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A Study on Information Service Models and Capabilities for Implementing Industry 4.0

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Abstract

This study investigates the organizational capabilities and service models required by information technology (IT) service providers to support Industry 4.0 and digital transformation. Grounded in the resource-based view, lean manufacturing, and value creation perspectives, a qualitative approach is employed through case interviews with Taiwanese IT service providers to examine capability development. The findings classify IT services into functional and solution-based models and identify six key organizational capabilities: human resource management, knowledge absorption and co-creation, IT application, collaborative partnership, problem-solving and continuous improvement, and relationship-building and maintenance. Results further show that the deployment and application of these cap abilities vary across service models. This research provides theoretical insights and practical implications into how providers can enhance their organizational capabilities to meet the evolving demands of Industry 4.0.

Keywords: Industry 4.0, information technology service, organizational capability, service model, value creation

1. Introduction

Since Germany announced the Industry 4.0 initiative in 2013, the global manufacturing industry has evolved toward intelligent and data-driven systems. By leveraging advances in information technology (IT), enterprises can collect data through the Internet of Things (IoT). These data are analyzed and applied using artificial intelligence (AI) and deep learning (DL) to identify customer preferences. Such efforts drive innovation in manufacturing processes and business models through digital transformation.

However, the implementation of Industry 4.0 remains challenging for many enterprises. The core technologies of Industry 4.0 include big data, IoT, AI, cloud computing, and digital twins [1-3]. These emerging technologies require practitioners with advanced IT expertise. Moreover, to achieve digital transformation goals and create value, IT service providers must align with enterprises' objectives and contribute to improving business operations. For example, installing sensors on machines can generate operational data that enables the optimization of energy consumption. Enterprises must clearly define the objectives of IT implementation and rely on IT service providers for support. Likewise, IT service providers must thoroughly understand enterprises' practical needs and offer effective recommendations for introducing digital technologies if Industry 4.0 initiatives are to succeed.

Based on past research, IT service providers supporting Industry 4.0 require not only point-technology expertise but also technical, integration, and co-creation capabilities [4]. However, for external IT service providers, the precise meaning of co-creation capabilities and the mechanisms for interacting with customers remain areas for further exploration. The objective of this study is to explore the service models and organizational capabilities of IT service providers. IT services include IT

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infrastructure setup, business process systematization, software support, hardware maintenance, and IT consulting. Typically, IT providers deliver solutions involving multiple information services rather than isolated tasks. A theoretical framework is first developed to conceptualize the organizational capabilities and service models of IT service providers, and then conducts case studies within the theoretical framework for empirical validation.

The remainder of the paper is organized as follows: Section 2 presents the theoretical background; Section 3 describes two types of information service models; Section 4 identifies the key capabilities of IT service providers; Section 5 outlines the case studies and research methodology; Section 6 discusses the empirical results and provides a detailed discussion. Finally, Section 7 provides the conclusions, practical implications, and suggestions for future research.

2. Theoretical Background

The theoretical development of this research is grounded in a resource-based perspective and systematically examines the concepts of organizational capability, its formation, and the relationship with resource development. In 1983, Daft [5] proposed the concept of corporate resources, which encompasses assets, capabilities, organizational processes, corporate attributes, information, and knowledge. These resources enable firms to formulate and implement strategies that enhance efficiency and effectiveness.

Grant [6] argued that organizational capability is a firm's ability to perform activities more effectively than its competitors. He further suggested that firms should first identify and classify their key resources, use them as the sources of capabilities, and integrate and strengthen these capabilities. Previous research has shown that organizational capability is a primary source of sustainable competitive advantage, and resources are the source of organizational capability. Organizational resources are categorized into human resources, knowledge, IT, relationships, processes, financial resources, and physical resources [7-8], as shown in Fig. 1.

