
	Research Services Provision
	Student Services Provision
	Student Services Termination
	Cultural and Social Services & Products Provision
	Cultural and Social Facilities Provision
	Out-of-School Services Provision
	Facilities and Benefits Provision For HRs
	Safety and Health Resources Provision For HRs
	Expense Payments

Phase 4: evaluation of the RS-based operational alignment technique

Phase 4 rigorously assesses the artifact's practical applicability, confirming its utility through structured expert workshops. Results demonstrate the RS-based technique's effectiveness, usability, and minimal resource requirements, thus reinforcing its potential for adoption in real-world organizational contexts. This phase provides rigorous empirical evidence of the artifact's practical applicability, clearly demonstrating its effectiveness, usability, and minimal resource requirements, reinforcing its real-world utility and potential for widespread organizational adoption.

Delphi-based evaluation of RS attributes

The Delphi method was reapplied in this phase using three rounds of structured questionnaires and semi-structured interviews with ten experts. The goal was to assess two key design attributes of the RS artifact:

1. **Abstraction:** The ability of the RS to conceal the underlying mechanisms for computing BP activity and IS task relevance.
2. **Idealization:** The RS's capacity to focus only on high-priority BPs and ISs, ignoring less relevant ones.

These attributes were evaluated based on three criteria: meaningfulness, usefulness, and applicability. Consensus was reached after three rounds, with Kendall's W increasing from 0.65 in Round 1–0.81 in Round 3. The marginal change in W (0.02) between Rounds 2 and 3 indicated the stabilization of expert agreement. Table 8 summarizes the average scores for each attribute across the three rounds.

Workshop-based usability evaluation

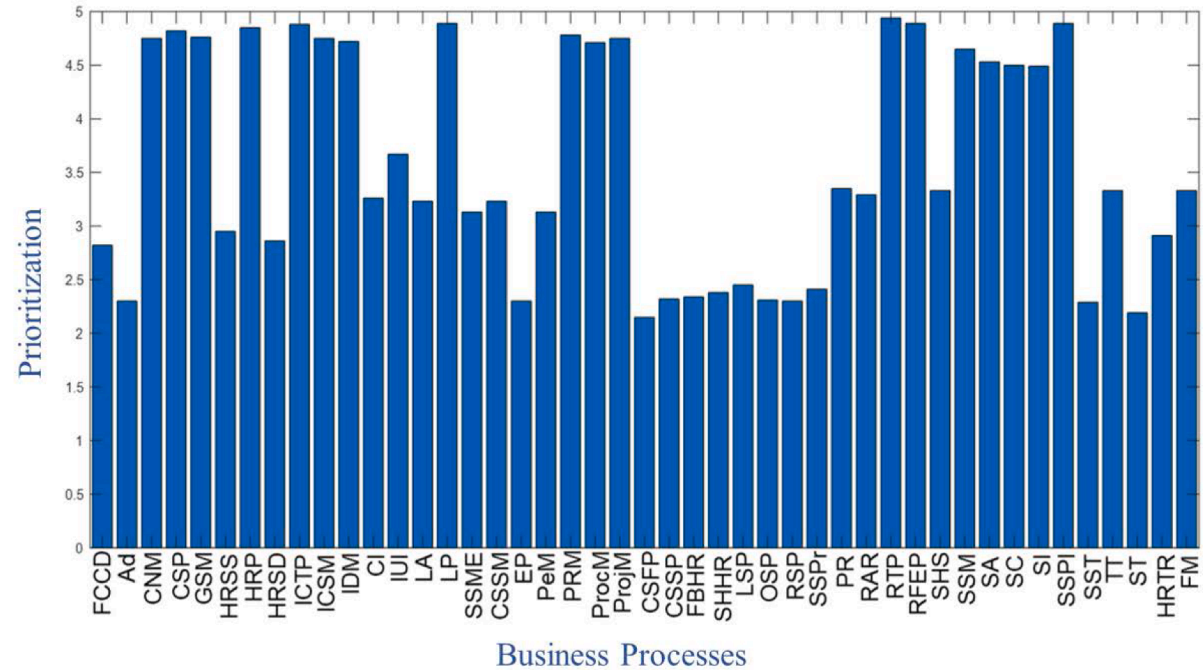
A workshop involving 10 CIOs and IT managers, including three Delphi participants, was held to assess the RS's practical usability. Participants were trained and asked to apply the RS in real alignment tasks. They then rated the RS using a structured questionnaire assessing four criteria: applicability, usability, ease of use, and required time and effort.

Responses were recorded on a 5-point Likert scale (1 = extremely low, 5 = extremely high), and participants were allowed two weeks to reflect on the tool's effectiveness using real-world data. Overall, the RS received high marks for ease of use and low time/effort requirements, confirming its utility. Table 9 summarizes the results.

Delphi evaluations demonstrated increasing consensus on meaningfulness, usability, and applicability across iterative rounds, confirming the robustness of the technique. Workshop evaluations involving practical alignment tasks yielded high scores for applicability and usability, detailed quantitatively in Table 8. These outcomes highlight the RS-based technique's practical value, effectively addressing the research objective by demonstrating its potential for adoption in real organizational contexts.

Discussion and conclusion

This study introduced and empirically validated an RS-based operational alignment technique specifically designed to address the structural complexity arising from the intricate many-to-many relationships between BPs and ISs. We first established a robust baseline by categorizing 132 subprocesses into 45 distinct BPs and grouping 116 subsystems into 13 ISs. This provided a clear foundation for alignment



Legend for business processes

FCCD: Financial Credits Collection and Distribution
Ad: Admission
CNM: Communication and Network Management
CSP: Cultural and Social Planning
GSM: Goods and Services Management
HRSS: HR Hiring, Supply, and Selection
HRP: Human Resources (HR) Planning
HRSD: HR Skills Development
ICTP: ICT Planning
ICSM: Information and Communication Security Management
IDM: Information and Data Management
CI: Community Interaction
IUI: International University Interactions
LA: Learning Assessment
LP: Learning Planning
SSME: Student Services Monitoring and Evaluation
CSSM: Cultural and Social Services Monitoring
EP: Expense Payments
PeM: Performance Measurement
PRM: Physical Resources Management
ProcM: Process Management
ProjM: Project Management
CSFP: Cultural and Social Facilities Provision
CSSP: Cultural and Social Services & Products Provision
FBHR: Facilities and Benefits Provision for HR
SHHR: Safety and Health Resources Provision For HR
LSP: Learning Services Provision
OSP: Out-Of-School Services Provision
RSP: Research Services Provision
SSPr: Student Services Provision
PR: Public Relations
RAR: Research Achievements Release
RTP: Research and Technology Policy
RFEP: Resource and Financial Expenses Planning
SHS: Software and Hardware Support
SSM: Software and Systems Management
SA: Strategy Assessment
SC: Strategy Compilation
SI: Strategy Implementation
SSPI: Student Services Planning
SST: Student Services Termination
TT: Technology Transfer
ST: Study Termination
HRTR: HR Transfer and Retirement
FM: Financial Monitoring

Fig. 2. Recommended Priority for Integrated ESS and DSS for Planning-related Process at TPU.

analysis. The convergence of expert opinions in the Delphi study validated the reliability of the identified alignment criteria and the soundness of our theoretical constructs, ensuring that the results accurately represent real-world scenarios. Moreover, a core element enhancing the technique's effectiveness was the use of collaborative filtering within the RS artifact, which allowed us to accurately estimate incomplete performance data. This methodological choice significantly improved the precision of aligning BP performance metrics with IS capabilities,

Table 8
Average scores of RS attributes in delphi evaluation.

