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Article

Competency-driven decision making in data-centric offshoring: A fuzzy analytical hierarchy approach

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Abstract: This research addresses a gap in offshore outsourcing studies by examining service providers' competencies in Big Data Analytics as a Service (BDAaaS), Business Process Outsourcing (BPO), and Artificial Intelligence as a Service (AIaaS). The accelerating evolution of AI and data-centric industries necessitates this research to elucidate the essential competencies for achieving excellence in these domains. To overcome subjectivity in evaluating qualitative attributes, the fuzzy Analytic Hierarchy Process (AHP) is employed to assess the significance of service provider capabilities. The findings reveal variations in the importance of provider capabilities across BDAaaS, BPO, and AIaaS sectors. These results align with the strategic goals of many Indian IT outsourcing firms. By highlighting the differing competency requirements in these emerging cloud-based services, the study contributes valuable insights for service providers looking to enhance their competitive position in the global market. This research provides a foundation for future studies on provider competencies in the evolving landscape of data-driven cloud services.

Keywords: Big Data Analytics as a Service (BDAaaS); Business Process Offshoring (BPO); Artificial Intelligence as a Service (AIaaS); Competency-Value-Output (CVO); cloud-based solution

1. Introduction

The delivery model for information technology-enabled services (ITES), traditionally focused on offshoring, is undergoing a significant transformation. This shift extends beyond the well-established practice of offshoring IT functions. It now comprises a wider array of data-driven services that leverage information for analysis and strategic decision-making. This includes Big Data Analytics as a Service (BDAaaS), Business Process Offshoring (BPO), and Artificial Intelligence as a Service (AIaaS). These trends reflect the growing importance of data analysis and automation for decision-making in today's business environment. "Today's pervasive and interconnected world, in fact, puts people at the center of a continuous sensing process, where an enormous amount of data is generated and collected every minute" [1]. The explosion of data presents both opportunities and challenges for businesses. Valuable insights lie buried within these massive datasets, but extracting and using them effectively requires specialized skills and significant resources. Many companies, particularly smaller ones, struggle to manage this internally due to a lack of expertise. The emergence of data-driven ITES like BDAaaS and AIaaS offers a solution that allows businesses to tap into external capabilities and gain a competitive advantage. Big data analytics is a powerful field that combines cutting-edge information technology, mathematics, and scientific methods to extract insights from

massive and complex datasets [2]. Both startups and established players are jumping into the big data game, offering advanced analytics solutions. “Big data analytics can be defined as the process of collecting, organizing, and analyzing big data to discover patterns, knowledge, and intelligence as well as other information within the big data” [3]. On the other hand, BPO can be defined as, “The strategic contracting of business processes to external service organizations” [4]. Both these types of services have witnessed significant growth over the years to meet the increasing demand for data analysis.

Despite variations in market estimates, a study by Mordor Intelligence suggests that the “AI-as-a-Service Market size is estimated at USD 15.09 billion in 2024, and is expected to reach USD 72.22 billion by 2029, growing at a CAGR of 36.78% during the forecast period (2024–2029)”. Imagine software that gets smarter with every task it tackles. Artificial Intelligence as a Service (AIaaS) makes this a reality. These services bring the power of Artificial Intelligence (AI) to businesses of all sizes, removing the need for massive investments in infrastructure or expertise. AIaaS lets you automate repetitive tasks, predict customer behavior with surprising accuracy, and even generate creative content. This technology is revolutionizing how businesses operate, putting AI within reach for anyone who wants to leverage its power. The AIaaS (Artificial Intelligence as a Service) is a subset of cloud services that can provide technical environments and resources to enable customers to undertake their own machine-learning applications. It also offers “access to pre-built models that customers can seamlessly integrate into their applications” [5]. Data-driven ITES services are transforming how businesses function. These services offer a powerful combination of features: they’re adaptable to changing needs, can be adjusted on the fly, and grant access to the latest advancements.

Current research on successful offshoring results tends to concentrate on well-known, traditional services. But the exponential growth of data has created entirely new kinds of services that can be offshored. Nevertheless, from the lens of organizational business performance, the offshoring outcome can be characterized as “the extent to which an organization achieves firm-level business performance improvements as a consequence of an outsourcing decision, such as stock price performance” [6], “return on assets, expenses, and profits” [7]. Few research reveals that a client business’s overall success regarding offshoring depends on the use of parameters such as cost savings [8], better quality of services [9], return on assets, net profits, expenses, changes in market share, and/or earnings per share [10].

An in-depth review of the existing literature regarding BDAaaS, BPO, and AIaaS highlights commonalities among the three types of offshoring services in terms of characteristics of the client firms, attributes related to business engagements, and reasons behind outsourcing. In addition to the usual reasons for offshoring success, researchers have identified several other key factors that include the characteristics and culture of the concerned countries, behavioral aspects that govern the management of contracts, and service delivery capabilities of the service provider. Since the count of such studies carried out in the context of BPO is less, research findings on ITES have found more reasons for outsourcing decisions and outcomes than those on BPO. Common observations on AIaaS indicate that the provision of services is centered around experience in certain fields, technological proficiency, effective knowledge

management, and sound engineering judgment. However, these same characteristics are also necessary for achieving success in BDAaaS and BPO. Workforce and management in the BDAaaS (Big Data Analytics as a Service) and AIaaS (Artificial Intelligence as a Service) primarily consist of engineers with programming experience. Typically, professionals in the BPO industry possess degrees in social science and business, although a significant portion of experts in AI and data science are also hired in this area. Since all three services are facilitated by IT and have numerous commonalities in terms of service delivery, is there any distinction among them? Within the scope of this study, the specific problem at hand gives rise to the following inquiries:

(i) How does AIaaS differ from BDAaaS and BPO?
(ii) What are the key competencies typically possessed by organizations in the AIaaS, BDAaaS, and BPO sectors, and how are these competencies prioritized across the three sectors?
(iii) What are the main distinguishing factors from the perspective of service providers?

Objectives emerging from these research questions are as follows:

(i) To distinguish AIaaS, BDAaaS, and BPO in scope and functionality.
(ii) To identify and prioritize key competencies across these sectors.
(iii) To explore distinguishing factors from the service providers' perspective.

When investigating the study subject, it has been observed that there is a lack of empirical research that examines AIaaS, BDAaaS, and BPO together. Any differences between these services have only been identified from the client's point of view. There is a scarcity of recorded studies that include the perspective of service providers. Another important aspect to consider in this study is assessing the importance of common skills among these services and distinguishing between the three sectors.

Addressing the problem defined, the research aims to determine the most important abilities that service providers in different sectors need. This will be done by quantitatively evaluating the crucial abilities (identified from ITES literature) that are likely to have an impact on other sectors of interest.