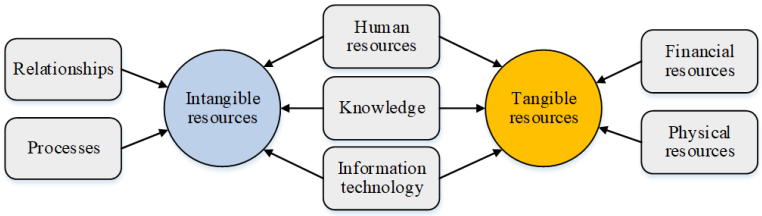

Fig. 1 The resources of Information service organizations

Organizational capabilities are closely related to resources. The ability to utilize resources, or multiple resources, to perform tasks or activities is a major source of competitive advantage. Compared to tangible resources that can be acquired quickly, intangible resources developed through organizational capabilities are more valuable for building a competitive advantage because they are difficult to imitate or replicate. In this study, only intangible resources are considered, as shown in Fig. 2.

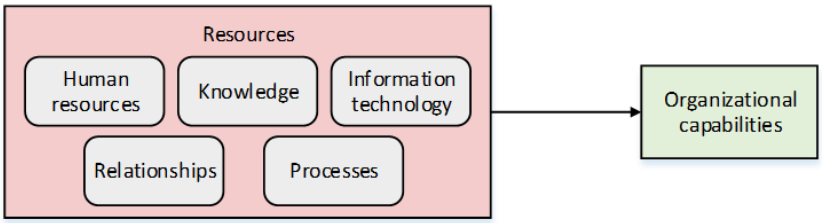

Fig. 2 Organizational capabilities develop from organizational resources

IT services are considered a type of knowledge-based service that provides knowledge and technology. These services involve the transfer of knowledge between the service provider and the customer, as well as a process of mutual communication, interaction, and co-creation [9-10]. During the interaction, customers raise questions that require assistance. The IT service

provider strives to understand the root cause of the problem and propose feasible solutions. Efficient and effective knowledge services are what both customers and knowledge service organizations expect.

In recent years, scholars have proposed the concept of "digital lean manufacturing," which applies lean thinking to Industry 4.0. For instance, lean methods are implemented to reduce manufacturing waste and improve efficiency [11-12]. For IT service providers, integrating lean thinking into organizational capabilities is crucial when assisting clients in implementing Industry 4.0 service processes. This section summarizes the theoretical foundations supporting the research framework.

2.1. Organizational capability accumulates from resources and processes

Resources form the basis of organizational capabilities. Scholars identify resources as comprising human capital, finance, knowledge, IT, relationships, and processes. During digital transformation, IT service providers must understand their customers' objectives and collaborate with them to achieve digital transformation goals.

2.2. Organizational capabilities master digital transformation

Scholars argue that organizational capabilities are pivotal to successful digital transformation. Key themes include strategy and ecosystem, innovative thinking, digital transformation technologies, data analysis, operations, organizational design, and digital leadership [13]. Implementing Industry 4.0 entails redesigning business models. Teece[14] notes that a firm's capabilities not only guide the structuring of its business but are themselves enhanced through this process.

2.3. Knowledge service as a co-creation process with customers

In the knowledge society, knowledge is practical and context-dependent [15-16]. Knowledge service is the transfer of knowledge between providers and customers. IT service companies, as providers of knowledge-based services, may employ functional or solution-based service models and must align their capabilities with customers' strategies.

2.4. Lean manufacturing increases customers' value

Customer value is central to lean manufacturing [17]. Applying lean principles enables the identification of customer value in operations and daily routines [18]. During digital transformation, enterprises need to redesign their business models and processes. IT service providers should, therefore, apply lean thinking to understand customers' needs and support process redesign for implementing Industry 4.0.

3. Two Types of Information Service Models

IT services are classified as knowledge-based services. Unlike typical service organizations, knowledge service organizations do not simply provide knowledge services. Instead, they need to understand and uncover the customer's problems and needs—often knowing the requirements better than the customers do—and efficiently provide professional knowledge and technology. Providers offer professional knowledge and experience [19] and focus on customer processes. A systematic literature review distinguishes between two information service models: functional service and solution-based service, as illustrated in Fig. 3. Functional value is created by the IT service provider, with the customer acting as the recipient of that value. Conversely, solution value is the value that satisfies customer needs. To deliver this, the IT service provider needs to interact closely with customers to understand their contexts and then propose appropriate solutions. In this case, the customer is a co-creator of value.