Main Attributes of the RS	First Round			Second Round			Third Round		
	Num of Experts: 28 W: 0.65			Num of Experts: 28 W: 0.79			Num of Experts: 28 W: 0.81		
	M	U	A	M	U	A	M	U	A
Matching IS and BP	4.46	4.72	4.67	4.70	4.78	4.80	4.75	4.78	4.83
Mutual prioritization of IS and BP	4.48	4.46	4.79	4.57	4.58	4.87	4.61	4.67	4.91

Legend
Average score out of 5
M: Meaningfulness
U: Usefulness
A: Applicability

Table 9
Average, median, and standard deviation of the users' viewpoint in workshop.

Property	Average	Median	Standard Deviation
Applicability	4.1	4	0.73
Usability	4	4	0.66
Ease of Use	4.3	4	0.68
Time and Effort Required	4.5	4	0.53

Legend
Number of participants: 10

leading to more actionable alignment recommendations. Notably, this actionable approach uniquely applies RS logic, traditionally used commercially for personalized recommendations (Tintarev and Masthoff, 2015), directly to the operational alignment domain.

Practical evaluation workshops with CIOs and IT managers further demonstrated the technique's pragmatic value. Participants gave high ratings for applicability (4.1/5), usability (4.0/5), ease of use (4.3/5), and minimal resource requirement (4.5/5). These outcomes show that stakeholders found the approach both practical and easy to implement in an organizational context. Such positive feedback, combined with the Delphi consensus, indicates that the RS-based technique is both conceptually robust and practically viable. Most critically, these empirical findings provide a clear and direct answer to our research question: "How can abstraction and idealization be balanced to make operational alignment feasible and effective for organizations?" The study demonstrated that the RS-based approach effectively balances manageability and realism in operational alignment. Specifically, it strategically abstracts complex operational interactions through alignment indicators (importance and performance of BP activities and IS tasks, and their relationships based on Venkatraman's 1989 matching perspective of fit). Additionally, by idealizing feasible improvements, the technique explicitly focuses attention on high-priority areas. This balance yielded tangible results, for instance, critical strategic and quality management activities scored highly on importance, immediately highlighting high-priority alignment areas. Additionally, the system identified overlaps among IS modules (e.g., in student registration processes), which led to recommendations for consolidations; this shows how focusing on realistic improvements (idealization) guided stakeholders toward impactful changes. Consequently, the study bridges the theoretical–practical gap by aligning abstract alignment concepts with actionable decisions. It provides a replicable solution for managing the inherent structural complexities of operational alignment in organizations.

Positioning the results in the context of the literature

This research situates its findings within the existing operational alignment literature, addressing previously noted theoretical and practical gaps. Operational alignment is conceptually distinct from strategic alignment (the latter has been extensively studied through frameworks such as Henderson and Venkatraman's 1993 Strategic Alignment Model; Luftman's 2000 maturity model; and related works (Chan and Reich, 2007; Broadbent et al., 1999; Amarilli et al., 2023; Van de Wetering, 2021; Yoshikuni and Albertin, 2018)). Unlike strategic alignment, operational alignment has been under-theorized; it is often treated as a purely managerial or technical issue in prior studies (e.g., Cataldo et al., 2012; Teo and King, 1997), leading to conceptual ambiguity and a lack of robust methods. We directly address this ambiguity by adopting Venkatraman's (1989) matching perspective on alignment, which requires a tight structural fit between business and IS components. Under this lens, our unit of analysis is the pairwise correspondence between BP activities and IS tasks/capabilities, which is the appropriate level of granularity for prescriptive operational design.

Moreover, anchoring the study in fit as matching is consistent with established operational-level literature and clarifies how we conceptualize and address complexity. In this study, matching operationalizes a specific facet, structural complexity, at the BP-IS interface, where decision-makers must render coherent a large set of activity-task correspondences. The RS routine, combined with abstraction and idealization, acts as a complexity-management mechanism: abstraction limits cognitive overload, idealization preserves implementability, and the RS prioritizes interventions under constraints. This yields prescriptive, pairwise guidance while acknowledging dynamic/process complexity, which we address pragmatically through iterative re-elicitation and re-application rather than explicit modeling. Task-Technology Fit models alignment as a correspondence between task requirements and technology functionalities, and enterprise-system fit/misfit identifies concrete domains (functionality, data, usability, role, control, and culture) where system capabilities must match work needs (Goodhue and Thompson, 1995; Strong and Volkoff, 2010). We recognize, however, that other fit perspectives serve different purposes: moderation tests whether the strength of BP-IS matches conditions the IS-performance relationship (Cragg et al., 2002); mediation treats alignment as an intervening mechanism linking IS capabilities to performance (Bergeron et al., 2001); and profile deviation, gestalts, and covariation capture configurational coherence or distance from ideal profiles at higher levels (Bergeron et al., 2004; Venkatraman, 1989). These lenses are complementary; however, they do not yield pairwise design prescriptions. Our contribution fills that need by providing operational, pairwise recommendations for implementation.

Against this backdrop, prior literature has only implicitly hinted at such structural matching and has not provided a formal mechanism to achieve it. Our study fills that gap: we demonstrate that the RS-based technique operationalizes the matching concept by linking each BP activity with relevant IS tasks using quantifiable metrics. In contrast, existing approaches either lack this structural focus or address only parts of the problem:

- **Driver-based approaches** focus on social or structural factors (e.g., communication, governance) influencing alignment, but they tend to neglect technical execution details. This can limit their practicality when it comes to implementation (Wagner et al., 2014; Bagheri et al., 2019; Santa et al., 2020; Njanka et al., 2021). Our RS approach moves beyond that limitation by including detailed IS-task data in the alignment analysis.

- **ML-based approaches** (e.g., UML or BPMN-driven methods) offer theoretical precision but often struggle with practical complexity and rigidity. They require detailed modeling of processes and systems (Aversano et al., 2016; Kawtar et al., 2019), which makes them hard to adapt to changing environments. In contrast, our technique uses strategic abstraction to include only essential details, improving adaptability without losing important information.
- **BP-based approaches** emphasize BP workflows and their optimization, but they may insufficiently account for IS elements, risking misalignment when processes change or IS capabilities evolve (Millet et al., 2009; Broadbent et al., 1999; Strong and Volkoff, 2010; Jonathan et al., 2021). Our RS-based method integrates IS dependencies and flags potential BP–IS misfits through data-driven indicators, thereby managing areas that BP-only approaches might overlook.

By positioning our technique in this way, we show that the study not only builds upon prior research but also addresses specific shortcomings of existing solution categories. In summary, we contribute a necessary operational-level perspective to the alignment debate by combining the structural rigor of matching theory with the flexibility of a data-driven RS approach.

Theoretical and practical contributions to operational alignment literature

This study advances operational alignment literature by providing a comprehensive approach to address the complexity inherent in aligning BPs and ISs. Through the introduction and empirical validation of an RS-based operational alignment technique, the research specifically addresses the theoretical gap between abstraction, essential for theoretical manageability, and idealization, crucial for practical applicability. Grounded in established theoretical frameworks, this research integrates foundational alignment dimensions and introduces indicators designed to simplify alignment challenges, while maintaining critical details needed for informed decision-making. Furthermore, recognizing the broader impacts of this methodological approach, this study addresses the social and ethical considerations of algorithmic prioritization, exploring both the strategic role of the RS-based operational alignment technique in identifying alignment gaps and the ethical implications associated with prioritization decisions. Consequently, the proposed approach connects theoretical insights, design-science principles, ethical considerations, and actionable implications, which are elaborated in the following detailed subsections.