This study is focused exclusively on BDAaaS, BPO, and AIaaS. It excludes other IT services. Since this research is mainly focused on identifying the key determinants for successful offshoring from the perspective of service providers operating from India, the scope of the study is limited to Indian offshore service providers. In order to get an objective assessment of the degree and variety of differences in skills and abilities between these three types of IT-enabled services, input data were collected from executives of IT firms who carry out all three forms of offshoring services.

2. Review of literature

Charles et al. [10] explore the impact of strategic outsourcing on firm performance, emphasizing the importance of core competencies and competitive intensity. The research identifies how outsourcing non-core activities can enhance efficiency, profitability, and customer satisfaction while retaining critical functions in-house. Utilizing frameworks like Resource-Based Theory and Transaction Cost Economics, the study proposes a theoretical model that illustrates the positive

relationship between strategic outsourcing and firm performance. The authors suggest that effective management of resources and competitive dynamics is crucial for leveraging outsourcing to achieve better operational outcomes and maintain a competitive edge in the market. Mani et al. [9] investigate high-performance work configurations in offshoring R&D and product development, emphasizing the role of task characteristics in choosing coordination strategies like modularization and information sharing. They highlight the importance of understanding these dynamics for improving distributed R&D performance and address potential biases in survey data collection. Mukherjee et al. [6] outline a framework for value creation in offshore outsourcing, focusing on the strategies of resource restructuring, rebuilding, and leveraging. The critical role of effectively managing both internal and external resources to address global competition and adapt to environmental challenges is presented.

The critical capabilities that are found to be associated with ITES are shortlisted in **Table 1**. Studies on availing services, both in-depth interviews and statistical analyses, show that companies often haven't achieved the expected benefits. This is because they haven't effectively managed communication, expectations, relationships, service delivery, or resources. Existing literature reveals very few studies that focus on the similar and dissimilar skills and abilities that are required for a successful offshore service among the three types.

Table 1. Capabilities/competencies of IT-enabled offshoring services.

Capability/Competency	Description	Source
Service Delivery Capability	The "set of skills, resources, and processes that enable a business to consistently provide superior value to its customers through the effective delivery of services. It involves understanding the customer's value chain and adapting to their evolving needs over time."	[11]
Subject Matter Expertise	Subject matter expertise refers to a "deep level of knowledge and proficiency in a specific area or field, typically held by individuals who are considered experts in that particular subject."	[12]
Process Reliability	The "degree to which a measurement operation is consistent and repeatable. It indicates the reliability of a measure in consistently producing the same results when repeated."	[13]
Agility	It involves being flexible, adaptive, and responsive to evolving circumstances, focusing on people's skills and talents to drive innovation and success.	[14]
Extensibility	Extensibility refers to the "ability of a system or software to easily adapt & incorporate new features, functionalities, or components without requiring major modifications to the existing structure."	[15]
Software Project Management	The "Software project management comprises the tools, techniques, and knowledge necessary to manage the development of software products. It involves planning, organizing, staffing, tracking, and controlling the software engineering activities that are part of the software development cycle".	[16]
Onsite Presence	"The presence of an onsite team that can engage with customers face to face to understand their requirements, convey them offshore, and ensure client satisfaction during the process."	[17]
Software Quality Assurance	Aims to "review internal control mechanisms, ensure adherence to standards, assess internal controls, improve quality, and reduce risk while meeting schedule and budget constraints."	[18]

Table 1. (*Continued*).

Capability/Competency	Description	Source
Information Security	Implementing measures to "ensure the integrity, availability and confidentiality of data and resources within an organization or system."	[19]
Organizational Change Capability	Defined as a "dynamic organizational capability that encompasses adaptive cultures, resilient employees, effective leadership, and an organizational infrastructure conducive to change."	[20]
Technology Commercialization	The process of transferring technology from research institutions to the market for practical applications, aiming to generate economic value and societal benefits through the development and sale of innovative products or services.	[21]
Organizational Knowledge Management	Practice of "effectively creating, using, sharing, and managing information and knowledge within an organization to achieve strategic objectives, enabled by factors such as culture, organizational structure, strategy alignment, skilled personnel, measurement, and supportive technology infrastructure."	[22]
Data Analytics Capability	An organization's proficiency in leveraging information technology resources, analytical processes, and marketing expertise to acquire, store, analyze large datasets, and deliver timely, actionable insights that drive business value.	[23]
Software Reverse Engineering	Defined as the "process of developing a set of specifications for a complex hardware system by systematically examining specimens of that system."	[24]
Business Process Reengineering	The "fundamental rethinking and radical redesign of business processes to achieve dramatic improvements in critical, contemporary measures of performance, such as quality, cost, speed, and service"	[25]
Regional Market Expertise	Encompasses the experiential knowledge of clients, the market, and competitors in a specific region. It also includes understanding the institutional framework, government, values, rules and norms of that particular region.	[26]
Product Innovation	The introduction of a novel product or service that is better than the earlier offerings.	[27]
Client Proximity	Physical or geographical closeness between a service provider or business and its clients. It can also refer to the "level of accessibility and availability of the service provider to the clients, which can impact communication, collaboration, and overall relationship management."	[28]
Contract Governance	Contract governance refers to the governance mechanisms specified in the contract to facilitate monitoring, coordination, and control of the client-vendor relationship.	[29]
Relationship Management Capability	"Firm's ability to integrate resources and capabilities from external sources through establishing, maintaining, and developing relationships with other firms."	[30]
Corporate Reputation	"General organizational attribute reflecting how external stakeholders perceive a firm as 'good' rather than 'bad.'"	[31]
Collaborative Capability	Refers to the "ability of service provider to leverage heterogeneous knowledge derived from disconnected contacts to generate creative solutions." It involves the integration of diverse knowledge pieces and sidesteps the issue of information redundancy.	[32]
Global Presence	Geographic distribution and reach of a multinational firm's operations across different countries and regions worldwide.	[33]
Customer Knowledge	The "ability of a service provider to understand a customer's needs, preferences, and behaviors.".	[34]
Customer Relationship Management	A "strategic approach concerned with creating improved shareholder value through the development of appropriate relationships with key customers and customer segments."	[35]

3. Materials and methods

The research has a resemblance to a multi-criteria decision-making challenge that includes subjective criteria that aim to estimate the importance weights of the specified

skills for achieving successful outcomes in offshore services, specifically for each type of offshoring. A solution methodology called the Analytical Hierarchical Process (AHP) is commonly used in such instances. AHP involves comparing capabilities at each level in terms of their contribution to successful offshore results. These comparisons are made using a nine-point scale, expressed as "preferences between options as extremely preferred, very strongly, strongly, moderately, or equally," which is normally used in such studies [36,37]. "These preferences are translated into pairwise weights of 1, 3, 5, 7, 9, respectively, with 2, 4, 6, and 8 as intermediate values" [38]. The pairwise comparison ratios, which estimate the priority of the compared capabilities, are represented precisely in terms of numbers that are real. Nevertheless, the depiction of the attributes typically tends to be expressed in a verbal manner and lacks specificity. Their interpretation is always characterized by ambiguity and plurality of meaning. Furthermore, humans' assessment of qualitative attributes is inherently subjective and so lacks precision. Therefore, despite the benefits of simplicity and user-friendliness that come with the 1–9 discrete scale, it fails to consider the inherent uncertainty in assigning a numerical value to one's opinion or judgment. Hence, the traditional AHP method is insufficient for accurately interpreting capabilities and determining the importance weights (**Figure 1**).