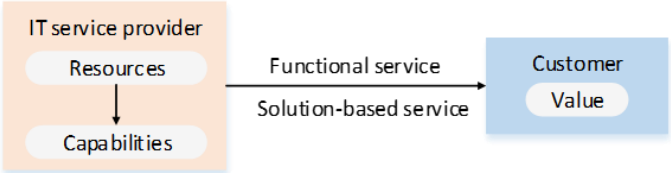

Fig. 3 Two types of information service models

3.1. Functional service provides functional value

Functional value is created and delivered by IT service providers when they solve a specific functional problem or fulfill a clear functional requirement [20]. Customers articulate the need, and the corresponding functional unit supplies the service. Functional service processes are similar and repeatable. Functional service emphasizes efficiency [19].

3.2. Solution-based service provides solution-based value

Solution-based value is co-created by providers and customers, is subjectively assessed by customers during use, and is often difficult to monetize [21-22]. To solve customer problems, IT service providers concentrate on manufacturing and business processes, delivering comprehensive solutions that integrate cross-departmental resources. Providers interact closely with customers throughout the service process [23], prioritizing effectiveness over efficiency [20].

Generally, IT service providers respond to customer needs and expectations, accounting for resources (personnel, equipment, space, etc.) and costs. They assign suitable organizational members to interact with them and select appropriate service models. However, beyond resource and cost considerations, IT service providers select suitable customers, gain a deep understanding of the customer's business development direction, and participate in the customer's processes. These actions enable them to gain insight into the customer's true needs, jointly develop valuable services, and seek opportunities to serve customers with similar needs in the future [24].

4. The Key Capabilities of IT Service Providers

IT service providers play a pivotal role not only in delivering functional services but also in fostering the development of professional and technical competencies. By leveraging their domain expertise, these firms align their services with customers' strategic objectives, organizational structures, division of labor, and workforce training needs. Moreover, they actively contribute to the design of incentive schemes and performance evaluation systems, aiming to enhance service quality and operational efficiency. Such integrative efforts underscore the strategic value that IT service providers bring to organizational performance and long-term capability building.

In offering solution-based services, IT service providers adopt a problem-solving orientation, tailoring their organizational structures to be adaptive and responsive to customers' needs. They recruit and cultivate professionals who demonstrate strong communication skills, a collaborative mindset, and a deep commitment to understanding and resolving client-specific challenges. Beyond technical training, employees possess specialized knowledge as well as a comprehensive understanding of customers' industry ecosystems.

Through the systematic resolution of customers' problems, IT service providers accumulate a repository of effective solution practices, which serves as a foundation for horizontal knowledge diffusion. This accumulated expertise also underpins internal knowledge management practices and is frequently linked to performance-based incentives, thereby reinforcing organizational learning and sustained service innovation.

To effectively respond to evolving customers' expectations, IT service providers must develop a robust set of organizational capabilities. This study identifies six critical capabilities essential for sustaining competitive advantage and delivering value to customers.

4.1. Human-resource management capability

IT service providers need to recruit, train, empower, and evaluate professional personnel. Because IT changes rapidly, providers require staff who can acquire new IT knowledge quickly and maintain a deep understanding of customer industry practices.

4.2. Knowledge absorption and co-creation capability

Beyond IT expertise, providers must learn and internalize customers' domain know-how. This requires a highly efficient capability for knowledge absorption. Interaction during Industry 4.0 implementation often generates valuable experience and tacit knowledge, which demands the capability to co-create knowledge with customers.

4.3. IT application capability

The capability to apply IT is foundational. Effective utilization of IT requires a comprehensive understanding of technological development trends and appropriate application contexts. Furthermore, it demands the competence to assess hardware and software resource requirements and integrate IT solutions with customers' existing processes. Crucially, it also entails accurately identifying clients' underlying needs and delivering suitable IT solutions accordingly.

4.4. Collaborative partnership capability

Providers must collaborate across departments within the organization to develop solutions and serve customers. Often, in order to solve customer problems, IT service providers need to interact closely with customers to design and implement solutions.

4.5. Problem-solving and continuous improvement capability

Providers respond to customer questions and assist in resolving them through specialized expertise. To provide solutions for specific problems, providers need to observe services closely, proactively focus on the customers' use of IT services, and help them establish value-creating processes.