Theoretical implications

This study significantly advances the theoretical understanding of operational alignment by positioning the RS-based operational alignment technique within foundational alignment dimensions extensively discussed in the literature: Integration Level, Integration Direction, Perspective of Fit, and Categories of Misfit (Henderson and Venkatraman, 1993; Teo and King, 1997; Venkatraman, 1989; Strong and Volkoff, 2010).

First, in terms of *Integration Level*, prior literature distinguishes strategic from operational alignment (Henderson and Venkatraman, 1993; Chan and Reich, 2007; Luftman, 2000, 2003). The RS-based technique contributes by providing the micro foundations of operational alignment through an algorithmic execution mechanism that links strategic intent to executable BP↔IS mappings under structural complexity. Specifically, it represents BP Activity Importance and IS-Task Capability as indicators, computes pairwise fit/misfit at the activity-task granularity using the matching perspective, and prioritizes the resulting adjustments via an RS routine. This specification explains how alignment is accomplished at the element level and yields ordered, implementable actions. The RS-based technique thus bridges a critical theoretical gap regarding practical alignment execution by operationalizing matching logic (Venkatraman, 1989) through a prescriptive, design-science mechanism (Gregor and Hevner, 2013) aligned with misfit-based diagnostics (Strong and Volkoff, 2010). Taken together, these elements constitute a mid-range, design-oriented theory of alignment execution. It is mid-range in the design-science sense (Gregor and Hevner, 2013) because its scope is bounded to operational BP↔IS mapping, it specifies explicit constructs and a generative mechanism, and it is amenable to empirical evaluation.

Second, regarding *Integration Direction*, prior literature defines four primary types: administrative, sequential, reciprocal, and full integration. Administrative direction involves separate planning for business and IS; sequential direction is characterized by a one-way planning process supporting business objectives; reciprocal direction involves two-way mutual influence between BPs and IS tasks, and full integration is concurrent, unified planning (Teo and King, 1997). The RS-based technique adopts reciprocal integration, emphasizing continuous, iterative adjustments and mutual influence between BPs and IS tasks. Adopting reciprocal integration contributes to theory by showing iterative two-way adjustments as critical for ongoing alignment effectiveness, extending the conceptual scope beyond traditional administrative or sequential planning methods.

Third, from the standpoint of the *Perspective of Fit*, Venkatraman (1989) presents multiple conceptualizations, including moderation, mediation, matching, covariation, profile deviation, and gestalt. This study operationalizes alignment through Venkatraman's matching perspective, defining alignment as a direct structural congruence between detailed BP activities and corresponding IS tasks. Operationalizing alignment via this matching perspective provides theoretical advancement by structuring previously ambiguous alignment concepts into measurable metrics (Venkatraman, 1989). Applying measurable criteria through defined indicators addresses literature calls for operationally-oriented conceptualizations of alignment (Cragg et al., 2002; Strong and Volkoff, 2010), thus enabling precise identification and targeted resolution of operational misalignments.

Fourth, regarding *Categories of Misfit*, Strong and Volkoff (2010) categorize alignment misfits into functionality, data, usability, role, control, and culture. This research focuses on the functionality misfit category, identifying and prioritizing alignment issues related to efficiency or effectiveness during BP execution. Addressing functionality misfits explicitly advances misfit theory by operationally defining how to prioritize and resolve practical misalignments, thus clarifying how misalignment can be methodologically identified, analyzed, and resolved in operational contexts (Strong and Volkoff, 2010).

Considering these foundational alignment dimensions collectively, the RS-based technique strategically manages structural complexity inherent in operational alignment, defined in this study as intricate interactions between BP activities and IS tasks. Structural complexity arises from balancing foundational alignment considerations (Integration Level, Integration Direction, Perspective of Fit, Categories of Misfit) against practical needs to simplify organizational reality into actionable strategies. This research manages complexity through strategic abstraction and practical idealization:

- Abstraction refers to transforming complex operational interactions into indicators, retaining essential details for decision-making while simplifying intricate relationships.
- Idealization involves prioritizing achievable improvements rather than attempting perfect yet unattainable alignment, ensuring practical, actionable solutions.

The interplay between abstraction and idealization, guided by foundational alignment dimensions, provides a theoretically rigorous framework for operational alignment. Within this framework, the RS-based technique introduces specific indicators, importance, and performance of BP activities and IS tasks, and the relationships between them, grounded explicitly in these foundational alignment dimensions. Designed to effectively balance abstraction (simplifying complexity) and idealization (targeting realistic improvements), these indicators illustrate the unique contributions of each dimension to alignment theory. Thus, our approach significantly enhances theoretical clarity and practical relevance within the operational alignment literature. Specifically, by explicitly operationalizing abstract alignment concepts through clearly defined, quantifiable indicators, our RS-based technique translates foundational alignment dimensions, as articulated in the previous paragraph, into empirically testable constructs. This operationalization advances Venkatraman's (1989) matching perspective from a purely conceptual framework toward practical applicability, providing a robust foundation for systematic hypothesis formulation and empirical testing. Furthermore, these structured indicators of abstraction and idealization explicitly refine theoretical mechanisms that have been predominantly qualitative or implicit in prior studies, effectively transforming operational alignment into a measurable phenomenon. Consequently, our study significantly extends the theoretical boundaries of operational alignment literature, moving beyond descriptive conceptualizations toward measurable and actionable theoretical frameworks. Building upon this enhanced clarity and operational rigor, the RS-based technique resonates strongly with the theoretical principles underpinning complexity management and strategic abstraction, as discussed subsequently.

Moreover, the theoretical principles underpinning the RS-based operational alignment technique resonate strongly with key dynamics identified in the open innovation literature. Both operational alignment and open innovation contexts face structural complexity arising from dynamic multi-actor interactions, bounded rationality, and collective intelligence. Consequently, our approach of managing complexity through strategic abstraction and practical idealization has broader applicability beyond operational alignment. Specifically, it provides valuable insights for addressing innovation-driven complexity in collaborative environments such as platforms, SMEs, and diverse stakeholder ecosystems (Pyo et al., 2021; Turoń and Kubik, 2022; Yun et al., 2016). Therefore, the validated methodological insights from this study not only enrich operational alignment scholarship but also contribute meaningfully to open innovation theory, establishing a coherent theoretical and practical foundation for managing intricate system interactions across various innovation ecosystems.

Contribution to design science research knowledge

By carefully weaving these theoretical dimensions into the RS technique, our study offers a clearer conceptual model for operational alignment. In essence, we demonstrate that it is feasible to quantify alignment at an operational level in a way that is theoretically sound. This directly addresses calls in the literature for more operationally-oriented alignment conceptualizations (e.g., Cragg et al., 2002; Strong and Volkoff, 2010). Furthermore, from a design-science perspective, our work can be classified as an "exaptation" in Gregor and Hevner's (2013) taxonomy of knowledge contribution. We adapted a known solution approach (RS technique) to solve a novel problem in a new domain (BP–IS alignment). This classification is illustrated in Fig. 3.