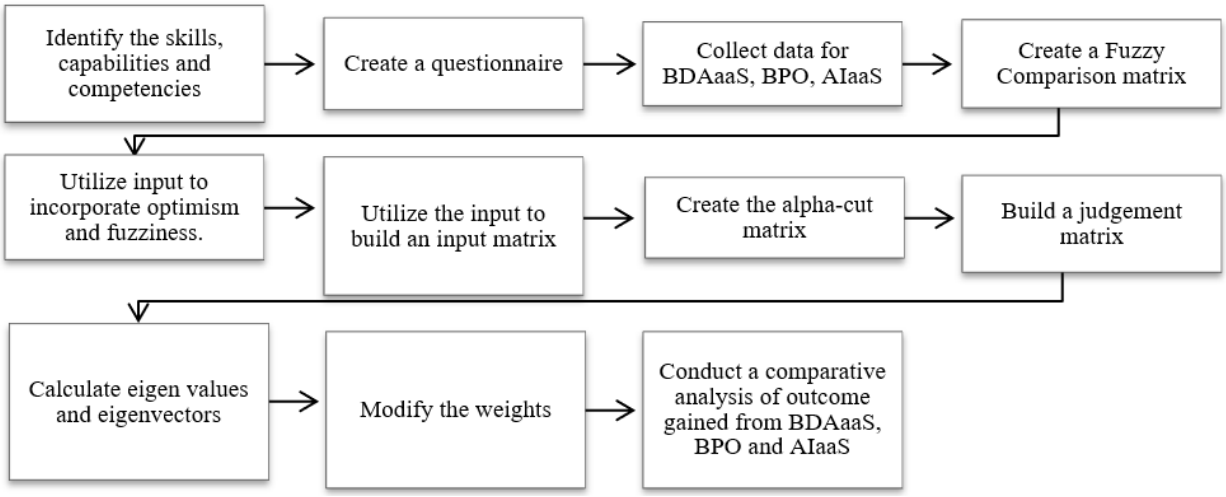

Figure 1. Illustrates the methodology employed to distinguish between BDAaaS, BPO, and AIaaS using Fuzzy AHP.

Fuzzy AHP is highly suitable for ITES competency prioritization due to its ability to handle subjective and uncertain input, making it ideal for emerging domains like AIaaS and BDAaaS where uncertainty is inherent in defining skill priorities [39]. Whereas, traditional AHP works well for structured, well-defined competency models but may oversimplify scenarios involving ambiguity. Furthermore, TOPSIS is better for alternative ranking tasks but lacks the nuanced weighting capabilities of Fuzzy AHP.

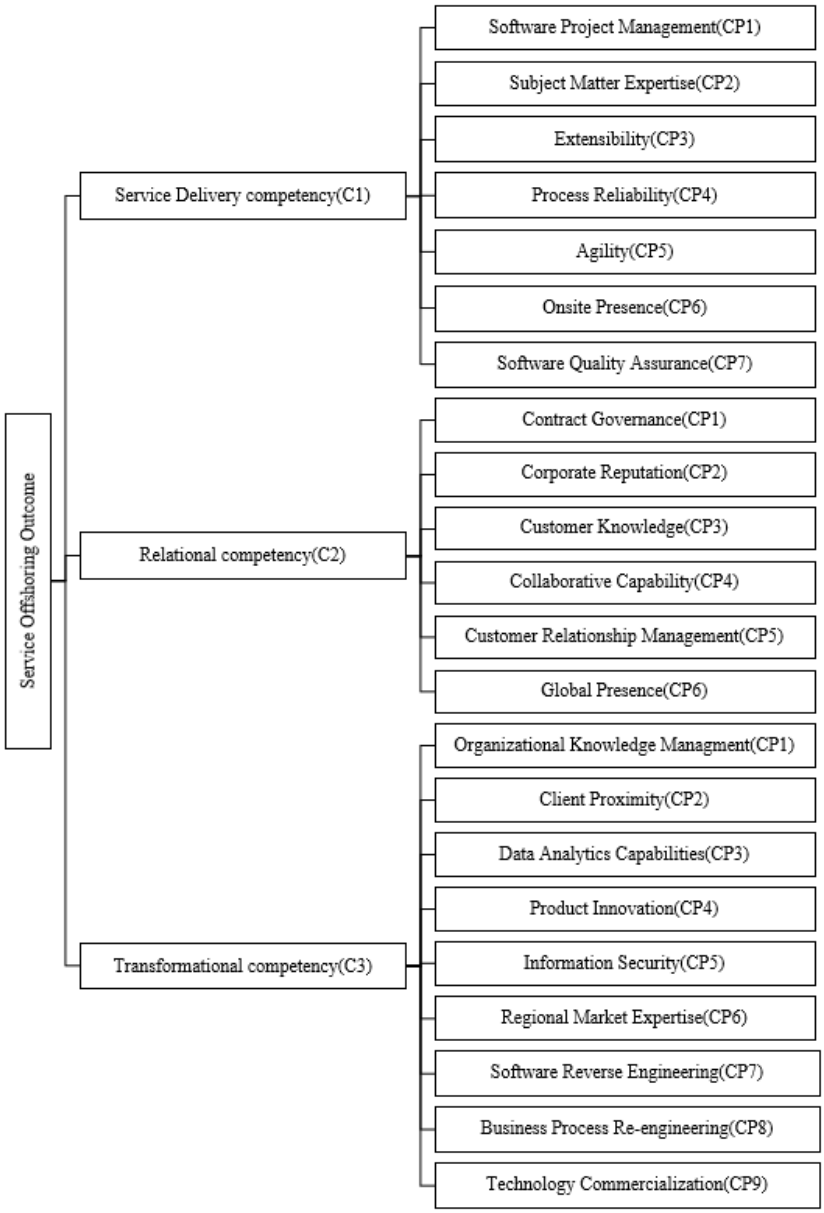

Figure 2. Representation of capabilities grouped under various competencies.