4.6. Relationship-building and maintenance capability

Sustained, trust-based relationships with customers enable providers to deliver knowledge services and pursue long-term cooperation. Providers periodically maintain good interaction with customers to foster a sustainable cooperative relationship and mutual trust.

5. Case Studies

This research adopts a multiple case study approach. All four companies are publicly listed firms with annual revenues exceeding NT$1.7 billion. Their information services include software sales and implementation, customized information systems, consulting services, and the construction of information security infrastructure, thereby covering the information service needs across all aspects of Industry 4.0. Detailed information for these companies is shown in Table 1.

Table 1 Background of case studies company

Case studies	D company	G company	M company	S company
Net sales	10,576,043,513	1,735,871,000	1,773,324,000	7,536,746,000
Gross profit	706,277,441	907,573,000	246,959,000	1,885,273,000
Market position	Digital transformation, Smart manufacturing, Information system development	Software sales, Software cloud service, Software consultant	Software sales and technical service, Information system development and implementation	Computer server sales, Information security service, Information system design
Technological specialization	Enterprise resource planning system, Material resource planning system, Industry IoT system	Enterprise e-commerce system, Cloud service, Information system maintenance services	Financial consolidation statements system, Carbon inventory management system	IT security management, AI, Hybrid cloud service

Note: Net sales and gross profit are based on the 2024 financial reports of companies

Through interviews with senior executives from these four Taiwanese IT service companies, this study elucidates how these accumulate organizational capabilities to help their customers implement Industry 4.0. A series of semi-structured interviews have been conducted to investigate and summarize their service models and the require organizational capabilities.

In human resources management, company G conducts regular training courses to develop employees' professional skills. For example, in business departments, department heads take turns as conveners to plan and propose necessary training courses, facilitating both internal and external training to develop colleagues' management abilities. An evaluation system is in place to assess productivity and future development potential. Each individual has a development plan, and an exceptional promotion system exists that requires approval from the organizational development department and the committee. While different skills are developed for personnel providing solutions or functional services, collaborative work remains a crucial skill regardless of the service type. Employees should possess teamwork abilities, and a positive attitude is equally vital.

Regarding knowledge absorption capabilities, both company D and G have established customer knowledge management systems. A representative from company G stated, "Everyone has very good habits. They are very clear about what cases they are discussing with clients. For example, if a case has been discussed 10 times, these will be recorded in the customer knowledge management system. Before visiting a client, they will review these records."

Hardware sales are one of company S's main business lines. Prior to a sale, company S conducts a site survey to investigate client requirements, such as CPU and capacity, user count, and speed requirements. If the system is to be integrated with an enterprise resource planning (ERP) system, the company considers equipment performance and user volume along with client's business operations to determine the required database storage hardware. Company S believes that "even with machines that provide functionality, we hope to co-create with our clients."

In company M's experience with system development, "customer feedback" serves as the primary driver for the success of subsequent versions. The firm considers issues and feedback received from different customers, reflect on the troubles these problems caused, and gains a deeper understanding of these businesses. Company M stated, “We would then judge whether a feature might be very important to the customer, incorporate it into the product itself, and provide it to all customers for use, so that other customers would also benefit from it."

This present research proposes a framework for IT service organization capabilities, identifying six essential organizational capabilities that such organizations should possess. Empirical research is conducted to determine whether the services provided are functional services (solving specific functional problems or achieving functional objectives) or solution-based services (focusing on customer processes and value creation), as shown in Table 2.

Table 2 Organizational capability related to functional and solution-based IT service models

Organizational capability	Functional service model	Solution-based service model
Human resource management	Clearly defining organizational and managerial processes and developing personnel through recruitment, training, empowerment, and performance evaluating of members based on required professional knowledge and skills.	Aligning organizational roles with strategic objectives and training personnel in industry-specific knowledge.
Knowledge absorption and co-creation	Effectively leveraging IT expertise and experience to enable organizational members to rapidly acquire and apply knowledge in their work, while systematically accumulating service-based experience to develop shared organizational knowledge.	Acquiring customers’ industry experience and knowledge through interactions and systematically categorizing and disseminating this knowledge within the organization to form shared organizational knowledge.
IT application	Applying IT to digitally record, manage, and utilize knowledge and information.	Applying IT to digitally record, manage, and utilize knowledge and information.