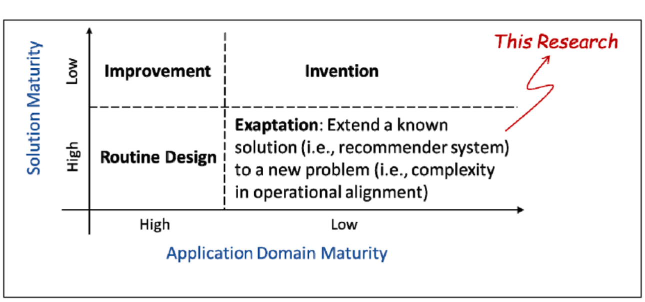


Fig. 3. RS-based Operational Alignment Technique Knowledge Contribution (based on Gregor and Hevner, 2013).

By applying an existing technology in an innovative way for alignment, we contribute both prescriptive knowledge (Λ), in the form of an actionable artifact/method, and descriptive knowledge (Ω), in terms of empirical insights about alignment patterns and principles. In summary, the theoretical contribution lies in clarifying the concept of operational alignment and demonstrating a method to achieve it, thereby extending alignment theory into the operational realm. However, implementing this innovative RS-based operational alignment technique also requires careful consideration of social and ethical implications arising from algorithmic prioritization, as discussed in the following section.

Social and ethical considerations of algorithmic prioritization

This section explores two complementary perspectives regarding the implications of algorithmic prioritization within RS-based operational alignment techniques.

Perspective 1: identifying and closing alignment gaps. The RS-based technique primarily functions as a diagnostic tool to identify alignment gaps by revealing BP activities currently unsupported by IS tasks. Although the RS method inherently involves prioritization, it is not designed to permanently deprioritize or neglect specific BP activities or IS tasks. Rather, it highlights existing gaps to facilitate strategic planning for incremental improvements. Ultimately, every BP activity should be supported by appropriate IS functionalities; if an activity lacks IS support, the necessary capabilities should be developed within the IS to fully support that specific BP, thereby progressively enhancing the organization's alignment maturity.

Perspective 2: ethical implications and mitigation strategies. While offering practical benefits and methodological rigor, RS-based prioritization also introduces ethical concerns related to fairness, equity, transparency, and accountability, particularly within public-sector organizations. Fairness necessitates that algorithms proactively identify and mitigate biases; transparency demands clear, comprehensible explanations for prioritization decisions; and accountability requires robust oversight mechanisms to address any adverse outcomes (Floridi and Cowls, 2019; Veale and Binns, 2017). For instance, prioritizing IS investments in student admissions processes over student support services could inadvertently disadvantage students heavily reliant on those services, potentially exacerbating educational inequities. Similarly, non-transparent prioritization processes may cause stakeholders, such as students, faculty, and staff, to feel excluded from decision-making, thereby diminishing trust and weakening collaborative governance. To mitigate these ethical risks, transparency about prioritization criteria is essential. Organizations should actively involve diverse stakeholder groups from the early stages and sustain continuous feedback mechanisms to ensure recommendations remain aligned with institutional values. Regular audits and reviews are also critical for promptly identifying and addressing biases or unintended consequences, thus safeguarding fairness and equity.

By carefully addressing these ethical dimensions, the RS-based approach ensures responsible and equitable implementation of operational alignment, strengthening stakeholder trust and institutional legitimacy. Such thorough consideration of ethical and social factors provides a robust foundation for transitioning from theoretical insights into practical organizational applications. Building upon this foundation, the practical contributions of the RS-based operational alignment technique become evident, offering organizations a tangible, actionable tool for diagnosing and improving BP–IS alignment, ultimately benefiting diverse stakeholders through enhanced decision-making and operational effectiveness.

Practical implications

The practical contributions of this work are equally significant. We provide a tangible technique that organizations can use to diagnose and improve BP-IS alignment on the ground. Different stakeholders can derive specific benefits:

- Executives gain a high-level overview through the alignment indicators, which serve as early warning signals for misalignment. For example, an executive can see which BPs have low alignment coverage or which ISs support many critical processes, which helps in strategic decision-making and resource allocation. In our case study, executives used RS-generated insights to identify redundant IS modules supporting overlapping administrative processes, leading to strategic consolidation and cost savings.
- IT Managers receive concrete, data-driven recommendations on where to focus IS improvements. The RS output highlights which IS components or modules are underperforming or causing bottlenecks for important processes. In the case study, IT managers learned which systems were overloaded or overlapping (for instance, two systems offering similar functions for student services) and could prioritize those for upgrades or integration. This guided investment decisions and reduced system redundancies.
- Business Process Owners are empowered with evidence to advocate for changes. The technique produces understandable reports showing specific BP-IS misfits (e.g., a critical process step not well supported by any IS). Armed with this information, process owners in our study (such as those managing student registration or financial workflows) could engage in informed discussions with IT departments, clearly pointing out unmet needs or inefficiencies. This led to targeted process improvements and better alignment of IS support with operational needs.

Moreover, the RS-based approach is specifically designed to be flexible and adaptable, suitable for diverse organizational contexts and sectors. It does not rely on any particular industry-specific process but instead leverages generic alignment indicators applicable broadly. This flexibility allows CIOs and IT managers to integrate RS-based considerations across various phases of BP development, effectively aligning evolving IS roles with organizational needs. Specifically, the technique accommodates IS acting as an initiator, triggering new business opportunities or requirements (Hammer and Champy, 1993); as a facilitator, supporting workflow innovation (Kanter, 1996); and as an enabler, enhancing analytical capabilities and information sharing (Alavi and Yoo, 1995). These roles align with distinct stages of the BP lifecycle, before, during, and after process (re)design (Attaran, 2003), ensuring that organizations gain nuanced contextual awareness. This context-specific adaptability, summarized in Table 10, means organizations can effectively tailor the RS-based method to their unique stage and operational needs, thereby informing effective operational alignment decision-making.

We also provide guidance (Table 11) for adopting the RS-based alignment technique. Organizations aiming to utilize this approach must carefully assess their internal alignment characteristics relative to the original study context. Specifically, if an organization's context closely mirrors our case (e.g., a university environment with numerous administrative processes and legacy systems), the technique can be implemented directly and rapidly yield practical benefits. In scenarios where contextual differences exist, organizations can tailor or extend the approach by modifying how BP activities and IS tasks are categorized or incorporating additional domain-specific alignment criteria. Such adjustments enable organizations to derive both descriptive (Ω) and prescriptive (Λ) insights through systematic reclassification of BP activities and IS tasks, thereby ensuring ongoing relevance, adaptability, and enhanced operational effectiveness across diverse organizational contexts.

Organizations with significantly different BP and IS contexts (as indicated in the "Different" row of Table 10) can effectively generalize the RS-based alignment technique by following the structured adaptation steps outlined in this study. Initially, organizations should identify their unique BP activities and IS tasks, assessing relationships among them, specifically, evaluating how effectively current IS tasks support critical BP activities and the relative importance of these tasks to business performance. Based on this analysis, they can tailor the RS-based alignment artifact by redefining their BP activities, IS tasks, and corresponding alignment indicators to fit their distinct operational contexts. Rigorous evaluation will subsequently confirm the effectiveness and practical utility of the adapted technique. Although our empirical validation was conducted within the higher education sector, thus providing a concrete reference model, this structured adaptation approach significantly simplifies application across diverse contexts, such as healthcare, government, manufacturing, finance, or retail. For example, a healthcare organization might redefine BP activities around patient care management and regulatory compliance, aligning these with specialized IS tasks like electronic health records management. Such deliberate customization would yield meaningful, measurable alignment outcomes, clearly demonstrating the technique's broad versatility. Nevertheless, organizations should carefully consider their internal readiness and specific contextual factors, as domain-specific complexities may require additional adjustments. Future empirical validation across various sectors could further reinforce the robustness and generalizability of the RS-based operational alignment method.