To resolve the uncertainties mentioned above, fuzzy AHP has been used to calculate the significance weights of the indicated capabilities for each competency. This is done to ensure the successful conclusion of each type of offshoring. The efficacy of the Fuzzy Set Theory-based Analytic Hierarchy Process (F-AHP) was demonstrated through its deployment in prioritizing cost elements in the software development arena that used the Agile Software Development (ASD) model [40]. The F-AHP technique was used to rank factors based on the categories relevant to ASD projects (e.g., People, Product, Process, Project). By utilizing F-AHP, the study aimed to address the limitations of traditional AHP by incorporating fuzzy theory to handle uncertainties and imprecisions in decision-making. The framework provided a structured approach to prioritize factors, enhancing the accuracy and effectiveness of decision-making in cost estimation for ASD projects. Fuzzy AHP (Analytic Hierarchy Process) is utilized to address the decision-making ambiguity in the selection of power plant sites, particularly in the context of a study conducted in Indonesia focusing on

Nuclear Power Plant (NPP) development by Abdullah et al. [41]. This study employs AI-based (Artificial Intelligence-based) MCDM (Multi-Criteria Decision Making) to identify key attributes crucial for NPP site selection. Through pairwise comparisons, criteria for NPP site prioritization are established, considering factors such as land use, proximity to wetlands, and accessibility to evacuation routes. The application of Fuzzy AHP enables the handling of complex criteria structures at different levels, enhancing the decision-making process for optimal NPP site selection. Identified capabilities are grouped under 3 competencies as shown in **Figure 2**.

The fundamental procedures involved in the implementation of the Fuzzy Analytic Hierarchy Process (AHP) for this investigation can be succinctly outlined as follows (**Figure 1** illustrates a schematic depiction of the implemented methodology):

(i) The multi-criteria decision-making problem is broken down into smaller, understandable sub-problems that can be quickly evaluated in a hierarchical manner.

(ii) Establishing the order of importance of the specified skills within each skill set for each level of the organizational structure.

(iii) The process of combining the priorities to assess the overall priorities of the choice alternatives.

3.1. Data collection

In order to test the research model and the set of hypotheses, a questionnaire survey has been administered among executives (having more than 5 years of experience) of service-providing organizations based in India and engaged in AIaaS, BDAaaS, and BPO. Each of the variables in the questionnaire has been rated using a Likert-type scale ranging from 1 to 9. A total of 2000 questionnaires have been distributed (1500 by mail and 500 through self-delivery). While the response rate through the mail survey is only 6%, the number of valid responses through the mail survey is 71. However, the number of valid responses obtained through personal visits to the organizations has been 450. Hence, there have been a total of 521 valid responses (complete in all respects), which have been used as the sample for this research work.

3.2. Steps to follow while implementing fuzzy AHP

The solution comprises the subsequent steps as delineated below:

Step 1: Identifying the necessary skills (competencies) and corresponding abilities for BDAaaS, BPO, and AIaaS.

The competencies and related capabilities that are common to the sectors of offshoring services, namely BDAaaS, BPO, and AIaaS, have been determined based on secondary sources of data and previous research work. First, a hierarchy of capabilities is created by categorizing them according to their various skills. Then, a tree diagram is constructed to illustrate the hierarchy of competencies along with their corresponding capabilities. **Table 1** contains a list of the recognized competencies and related capabilities, together with their definitions and sources, for the purpose of this research. **Figure 2** illustrates a hierarchical tree diagram with three levels. The ultimate objective is to achieve a successful “service outcome”. The second level of the hierarchy consists of three distinct competencies: service delivery,

transformational, and relational. All essential traits have been included under the appropriate competence. These capabilities are situated at the lowest tier of the hierarchy. The term used to describe this is the attribute level.

Step 2: Comparing the capabilities of two items on an individual level.

To determine the importance of capabilities (attributes) relative to the element that is immediately preceding it, a pairwise comparison is conducted to assess their respective capabilities at that level. This research utilizes the triangular fuzzy number technique to address the lack of precision in human assessment of qualitative attributes related to capability definitions [42]. The technique is used in order to show the subjective pairwise comparisons of the importance of each capability (attribute) relative to others.

Authors such as Güngör et al. [43] define a fuzzy number as "a special fuzzy set $F = \{(x, \mu_F(x), x \in R\}$, where x takes its values on the real line, $R: -\infty < x < +\infty$ and $\mu_F(X)$ is a continuous mapping from R to the closed interval [0, 1]". A triangle fuzzy number, represented as $\tilde{a} = (a, b, c)$, where $a \leq b \leq c$, is characterized by a membership function of triangular type. Equation (1) represents the membership function and **Figure 3** illustrates the structure of a triangular fuzzy number.

$$\mu_{M^{\sim}} = \begin{cases} 0, \text{ x<a} \\ \dfrac{x-a}{b-a}, \text{ a} \leq x \leq b \\ \dfrac{c-x}{c-b}, \text{ b} \leq x \leq c \\ 0, \text{ x>c} \end{cases} \tag{1}$$

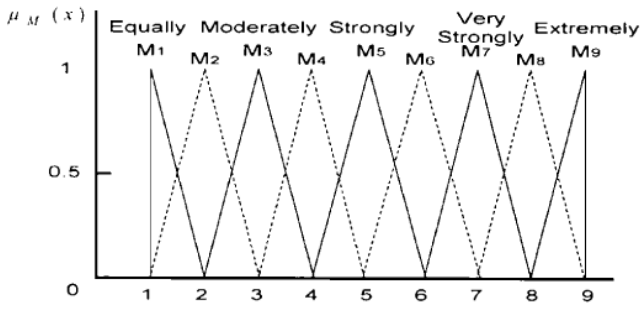

Figure 3. Definition of fuzzy set using triangular membership function.

Alternatively, the triangular fuzzy number can be described as a result of defining a confidence level α within an interval as,

$$\tilde{M}_{\alpha} = [a^{\alpha}, c^{\alpha}] == [(b-a)\alpha + a, -(c-b)\alpha + c] \tag{2}$$

$$for\ \forall\alpha \in [0,1]$$

Alpha-cut (α) is the interval of confidence. The alpha-cut considers the degree of certainty or confidence that experts have in their stated preferences or evaluations [44]. By plugging in the value of α into the above Equation (2), the triangular fuzzy numbers are transformed into an interval that is known as the alpha-cut range. These alpha-cut ranges can then be utilized as a substitute for fuzzy numbers. This transformation results in fuzzy pairwise comparison metrics.

Under the specific scenario, a variable δ denotes the degree of uncertainty in judgment, which is calculated as,

$$\delta = u_t - l_t$$

where u_t is the upper limit and l_t is the lower limit of the triangular fuzzy number which is represented by:

$$M_t = (\mathrm{lt}, \mathrm{mt}, \mathrm{ut}), \mathrm{t} = 1, 2, 3 \ldots \ldots, 9$$

In this case, the outcome is a real number where $\delta = 0$ and the values of δ normally range from 0.5 to 1 [45].