Returning to our original evaluation context in higher education, we now illustrate concrete examples demonstrating the practical value delivered to various stakeholders through the RS-based alignment technique:

- *Executives:* Using the RS dashboard, executives in the case study quickly spotted that two separate IS modules were both handling similar student administrative functions. This redundancy was not obvious before. The insight prompted a consolidation initiative, which reduced operational complexity and costs in the long term.
- *IT Managers:* The RS recommendations showed that a particular student registration system was critical to many high-importance processes but had below-average performance. In

Table 10
Improving the RS-based operational alignment technique.

Goal	What to Consider					DSR Knowledge	
Improving the RS-based operational alignment technique			**Phases of BP Development**			**Type**	**Form**
			Before Design	During Design	After Design	Ω-Descriptive knowledge	Explore additional IS tasks and re-classify them
	Roles of IS	Initiator	*				
		Facilitator		*			
		Enabler			*		
	Apply different features based on both the structural and the environmental contexts					Λ-Prescriptive knowledge	Technique

Table 11
Adopting the RS-based operational alignment technique in organizations.

Goal	What to Consider			DSR Knowledge	
	Type of Organization	Factors		Type	Form
		BP and IS	BP activities, IS tasks, importance of the BP for each of the ISs, and importance of the IS tasks for each of the BPs		
Effective adoption of the RS-based operational alignment technique in organizations	Same context	✓	✓	Λ-Prescriptive knowledge	Practical implementation of the presented technique in a different context.
	Similar	✓	×	Ω-Descriptive knowledge	Exploration of more BP activities and IS tasks and their reclassification.
	Different	×	×	Λ-Prescriptive knowledge	Technique

response, IT managers prioritized this system for an immediate upgrade. They also discovered overlapping functionalities in several IS modules, informing decisions to eliminate those overlaps. These actions enhanced service quality and user satisfaction because resources were focused on the most impactful areas.

- *Business Process Owners:* A process owner responsible for student onboarding saw through the RS analysis that some steps in the onboarding process were not well supported by any existing IS (a clear misfit). Backed by this data, the process owner successfully argued for acquiring a new module to fill the gap. This data-driven negotiation ensured that IS investments were directed to truly needed improvements.

Collectively, these examples show how the RS-based operational alignment technique can help various stakeholders address alignment issues. By making misalignments visible and measurable, it bridges the communication gap between business and IS perspectives. In practice, this means organizations can move beyond ad-hoc alignment fixes to a more governed, evidence-based alignment process. Ultimately, the approach helps turn alignment from a one-time project into an ongoing, managed activity, thereby improving operational efficiency and agility.

Furthermore, to enhance the real-world operationalization of the RS-based operational alignment technique, organizations could adopt practical integration approaches compatible with existing enterprise platforms. Specifically, the RS outputs can be seamlessly integrated with ERP or BPM systems using standardized APIs or middleware, facilitating automated data exchange and ensuring alignment recommendations immediately inform decision-making within ERP/BPM environments (e.g., SAP, Oracle, IBM BPM). Additionally, embedding analytical dashboards into ERP/BPM interfaces (e.g., using Power BI or Tableau) can improve stakeholder accessibility to alignment insights, thereby streamlining decision processes. Another complementary approach is to employ Robotic Process Automation (RPA) technologies (e.g., UiPath, Automation Anywhere) to automate the implementation of alignment adjustments recommended by the RS, reducing manual effort and accelerating corrective actions.

However, organizations considering implementation in significantly larger or more complex operational contexts should address scalability challenges. Although the proposed RS-based approach effectively managed complexity within moderate-sized environments (such as TPUs), substantial growth in the volume of BPs and IS tasks may necessitate leveraging scalable RS techniques, such as distributed computation, algorithmic enhancements, or dimensionality reduction methods. Proactively integrating these scalability-focused improvements ensures sustained computational efficiency and responsiveness, thereby enhancing the practical viability of the RS-based operational alignment technique across diverse organizational scales.

Limitations and future research

Despite its contributions, this research has some limitations, offering promising directions for future exploration. Firstly, our empirical evaluation, while robust, was limited in scope. Although Delphi rounds and workshops provided strong initial validation, the relatively moderate sample size restricts broader statistical generalizability. Future studies could extend this work by applying the RS-based technique in multiple organizational contexts, conducting controlled experiments, or employing large-scale surveys. Such broader validation would further demonstrate effectiveness and practical relevance across diverse environments.

Secondly, our model currently provides a static snapshot of alignment at a given point in time, overlooking the inherently dynamic nature of BPs and IS environments. Future research could explore longitudinal or real-time alignment monitoring systems. Integrating the RS-based technique with process mining tools or live dashboards could offer valuable temporal insights, enabling organizations to monitor evolving alignment trends effectively. Beyond dynamic monitoring, future work can also complement our matching-based artifact with moderation/mediation models to quantify the performance consequences of the recommended BP-IS matches and with profile-deviation analyses to benchmark organizations against ideal operational profiles.

Thirdly, scalability may become challenging as the volume of BPs and IS tasks substantially grows. While our approach demonstrated efficiency within moderately-sized TPUs, larger or more complex organizational contexts might face increased computational demands, affecting responsiveness. Future implementations should investigate advanced optimization methods, such as dimensionality reduction or distributed computing frameworks, to ensure sustained efficiency and accuracy at greater organizational scales.

Lastly, the current RS approach focuses exclusively on structural and functional alignment, intentionally excluding human-centric factors such as organizational culture, user attitudes, and change management. These soft factors significantly influence alignment outcomes and practical effectiveness. Extending the approach to incorporate qualitative metrics (e.g., user satisfaction or cultural fit) would result in a more holistic and human-centric alignment methodology, enhancing practical implementation in diverse contexts. Furthermore, future research should specifically explore how the RS-based operational alignment methodology could integrate open innovation principles, examining the management of complexity and multi-stakeholder dynamics prevalent in open innovation contexts, thus broadening its applicability and relevance.

In conclusion, addressing these limitations, expanding empirical validation, incorporating dynamic capabilities, improving scalability, integrating human-centered dimensions, and exploring open innovation integration will significantly enhance the robustness, practical utility, and theoretical depth of the RS-based operational alignment technique. We consider this study a foundational contribution, offering pathways toward an adaptable and comprehensive alignment framework that effectively responds to evolving organizational needs.

CRediT authorship contribution statement

Carson Woo: Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Mohammad Mehraeen:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Olfat Ganji Bidmeshk:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization.

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Ethical statement

This research complies with all ethical standards and guidelines. The study did not involve animals or any sensitive data requiring specific ethical approval.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. : Selected Studies on Operational Alignment

Operational alignment studies are categorized into three main categories: Driver-based, ML-based, and BP-based approaches.

A.1 Selected Studies on Driver-based Approach

Wagner et al. (2014) are among the first scholars who tried to develop an operational alignment model based on social antecedents. Their model combines a social perspective of IS and business with a view of the interaction between business and IS at the operational level. They examined the reasoning for common suggestions, such as more communication between IS and business units, and argued that these suggestions are insufficient for strengthening operational alignment. Moreover, they disclosed the role of the social capital between IS and business units in driving the operational alignment and, ultimately, the IS business value. The results from this study show that (1) social capital theory is a sound theoretical foundation for understanding how the business-IS alignment operates, and (2) managers need to focus on operational aspects of alignment beyond communication by fostering knowledge, trust, and respect. Zhou et al. (2018) attempted to discover the role of shared competence between business and IS departments in achieving operational-level IS alignment (OISA) ambidexterity. They conceptualized OISA as an ambidextrous capability consisting of structural and social alignments and examined its effect on organizational agility. Similarly, Bagheri et al. (2019) designed and evaluated a reference model-based user requirements elicitation process to address the user-related requirements elicitation problems and improve operational alignment implementation. They considered the design of the user requirements elicitation process to be triggered by the seven user-related elicitation problems. Their considered problems were: (1) communication flaws between the project team and customer, (2) terminological problems, (3) weak knowledge of the application domain, (4) stakeholders with difficulties in separating requirements from previously known solution design, (5) incomplete and hidden requirements, (6) missing traceability, and (7) inconsistent requirements. This reference model can improve the requirements elicitation process and, thus, create a shared understanding between the business and IS that will lead to better operational alignment. Building on the driver-based alignment view, Santa et al. (2020) empirically examined the alignment among corporate, operational, and information systems strategies and their impact on firm performance. Their findings emphasize that strategic coherence across these three levels positively influences performance outcomes. While the study adopts a more strategic lens, its inclusion of operational strategy as a mediating layer highlights the need to align business processes and IS execution to reinforce overall organizational alignment. This reinforces the importance of incorporating operational drivers, beyond communication, into alignment frameworks.

A.2 Selected Studies on the ML-based Approach

Studies using modeling languages can be categorized based on their emphasis on business requirements (BRs), BPs, or ISs for achieving operational alignment.

A.2.1 Studies Focusing on Aligning BRs and BPs

Several models and methodologies have been developed to address the alignment of BRs and BPs. Frankova et al. (2011) presented the BPs with the Service Level Agreements (BP&SLA) methodology. This method aimed to reduce the gap between early BRs and executable BPs. They carried out the following steps: (1) analyze the organizational context, using Tropos; (2) define a hypergraph as an intermediate for reasoning about BPs and their qualities; (3) build a hierarchy of BPs, using BPEL specifications, and (4) build a constraint system. Later, Kraiem et al. (2014) linked intentional and operational levels that defined the mapping rules to translate a MAP into a BPMN model. This study represented the MAP using UML formalism as a directed graph in which nodes are goals. Similarly, Sousa, do Prado Leite (2014) used i* to represent a goal model and BPMN to model BP. Their alignment approach consisted of mapping and merging i* to BPMN. They proposed GPI (Goals, Process, and Indicators), which aims to merge i*, BPMN, and KPI (Key Performance Indicators). Li et al. (2015) presented an approach (GSP) that includes a goal, scenario, and BP model. They represented the goal model by the Goal-Oriented Requirement Language (GRL), the scenario model by Use Case Maps (UCM), and the BP model by BPMN. To link the BR and BP levels, the researchers defined a set of mapping rules using the QVT operational language and established a set of rules from GRL to UCM and from UCM to BPMN.

A.2.2 Studies Focusing on Aligning BRs and ISs

Gehlert et al. (2008) proposed an approach to align BRs and ISs, using the Tropos' goal model to establish alignment. Another study focused on aligning BRs and ISs in a study by Han et al. (2009) that presented an approach to align goals to services. They used the Business Motivation Model (BMM) to represent a goal model and Service-oriented architecture Modelling Language (SoaML) for the representation of the service model. Wan-Kadir and Loucopoulos (2004) proposed one aspect of the Manchester Business Rules Management (MBRM) approach to map the business rules to the software design elements.

A.2.3 Studies Focusing on Aligning BPs and ISs

Aversano et al. (2016) presented an approach to align BPs and ISs in three phases. The first phase modeled alignment through the following steps: (1) representing BPs by using UML activity diagrams and adding notations; (2) representing the ISs by using UML use cases, classes, states, and sequence diagrams; (3) identifying the existing relations between the two models; and (4) identifying the functionalities of software that must be modified or implemented to support the BPs. In the second phase, they evaluated alignment by a proposed method that used a set of metrics to codify the concept of alignment. Thus, five metrics were used to measure the percentage of business elements supported by the ISs, and four metrics were used to specify the degree of adequacy offered by automatic support to the business entities. The third and final phase was evolution execution, which dealt with the evolution of the activities in case misalignment was detected. De Castro et al. (2011), however, exploited an approach based on MDA to specify the correspondence between the CIM (Computation Independent Model) and the PIM (Platform-Independent Model). Therefore, they used an e3 value to represent relations and values between actors of BPs and BPMN to represent the business view. The software view was represented by UML, with the following steps: (1) define mappings between models by natural language, (2) collect the mappings with a set of rules, and (3) implement rules with the ATL language. In another study, Elvesater et al. (2010) proposed a method based on eight mapping rules that allow researchers to transform a BPMN model into a SoaML model. They implemented the approach within CIMFlexMT, which supports the model-to-model transformation, using Atlas Transformation Language (ATL). Cibran (2009), consistent with Elvesater et al. (2010), provided an approach focusing on defining a set of mapping rules to transform each BPMN element to its corresponding in UML Activity metaclass. Their approach was then implemented using ATL.

A.2.4 Studies Focusing on Aligning BRs, BPs, and ISs

Vasconcelos et al. (2001) proposed a UML-based framework to solve problems rooted in the alignment of BPs and ISs that jeopardize the business model. The framework has three levels that are associated with each other. At the first level, goals represent the affinity to the manager's reality through concepts introduced in the Balanced Scorecard. BPs appear as a middle tier to operationalize goals without the details of the ISs. In contrast, the details of the relationships between BPs and ISs are represented in the third and final layer of the framework. Similarly, Doumi et al. (2013) presented a metamodel for business-IS alignment. This metamodel links the goal model to the BP and then aligns BPs to the ISs. They used UML to model business and IS domains, used i* formalism to represent a goal model, and finally proposed a set of metrics to evaluate the degree of alignment.

A.3 Selected Studies on the BP-based Approach

The supply chain operation reference (SCOR)-based alignment reference model, business process management (BPM) life cycle, and the architecture of integrated information systems (ARIS) method are BP-based approaches in achieving operational alignment. By viewing the supply chain as a BP, the SCOR model is a useful management tool to evaluate, control, measure, and improve the supply chain process by utilizing the best practices in the domain. This model's process map captures the physical product flows of the supply chain while ignoring critical BP dependencies (Millet et al., 2009). To overcome this limitation, Millet et al. (2009) proposed a SCOR-based alignment reference model based on BP's physical and informational dependencies. The SCOR-based alignment model enables the measurement of the consequences of business process redesign (BPR) on IS, and it facilitates the evaluation of the necessary IS support for BP. In a way, Millet et al. (2009) have considered the reciprocal integration between BP and IS as one of the main considerations in operational alignment.

The BPM life cycle divides the design and support of BPs into phases. During the design phase, BPs are (re)-designed according to business needs. In the configuration phase, designs are configured by a process-aware IS. The enhancement phase starts where the BPs are executed and leverages the configured IS. Finally, in the diagnosis phase, BPs are analyzed, and potential problems are troubleshot if needed. This lifecycle highlights the necessity of continuous BP reengineering to respond to the constant changes of the organizational environment. Because BPs are changing, the supporting IS must also adapt accordingly, which leads to a continuous cycle of alignment of IS with BP (Weske et al., 2004). In a way, Weske et al. (2004) considered the changes in business requirements to be another consideration in operational alignment.