A questionnaire has been created for this research to assess the relative importance of different capabilities within each competency related to a certain type of service. Experts were requested to conduct pairwise comparisons using a preference scale ranging from 1 to 9 in this questionnaire. The Fuzzy triangular numbers are obtained from comparison data using Equation (1).

The traditional version of the AHP pairwise comparison scale, as described by Millet and Saaty [46], has been defined by Nepal et al. [47] and is presented in **Table 2**. A matrix is derived from aggregating the replies provided by the experts at this stage and is referred to as the preference or judgment matrix.

Table 2. Fuzzy AHP Linguistic Scale.

Rating	Verbal Scale	Description
1	"Both the elements are of equal importance".	"Equal contribution of two elements".
3	"When one element is of moderate importance over another".	"Experience and judgment favor one element over another".
5	"When one element is strongly important over another".	"An element is strongly favored".
7	"When one of the elements is of very strong importance over another".	"An element is very strongly dominant".
9	"When one element is of extreme importance over another".	"An element is favored by at least an order of magnitude".
2, 4, 6, 8	"Intermediate values".	"Used to compromise between two judgments".

Step 3: Determination of the significance weight of each particular capability.

The relative significance of each capability was determined by calculating the primary eigenvector *X* of the preference matrix *A*, which was transformed into a crisp form. The equation utilized for this objective is expressed as,

$$AX = \lambda_{max} X \tag{3}$$

A is a fuzzy matrix of size ($n \times n$) that consists of crisp numbers, and *X* is a non-zero crisp vector of size $n \times 1$ that also contains crisp numbers x_i. The symbol λ_{max} represents the maximum eigenvalue of matrix *A*. Before solving Equation (2), it is initially converted into its fuzzy equivalent form, as stated by Kwong and Bai [48]:

$$[a^{\alpha}_{i1l} x^{\alpha}_{1l}, a^{\alpha}_{i1u} x^{\alpha}_{1u}] \oplus \ldots . \oplus [a^{\alpha}_{inl} x^{\alpha}_{nl}, a^{\alpha}_{inu} x^{\alpha}_{nu}] = [\lambda x^{\alpha}_{il}, \lambda x^{\alpha}_{iu}]$$

where,

$$\tilde{A} = [\tilde{a}_{ij}], \tilde{x}^t = (\tilde{x_1} \ldots \ldots \ldots \tilde{x_n})$$

$$a_{ij}^{\alpha} = [a_{ijl}^{\alpha}, a_{iju}^{\alpha}], \tilde{x_i} = [x_{il}^{\alpha}, x_{iu}^{\alpha}], \tilde{\lambda^{\alpha}} = [\lambda_l^{\alpha}, \lambda_u^{\alpha}] \quad (4)$$

for $0 \leq \alpha \leq 1$, where $i, j = 1, 2, 3, ..., n$.

Using Equation (5), a fuzzy preference or judgment matrix can be transformed into a crisp judgment matrix.

$$\hat{a_{ij}^{\alpha}} = \mu \cdot a_{ijn}^{\alpha} + (1 - \mu) \cdot a_{ijl}^{\alpha}, \forall \mu \in [0,1] \quad (5)$$

The symbol μ, referred to as "index of optimism, indicates the degree of optimism of an expert towards the judgment" [49]. "The value of μ reflects the attitude of an expert towards the fuzziness in the judgment. When μ approaches zero, it signifies that the expert's attitude is inclined towards more moderate values or underestimation of the crisp value. Alternatively, when μ approaches 1, then it means that the experts' mindset is disposed towards an overestimation of the crisp value" [47].

The imprecise preference matrix has been transformed into a precise matrix by replacing the numerical values of μ and α. The α and μ remain constant for a specific decision-making scenario and represent the degree of uncertainty or confidence in the judgments, as well as the overall attitude of the experts towards fuzziness. To validate the consistency of the pairwise comparisons, the maximum eigenvalue (λ_{max}) and the confidence interval (CI) have been computed for all the pairwise comparison matrices. This involves solving the equation:

$$AX = \lambda_{max} X \quad (6)$$

where

$$\mathrm{A} = \text{precise pair} - \text{wise matrix},$$

$$\mathrm{X} = \text{primary eigenvectors(column matrix)}$$

Similarly, the following equations are used to calculate the values of CI and CR:

$$CI = (\lambda_{max} - n)/(n - 1) \quad (7)$$

$$C = \frac{CI}{RI} \quad (8)$$

where

$$\mathrm{CI} = \text{Consistency Index},$$

$$\mathrm{CR} = \text{Consistency Ratio},$$

$$\mathrm{RI} = \text{Random Consistency Index}$$

A suitable RI value has been chosen to calculate the consistency ratio (CR), depending on the size of the matrix, *n*. The standard refractive index (RI) values are listed in **Table 3**. Few studies [47] claim that, in order for the CR to be consistent and acceptable, the value has to be less than 0.1. The investigation has determined that the CR values of all the pairwise comparison matrices are below 0.1.

Table 3. Standard refractive index values.

Size of Matrix	1	2	3	4	5	6	7	8	9	10
RI	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49

The vector of priority for elements at a certain level, in relation to the level above (i.e., the weights assigned to various capabilities within a competency for a specific type of offshoring), is determined by normalizing the vector *X*. Authors (e.g., Nepal et al. [47]) say that this comparative evaluation happens recursively at each tier of the orderly arrangement. The goal is to ascertain the relative importance or priority of all the capabilities within the same level, as determined by their contributions to the competencies in the level above.

Step 4: Calculating the overall prioritization weights of capabilities.

The following mathematical formula is used to find out the total prioritization weight (TW_{mk}) of a capability under a specific type of offshoring:

$$TW_{mk} = \sum_{m=1}^{n} \sum_{u=1}^{k} W_{mu} \times W_{uk} \tag{9}$$

where

$$TW_{mk} = \text{total prioritization weight}$$

$$\mathrm{W_{mu}} = \text{relative importance of a competency under a type of offshoring}$$

$$W_{uk} = \text{individual weights of the capabilities under each competency}$$

$$u = \text{type of competency under the type of offshoring}$$

$$m = \text{specific type of offshoring}$$

$$k = \text{type of capability under a competency}$$

4. Results and discussion

The data fed as input is concerned with the performance comparison matrices of the competencies and capabilities of the three categories of service. The MATLAB software was used to calculate the significance weights of the individual talents, accounting for various combinations of the confidence interval (α) and optimism level (μ). **Tables 4** and **5** present condensed results for different values of μ and α, specifically (α = 1.0, μ = 0.5) for AIaaS, BPO, and BDAaaS.

Table 4. Importance weights of capabilities for AIaaS, BPO, and BDAaaS with μ & α as 0.5.