The architecture of the integrated information systems (ARIS) method is function-based and takes a BP-based approach. ARIS supports BP modeling and documentation of enterprise architecture (Tbaishat, 2018). ARIS provides various models corresponding to different views: organizational, data, process, function, and product. (1) Organizational view demonstrates the units within the organization, or the "who". (2) Data view focuses on the objects, or the "what". (3) Process (control) view prioritizes the functions to be performed, or the "what is to be done?". (4) The function view represents the activities, and finally, (5) the product view refers to a service or a product (Scheer and Nüttgens, 2000). ARIS links all these views at the operational level. In other words, ARIS is a function-based method that connects applications with functionalities, tasks, and organizational units to represent an approach closer to the operational alignment requirement. ARIS is a method for analyzing the BPs that takes a holistic view of the BP design, management, workflow, and application BPs. Since ARIS's emphasis lies on the conceptual technical level, ARIS can also serve as a model for creating, analyzing, and evaluating business management process chains (Tbaishat, 2018). Therefore, this method is based on the BP-based approach, describes the changes in the BP's needs, and implements the business model in IS. Similarly, Van de Wetering (2021) provided empirical evidence showing that dynamic enterprise architecture capabilities, particularly those that support business process agility, positively influence organizational benefits. His findings reinforce the importance of maintaining flexible BP-IS alignment mechanisms that can adapt to evolving enterprise needs and structures. In parallel, Jonathan et al. (2021) emphasized the growing interdependence between digital transformation efforts and business-IS alignment, calling for new research that better integrates operational alignment into digital enterprise design. Their work underscores the significance of aligning operational processes and systems as foundational to broader digital transformation initiatives.

Appendix B. : Details of the Delphi Panel

Table B.1
Detailed Demographics of Delphi Panel

Expert	Sector	Area	Position	Experience (years)		
				IS	BP	Operational alignment
E1	Planning and Development Resources	Strategic Foresight of IT	Chief Information Officers (CIO)	> 7	5–7	> 5
E2	Academia	BP Management	Faculty Member	5–7	> 7	3–5
E3	Learning	Learning Management System	Dean of the Learning Sector	5–7	> 7	3–5
E4	R&D	Executive Management	Dean of the R&D Sector	> 7	> 7	> 5
E5	Planning and Development Resources	IS Project Management	Chairman of IS Consulting Group	> 7	5–7	> 5
E6	Academia	Business Informatics	Faculty Member	> 7	> 7	> 5
E7	Planning and Development Resources	Strategic IS (SIS) Management	Chief Executive Officer (CEO)	> 7	> 7	> 5
E8**	R&D	Business Informatics	Member of the Business Research Center	5–7	5–7	3–5
E9	Planning and Development Resources	Software Engineering	Head of IS Development	> 7	5–7	3–5
E10	Administrative and Financial Affairs	Financial IS	Vice-Dean of the Administrative and Financial Affairs Sector	5–7	> 7	3–5
E11	Academia	IT Engineering	Faculty Member	> 7	5–7	3–5
E12	R&D	Business-IT Alignment	Chairman of IS Research Center	> 7	> 7	> 5
E13	Learning	Learning Management System	Head of the E-Learning Center	5–7	5–7	3–5
E14	Academia	SIS Management	Faculty Member	> 7	> 7	> 5
E15	R&D	Business Project Management	Business Projects Consultant	5–7	> 7	> 5
E16**	Planning and Development Resources	BP Requirements	Member of BP Development Plan	5–7	> 7	> 5
E17	Learning	Learning Planning Management	Vice-Dean of the Learning Sector	5–7	> 7	3–5
E18	Academia	Software Engineering	Faculty Member	> 7	5–7	3–5
E19**	R&D	Business-IT Alignment	Member of the IS Research Center	> 7	5–7	> 5
E20	Planning and Development Resources	Business Process Automation (BPA)	Head of BP Development	5–7	> 7	3–5
E21	Cultural, Social, and Student Area	Student Services Planning	Dean of Cultural, Social, and Student Sector	5–7	> 7	3–5
E22*	Cultural, Social, and Student Area	Monitoring Social Services	Member of Cultural and Social Studies and Planning Group	5–7	> 7	3–5
E23**	Administrative and Financial Affairs	Financial Process Management	Director of Financial Affairs Sector	5–7	> 7	3–5
E24	R&D	IS Project Management	IS Projects Consultant	> 7	5–7	> 5
E25	Academia	Business-IT Alignment	Faculty Member	> 7	> 7	> 5
E26	Planning and Development Resources	Work System Design and Development	Member of the IS Development Plan	> 7	> 7	> 5
E27**	Learning	Assessment System	Director of Learning Assessment	5–7	5–7	3–5
E28	Academia	BP Software	Faculty Member	> 7	> 7	3–5

Legend
(1) Experience in IS development and BP development: 5–7 years & > 7 years
(2) Experience in IS operational alignment: 3–5 years & > 5 years
** means the expert's highest educational degree is a master's; * means the expert's highest educational degree is a bachelor's; all other experts have a Ph.D.

Appendix C. : Sub-processes and BPs at TPUs

C.1 Examples of sub-processes of two BPs

Table C.1
Two Examples of Sub-processes of the BPs

Sub-process	BP
Courses Scheduling During the Academic Semester	Learning Services Provision
Course Registration	
Course and Class Delivery	
Educational Problems Investigation	
Process Standardization	Process Management
Process Analysis	
Process Improvement	
Process Initialization and Stabilization	
Process Assessment and Control	
Organizational Content Management	

C.2 The list of BPs

Table C.2
The List of BPs

No	BP	No	BP
1	SC: Strategy Compilation	24	PR: Public Relations
2	SI: Strategy Implementation	25	CI: Community Interaction
3	SA: Strategy Assessment	26	IUI: International University Interactions
4	ProcM: Process Management	27	OSP: Out-of-school Services Provision
5	ProjM: Project Management	28	PRM: Physical Resources Management
6	PeM: Performance Measurement	29	GSM: Goods and Services Management
7	LP: Learning Planning	30	HRP: Human Resource (HR) planning
8	Ad: Admission	31	HRSS: HR Hiring, Supply, and Selection
9	LSP: Learning Services Provision	32	HRSD: HR Skills Development
10	LA: Learning Assessment	33	FBHR: Facilities and Benefits Provision for HR
11	ST: Study Termination	34	SHHR: Safety and Health Resources Provision for HR
12	RTP: Research and Technology Policy	35	HRTR: HR Transfer and Retirement
13	RSP: Research Services Provision	36	RFEP: Resource and Financial Expenses Planning
14	RAR: Research Achievements Release	37	FCCD: Financial Credits Collection and Distribution
15	TT: Technology Transfer	38	EP: Expense Payments
16	SPlan: Student Services Planning	39	FM: Financial Monitoring
17	SProv: Student Services Provision	40	ICTP: ICT Planning
18	SSME: Student Services Monitoring and Evaluation	41	CNM: Communication and Networks Management
19	SST: Student Services Termination	42	IDM: Information and Data Management
20	CSP: Cultural and Social Planning	43	ICSM: Information and Communication Security Management
21	CSSP: Cultural and Social Services & Products Provision	44	SSM: Software and Systems Management
22	CSFP: Cultural and Social Facilities Provision	45	SHS: Software and Hardware Support
23	CSSM: Cultural and Social Services Monitoring		

Appendix D. : Subsystems and ISs at TPUs

D.1 Examples of subsystems of two ISs

Table D.1
Two Examples of Subsystems of the ISs

Subsystem	IS
Manager Performance Assessment System	Integrated ESS and DSS
Project Management System	
Process Management System	
University Budgeting System	
Academic Program Assessment System	
Employee Performance Assessment System	
Salary and Benefits System	Knowledge-based MIS
Admissions and Registration System	
Document Management System	
Contracts and Tenders System	
Electronic Payments Management System	
Administrative Services Management System	
Learning Services Management System	
Workforce Management System	

D.2 The list of ISs

Table D.2
The List of ISs

No	IS	Description
1	Expert System (ES)	ES emulates the decision-making ability of a human expert. ES is designed to solve complex problems by reasoning through bodies of knowledge, represented mainly as "if-then" rules rather than through conventional procedural codes.
2	Executive Support System (ESS)	ESS is used for non-routine issues and problems for which not only information from various sources (internal and external) is used, but also it is necessary to use human inputs, like assumptions and the personal insights of the manager.
3	Integrated ESS and Decision Support System (DSS)	A system that has combined different functions of ESS and DSS to work as one entity.
4	DSS	DSS is aimed at monitoring, controlling, and making unstructured and ad-hoc decisions.