Capability (BPO)	Weights	Capability (AIaaS)	Weights	Capability (BDAaaS)	Weights
μ = 0.5	**α = 0.5**	**μ = 0.5**	**α = 0.5**	**μ = 0.5**	**α = 0.5**
Regional Market Expertise	0.002	Client Proximity	0.002	Client Proximity	0.002
Software Reverse Engineering	0.004	Global Presence	0.004	Regional Market Expertise	0.004
Client Proximity	0.006	Regional Market Expertise	0.006	Global Presence	0.005
Product Innovation	0.007	Onsite Presence	0.007	Corporate Reputation	0.006
Customer Relationship Management	0.008	Software Reverse Engineering	0.008	Business Process Re-engineering	0.006

Table 4. (*Continued*).

Capability (BPO)	**Weights**	**Capability (AIaaS)**	**Weights**	**Capability (BDAaaS)**	**Weights**
μ **= 0.5**	α **= 0.5**	μ **= 0.5**	α **= 0.5**	μ **= 0.5**	α **= 0.5**
Information Security	0.008	Business Process Re-engineering	0.009	Software Reverse Engineering	0.007
Data Analytics Capabilities	0.013	Technology Commercialization	0.013	Technology Commercialization	0.008
Corporate Reputation	0.013	Corporate Reputation	0.013	Product Innovation	0.013
Technology Commercialization	0.015	Information Security	0.014	Onsite Presence	0.019
Business Process Re-engineering	0.023	Product Innovation	0.016	Information Security	0.022
Collaborative Capability	0.020	Data Analytics Capability	0.023	Organizational Knowledge Management	0.023
Onsite Presence	0.020	Customer Knowledge	0.025	Collaborative Capability	0.025
Organizational Knowledge Management	0.030	Software Quality Assurance	0.028	Agility	0.030
Agility	0.031	Organizational Knowledge Management	0.030	Customer Knowledge	0.039
Customer Knowledge	0.037	Collaborative Capability	0.039	Software Quality Assurance	0.046
Process Reliability	0.045	Agility	0.046	Customer Relationship Management	0.065
Global Presence	0.068	Contract Governance	0.065	Extensibility	0.066
Extensibility	0.069	Software Project Management	0.068	Data Analytics Capability	0.068
Software Quality Assurance	0.092	Process Reliability	0.096	Process Reliability	0.098
Contract Governance	0.116	Customer Relationship Management	0.110	Contract Governance	0.110
Subject Matter Expertise	0.141	Extensibility	0.147	Software Project Management	0.145
Software Project Management	0.228	Subject Matter Expertise	0.227	Subject Matter Expertise	0.228

Table 5. Relative importance weights of capabilities under different competencies for AIaaS, BPO, and BDAaaS with μ & α as 0.5.

AIaaS		**BPO**		**BDAaaS**	
Service Delivery Competency	**Global Weights**	**Service Delivery Competency**	**Global Weights**	**Service Delivery Competency**	**Global Weights**
Onsite Presence	0.007	Onsite Presence	0.020	Onsite Presence	0.019
Software Quality Assurance	0.028	Agility	0.031	Agility	0.03
Agility	0.046	Process Reliability	0.045	Software Quality Assurance	0.046
Software Project Management	0.068	Extensibility	0.069	Extensibility	0.066
Process Reliability	0.096	Software Quality Assurance	0.092	Process Reliability	0.098
Extensibility	0.147	Subject Matter Expertise	0.141	Software Project Management	0.145
Subject Matter Expertise	0.227	Software Project Management	0.228	Subject Matter Expertise	0.228

Table 5. (*Continued*).

AIaaS		**BPO**		**BDAaaS**	
Transformational Competency	**Global Weights**	**Transformational Competency**	**Global Weights**	**Transformational Competency**	**Global Weights**
Client Proximity	0.002	Regional Market Expertise	0.002	Client Proximity	0.002
Regional Market Expertise	0.006	Software Reverse Engineering	0.004	Regional Market Expertise	0.004
Software Reverse Engineering	0.008	Client Proximity	0.006	Business Process Reengineering	0.006
Business Process Reengineering	0.009	Product Innovation	0.007	Software Reverse Engineering	0.007
Technology Commercialization	0.013	Information Security	0.008	Technology Commercialization	0.008
Information Security	0.014	Data Analytics Capability	0.013	Product Innovation	0.013
Product Innovation	0.016	Technology Commercialization	0.015	Information Security	0.022
Data Analytics Capability	0.023	Business Process Reengineering	0.023	Organizational Knowledge Management	0.023
Organizational Knowledge Management	0.030	Organizational Knowledge Management	0.030	Data Analytics Capability	0.068
Relational Competency	**Global Weights**	**Relational Competency**	**Global Weights**	**Relational Competency**	**Global Weights**
Global Presence	0.004	Customer Relationship Management	0.008	Global Presence	0.005
Corporate Reputation	0.013	Corporate Reputation	0.013	Corporate Reputation	0.006
Customer Knowledge	0.025	Collaborative Capability	0.020	Collaborative Capability	0.025
Collaborative Capability	0.039	Customer Knowledge	0.037	Customer Knowledge	0.039
Contract Governance	0.065	Global Presence	0.068	Customer Relationship Management	0.065
Customer Relationship Management	0.110	Contract Governance	0.116	Contract Governance	0.110

4.1. Capability importance in offshoring models

At a moderate level of confidence and optimism ($\alpha = 0.5$, $\mu = 0.5$), the importance weights of various capabilities for each form of offshoring can be observed in an analysis of the summarized results (**Tables 4** and **5**). It is revealed that AIaaS's top 4 capabilities in the increasing order of their relative weights for excellent service delivery are Software Project Management (0.068), Product Reliability (0.096), Extensibility (0.147), and Subject Matter Expertise (0.227). For BPO service providers, the five most crucial capabilities for service delivery competency, based on their associated importance weights, are Process Reliability (0.045), Extensibility (0.069), Software Quality Assurance (0.092), Subject Matter Expertise (0.141), and Software Project Management (0.228). For BDAaaS providers, the four essential characteristics and their corresponding relevance weights for service delivery are as follows: Extensibility (0.066), Process Reliability (0.098), Software Project Management (0.145), and Subject Matter Expertise (0.228). When it comes to building relationships with clients, the most important capability for service providers engaged in BPO and BDAaaS is Contract Governance, whereas, for AIaaS, it is Customer Relationship Management. For AIaaS service providers, the two other essential capabilities with associated weights are Collaborative Capability (0.065) and Contract

Governance (0.039). For the BPO service providers, two critical characteristics necessary for relational competency are Global Presence (0.068) and Customer Knowledge (0.037), and for BDAaaS, Customer Relationship Management (0.065) and Customer Knowledge (0.039). The essential Transformational qualities required for AIaaS service providers include Information Security (0.014), Product Innovation (0.016), Data Analytics Capability (0.023), and Organizational Knowledge management (0.030). The weights assigned in ascending order to the competencies for BPO service providers are as follows: Data Analytics Capability (0.013), Technology Commercialization (0.015), Business Process Re-engineering (0.023), and Organizational Knowledge Management (0.030). Regarding BDAaaS service providers, the increasing order of importance of transformational capabilities is Product Innovation (0.013), Information Security (0.022), Organizational Knowledge Management (0.023), and Data Analytics Capability (0.068).

While AIaaS, BPO, and BDAaaS service providers share many common characteristics, the relative relevance of these capabilities varies greatly. In general, it is vital to recognize that Contract Governance is crucial for all forms of offshoring. However, in the case of AIaaS (Artificial Intelligence as a Service) and BDAaaS (Big Data Analytics as a Service), Data Analytics Capability holds the highest level of significance compared to BPO (Business Process Outsourcing). The significance of Global Presence is significantly lower for BDAaaS and AIaaS service providers as compared to BPO. AIaaS and BDAaaS providers prioritize Information Security and Product Innovation while service providers in BPO prioritize Technology Commercialization and Business Process Re-engineering. However, the significance of Extensibility is substantially higher for AIaaS providers in comparison to service providers involved in BDAaaS. The necessity of having a physical presence on-site is less important for businesses involved in all three types of offshoring services. In the context of Business Process Re-engineering, this characteristic serves as a unique skill for service providers in the Business Process Offshoring (BPO) industry.

4.2. Sensitivity analysis

It is important to assess the influence of experts' degrees of optimism (μ) and confidence level (α) on subjective judgments regarding the ranking of various capabilities within each type of competency for a specific offshoring scenario. To accomplish this, it is required to analyze how variations in the values of α and μ affect the changes in the importance weights assigned to the capabilities. To facilitate this analysis, the variable μ has been assigned a value of 0.5, representing a moderate scenario. As an example, the relative significance weights of the capabilities for AIaaS have been established for a certain value of μ (0.5). The confidence level (α) varies between 0 and 1. Therefore, three graphs can be generated to depict the importance weights of the skills for the given value of μ. The graphs provide a comparative examination, spanning from the least uncertain scenario ($\alpha = 0$) to the most certain one ($\alpha = 1$), thereby enabling the assessment of the resilience and consistency of the significant skill weights. **Figures 4–6** have been shown to provide a concise representation of the AIaaS graphs. In addition, for the three offshoring services, the importance weights of capabilities, with a μ and α of 0.5 are presented in **Table 4**. The

study has revealed that the relative significance of all abilities within each competence category for each offshoring type remains constant for all combinations of μ and α. This exemplifies the resilience of the study's conclusions. The sensitivity analysis for Artificial Intelligence as a Service (AIaaS) is shown below, taking into account various combinations of α (μ = 0.5).

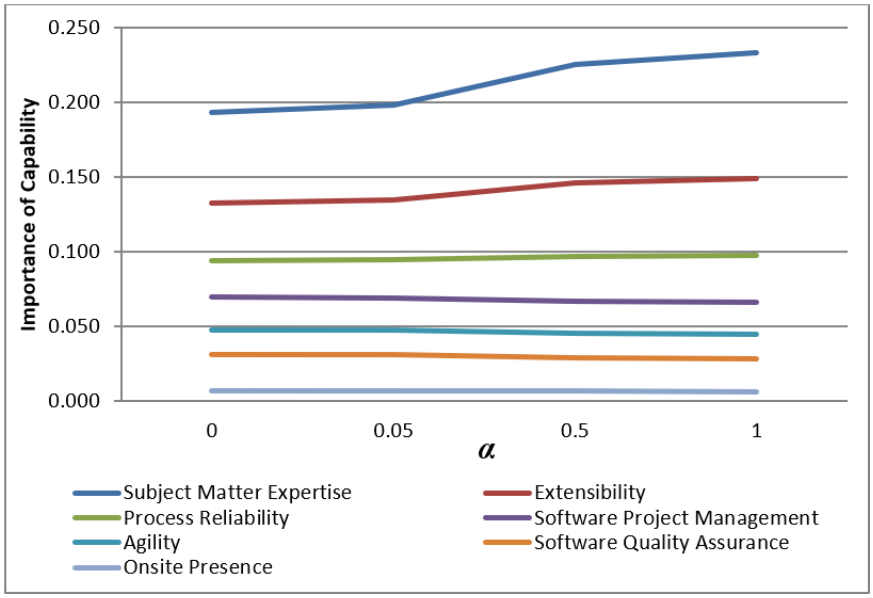

Figure 4. Sensitivity of capabilities within the service delivery competency for AIaaS (Artificial Intelligence as a Service) with a degree of optimism = 0.5.

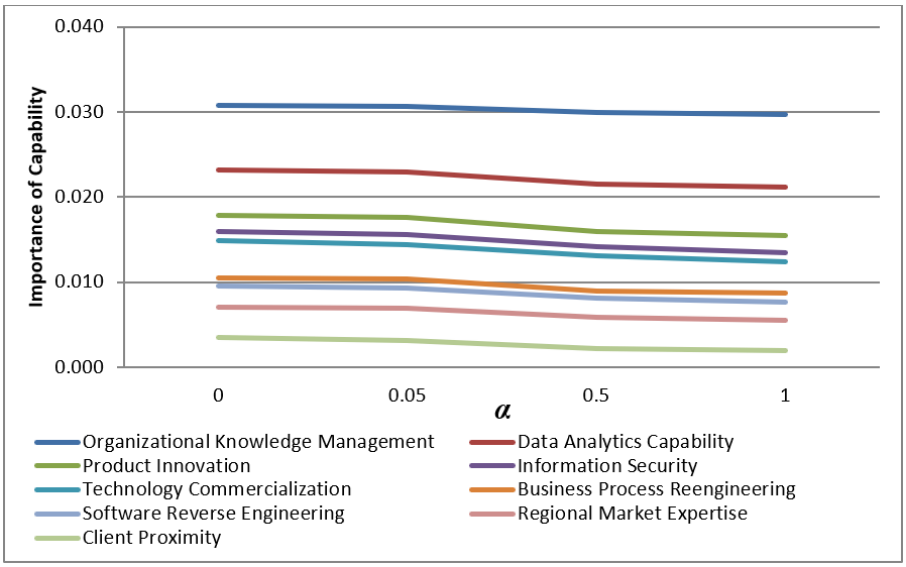

Figure 5. Sensitivity analysis of capabilities within transformational competency for AIaaS (Artificial Intelligence as a Service) with a degree of optimism = 0.5.