(*continued on next page*)

Table D.2 (*continued*)

No	IS	Description
5	Integrated DSS and Management Information System (MIS)	A system that combines different DSS and MIS functions to work as one entity.
6	MIS	MIS is aimed at monitoring, controlling, and making repetitive and routine decisions.
7	Knowledge-based MIS	A system that has combined different functions of MIS and KWS to work as one entity.
8	Knowledge Work System (KWS)	KWS is developed to create knowledge (e.g., computer-aided design).
9	Group Collaboration System (GCS)	GCS aims to support cooperation between employees and distribute the available knowledge within the organization (e.g., intranets or enterprise information portals).
10	Office System (OS)	OS primarily facilitates communication, agenda planning, and secretarial work (e.g., electronic mail and voice mail).
11	Office Automation System (OAS)	OAS collects, processes, stores, and transmits electronic messages, documents, and other forms of communication among individuals, workgroups, and organizations.
12	Integrated OAS and Transaction Processing System (TPS)	A system that combines different OAS and TPS functions to work as one entity.
13	TPS	TPS is data-oriented and focuses on historical data on organizational activities. This system's output can be used at higher organizational levels as input for other systems (e.g., payroll).

Appendix E. : Types of BP Activities and IS Tasks

E.1 Example of Two Types of BP Activities

Table E.1
Two Examples of BP Activities and Their Types

BP activities	Type
Student Enrollment Year Extension	Learning Management
Educational Problems and Cases Investigation	
Internship and Training Management	
Learning Outcome Report Development for Courses	
Course Design and Scheduling	
Course Transfer	
Course Add and Drop	
Online Course Offering	
Major Change	
Process Reengineering	Quality Management
Process Initialization and Stabilization	
Process Monitoring and Measurement	
Service Monitoring and Measurement	
Misaligned Service Control	
Document, Experience, and Knowledge Management	
Process Identification	
Documentation Editing and Accreditation	
Beneficiary Satisfaction Assessment	
Optimization	
Gap Analysis	
Continuous Process Improvement	
Process Redesign	

E.2 Examples of Two Types of IS Tasks

Table E.2
Two Examples of IS Tasks and Their Types

IS tasks	Type
Analyzing the Opportunities and Threats of the Environment	Strategic
Analyzing the Strengths and Weaknesses of the Business	
Creating Sustainable Competitive Advantages	
Knowledge Creation and Gathering	Knowledge-based
Knowledge Assessment	
Knowledge Sharing and Dissemination	
Knowledge Contextualization	
Knowledge Application	

Appendix F. : MATLAB Coding

F.1 MATLAB Coding for Recommending the Appropriate BPs for Each IS

```
function startupFcn(app, A)
global a
global c
a = 0;
c = 0;
close all
clear
clc
end
function ISFButtonPushed(app, event)
global S1
global a
global A
S1 = uiimport()
A = S1.data
a = size(A)
end
function ISBPButtonPushed(app, event)
global S2
global c
global C
S2 = uiimport()
C = S2.data
c = size(C)
end
function ButtonPushed(app, event)
global a
global c
global RPT
global C
global A
global B
global CC
global A_p
global C_p
A_OK = 0;
if a ~= 0
if (a(1)= =13)&(a(2)= =11)
A_OK = 1;
end
end
C_OK = 0;
error_counter = 0;
if ((c(1)= =13)&(c(2)= =45))
for i = 1:45
nan_counter = 0;
for j = 1:13
if isnan(C(j,i))
nan_counter = nan_counter + 1;
end
end
if ((nan_counter)> 2)
error_counter = error_counter + 1;
end
end
if error_counter = = 0
C_OK = 1;
end
end
if (C_OK == 1) &,& (A_OK == 1)
for i = 1:45
counter = 1;
```

```
j = 0
while counter< =(11)
j = j + 1;
if not(isnan(C(j,i)))
C_p(counter,1) = C(j,i);
A_p(counter,:) = A(j,:);
counter = counter + 1;
end
end
B(:,i) =inv(A_p)*C_p
end
CC = A*B;
xlswrite('Result1.xlsx',B','BP-Act');
xlswrite('Result1.xlsx',CC,'BP-IS');
end
end
end
```

F.2 MATLAB Coding for Recommending the Appropriate ISs for Each BP

```
function startupFcn(app, A)
global a
global c
a = 0;
c = 0;
close all
clear
clear A_p
clc
end
function BPCAButtonPushed(app, event)
%mydialog1
global S1
global a
global A
S1 = uiimport()
A = S1.data
a = size(A)
end
function BPISButtonPushed(app, event)
global S2
global c
global C
S2 = uiimport()
C = S2.data
c = size(C)
end
function ButtonPushed(app, event)
global a
global c
global RPT
global C
global A
global B
global CC
global A_p
global C_p
A_OK = 0;
if a ~= 0
if (a(1)= =45)&(a(2)= =4)
A_OK = 1;
end
end
C_OK = 0;
```

```
error_counter = 0;
if ((c(1)= =45)&(c(2)= =13))
for i = 1:13
nan_counter = 0;
for j = 1:45
if isnan(C(j,i))
nan_counter = nan_counter + 1;
end
end
if ((nan_counter)> 41)
error_counter = error_counter + 1;
end
end
if error_counter = = 0
C_OK = 1;
end
else
end
A_p = [0 0 0 0;0 0 0 0;0 0 0 0;0 0 0 0]
if (C_OK == 1) &,& (A_OK == 1)
for i = 1:13
counter = 1;
j = 0

while counter< =(4)

j = j + 1
if not(isnan(C(j,i)))
C_p(counter,1) = C(j,i)
counter
j
A_p(counter,:)
A(j,:)
A_p(counter,:) = A(j,:)
counter = counter + 1;
end
end
B(:,i) =inv(A_p)*C_p
end
CC = A*B;
xlswrite('Result2.xlsx',B′,'IS-Tas');
xlswrite('Result2.xlsx',CC,'IS-BP);
end
end
end
```

Appendix G. : Questionnaire for Evaluating the RS-based Operational Alignment Technique in Terms of Four Properties

Evaluate the RS-based operational alignment technique in terms of the following properties:

	Extremely low	Low	Moderate	High	Extremely high
Applicability	fx1	fx1	fx1	fx1	fx1
Usability	fx1	fx1	fx1	fx1	fx1
Ease of use	fx1	fx1	fx1	fx1	fx1
Time and effort required	fx1	fx1	fx1	fx1	fx1

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