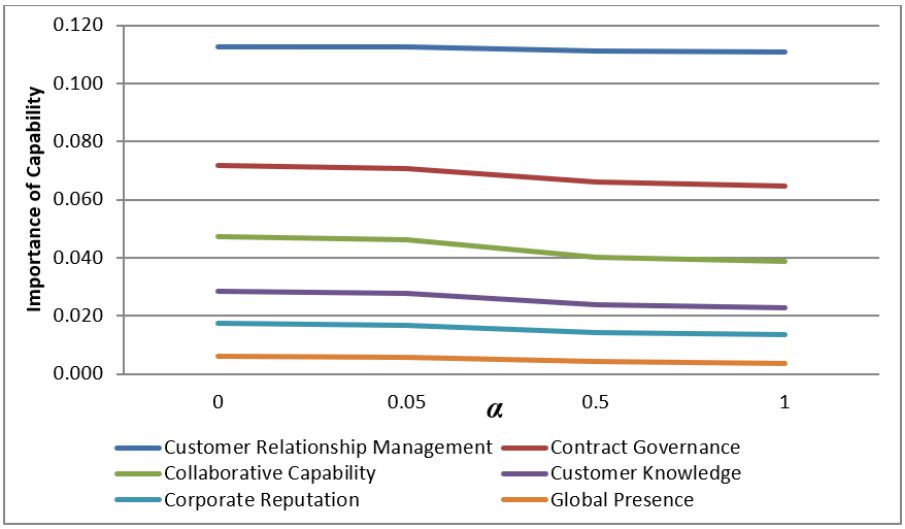

Figure 6. Sensitivity analysis of capabilities within relational competency for AIaaS (Artificial Intelligence as a Service) with a degree of optimism = 0.5.

5. Discussion

The findings of this research can be interpreted using the Resource-Based View (RBV) of the firm and the Dynamic Capabilities framework [50,51]. The differentiated importance of capabilities across BPO, AIaaS, and BDAaaS aligns with RBV's assertion that firms achieve competitive advantage through unique, valuable, rare, and inimitable resources and capabilities. For BPO providers, the emphasis on Technology Commercialization and Business Process Re-engineering suggests the need to develop dynamic capabilities to continuously adapt and reconfigure operational processes. This aligns with Eisenhardt et al. [52] conceptualization of dynamic capabilities as strategic routines through which firms achieve new resource configurations. On the other hand, AIaaS and BDAaaS providers focus more on Information Security and Product Innovation, highlighting the need for ambidextrous capabilities to balance exploiting existing competencies with exploring new opportunities for innovation [53].

The importance of Subject Matter Expertise and Data Analytics Capability for AIaaS and BDAaaS providers can be interpreted through the Knowledge-Based View and the concept of Absorptive Capacity [54,55]. Service providers must excel in integrating specialized knowledge across organizational boundaries, which is critical for combining domain expertise with advanced analytical skills. Absorptive Capacity—the ability to recognize the value of new, external information, assimilate it, and apply it to commercial ends—becomes especially crucial in rapidly evolving fields like AI and Big Data Analytics, where constant innovation is key to maintaining a competitive edge.

The varying importance of Global Presence and Contract Governance across service types can be analyzed using Institutional Theory [56] and the concept of Organizational Legitimacy [57]. BPO providers' emphasis on physical presence and global operations may be driven by coercive and mimetic isomorphic pressures, as they conform to client expectations and industry norms. Meanwhile, AIaaS and BDAaaS providers focus more on establishing cognitive legitimacy due to the relative

novelty of their services. This can explain the higher emphasis on Product Innovation and Information Security, as these firms aim to build credibility and trust in emerging markets by showcasing their expertise and safeguarding sensitive data.

The universal importance of Contract Governance across all service types highlights the relevance of Network Theory [58] and Social Capital [59] in managing offshoring relationships. While formal contracts are essential, service providers should also prioritize developing relational governance mechanisms grounded in trust and mutual interdependence. Boundary spanning capabilities are particularly important for BPO providers as they manage cross-organizational and cross-cultural relationships. Developing strong networks and maintaining social capital enhances their ability to navigate complex service environments and foster long-term client partnerships.

These theoretical insights have practical implications for strategic management in the offshoring services sector. First, capability portfolio management is essential, as service providers must align their investments with the specific capability needs of BPO, AIaaS, and BDAaaS. Second, firms offering multiple service types need to design ambidextrous organizational structures that can support different priorities simultaneously. Third, providers should focus on developing dynamic capabilities that allow them to reconfigure their existing competencies in response to environmental changes. Fourth, adopting an ecosystem strategy—especially for AIaaS and BDAaaS—can enable providers to leverage complementary capabilities and co-create value with partners and clients. Finally, as the industry evolves, service providers can engage in institutional entrepreneurship to shape emerging norms and expectations, positioning themselves as leaders in new service areas.

6. Conclusion

This research provides valuable insights into the distinctions and commonalities among AIaaS, BDAaaS, and BPO services from the perspective of service providers. Through a systematic analysis of capabilities and competencies, several key findings emerge that contribute to both theoretical understanding and practical implementation in the IT-enabled services sector.

The study reveals that while these services share common foundational capabilities, their relative importance varies significantly across service types. Subject Matter Expertise emerged as a critical capability across all three services, highlighting the fundamental importance of domain knowledge in delivering effective IT-enabled services. However, the research identifies distinct capability priorities: AIaaS providers emphasize Software Project Management and Product Reliability, BPO providers focus on Process Reliability and Software Quality Assurance, while BDAaaS providers prioritize Process Reliability and Software Project Management. A notable finding is the differential importance of transformational capabilities across services. AIaaS and BDAaaS providers place higher emphasis on Information Security and Product Innovation, reflecting the innovative nature of these services, while BPO providers focus more on Technology Commercialization and Business Process Re-engineering. This distinction highlights the evolving nature of IT-enabled services and the need for specialized capability development strategies.

The sensitivity analysis demonstrates the robustness of these findings across different levels of confidence and optimism, strengthening the reliability of the capability prioritization framework. This stability in rankings across various combinations of α and μ provides service providers with a dependable foundation for strategic decision-making. These findings have significant practical implications for service providers in the IT-enabled services sector. Organizations can develop targeted capability development strategies aligned with their service offerings. They can also allocate resources more effectively based on the relative importance of different capabilities. Furthermore, service providers can design training and recruitment programs that focus on building critical competencies.

Future research could extend this work by examining how these capability requirements evolve over time, particularly in response to technological advances and changing client needs. Additionally, investigating the interaction effects between different capabilities and their impact on service delivery performance could provide deeper insights into optimal capability portfolio management.

This study contributes to the growing body of literature on IT-enabled services by providing a nuanced understanding of the capability requirements across different service types. As organizations continue to leverage these services for competitive advantage, this research offers valuable guidance for both service providers and clients in navigating the complex landscape of IT-enabled services.

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