Table 2 Organizational capability related to functional and solution-based IT service models (continued)

Organizational capability	Functional service model	Solution-based service model
Relationship-building and maintenance	Establishing and maintaining strong customer relationships to support the delivery of knowledge-based services and foster sustained collaboration.	Establishing and sustaining strong relationships with lead customers to support jointly solution development and long-term collaboration.
Collaborative partnership	Developing customer-oriented solutions through cross-departmental collaboration within the organization.	Leveraging cross-departmental collaboration and close interaction to co-develop solutions.
Problem solving	Responding to customer problems and providing professional expertise to resolve them.	Closely observing service delivery and proactively engaging with customers during service use to help them establish value-creation processes.

Table 3 Empirical evidence of organizational capability case studies

Organizational capability	Functional service model				Solution-based service model			
	D company	G company	M company	S company	D company	G company	M company	S company
Human resource management	○	◎	○	○	○	◎	○	○
Knowledge absorption and co-reation	◎	◎	◎	◎	◎	◎	◎	◎
IT application	◎	◎	◎	○	◎	◎	◎	○
Relationship-building and maintenance	◎	◎	◎	◎	◎	◎	◎	○
Collaborative artnership	◎	◎	◎	◎	◎	◎	◎	◎
Problem solving	◎	◎	◎	◎	◎	◎	◎	◎

◎: very important; ○: important

After conducting semi-structured interviews with senior executives in four cases, each lasting approximately 1.5 to 2 hours, the interviewees' perspectives on the six organizational capabilities required for functional and solution-based services are compiled in Table 3. The following findings are derived from case interviews:

(1) The scale and organizational influence of IT service providers affect the development of human resource capabilities. Respondents emphasized the importance of human resource management; however, given resource constraints, acquiring IT knowledge and quickly understanding the customer's domain are more urgent priorities.

(2) Collaboration capabilities are essential for both functional and solution-based services. Consistent with previous studies, all cases highlight the critical role of collaboration for understanding customer needs, resolving problems, and creating value.

(3) The depth of customer relationships does not necessarily determine the feasibility of solution-based services. Customers tend to select trustworthy IT service providers based on practical needs. Even in the absence of deep relationships, capable providers can engage on-site effectively to address immediate needs.

(4) The importance of relationship building varies by project type. Hardware projects require intense interaction during the planning phase, but less so after installation. In contrast, software projects demand ongoing interaction because requirements evolve rapidly. Accordingly, IT service providers primarily engaged in hardware consider relationship maintenance important, although subordinate to the rapid acquisition of new IT knowledge.

6. Results and Discussions

Empirical evidence reveals that functional and solution-based IT service providers differ in their approach to capabilities. The current research yields the following five important findings.

6.1. Specialization vs. customer context knowledge

Functional IT service providers value deep IT professionals, whereas solution-based providers value talents who can learn from customers. In functional services, the rapid evolution of IT technologies requires human resource development to prioritize the swift acquisition of emerging technical knowledge, with a strong emphasis on specialization and technical depth. Organizations in this domain predominantly require personnel with advanced IT competencies to keep pace with continuous technological advancements.

Conversely, solution-based IT service providers must maintain proficiency in IT development while cultivating a deep understanding of customers' industry-specific domains. In implementing Industry 4.0, the customer's usage context is crucial. Such knowledge is essential for designing tailored, context-relevant solutions that address customers' complex needs. These organizations, characterized by their broader scope and emphasis on horizontal integration, demand a different talent profile—individuals who possess technical literacy along with the interpersonal and communication skills necessary to engage customers effectively. The ability to translate technical concepts into accessible, customer-centric language is particularly critical, as it ensures mutual understanding and facilitates the co-creation of value in service delivery.

6.2. IT-Centric vs. customer-centric knowledge management

Functional IT service providers focus knowledge management systems on IT, while solution-based providers build customer- and application-centered solution platforms. Functional providers typically acquire IT-related knowledge through technical support from established vendors or through independent in-house research. The emphasis in such settings is on speed and efficiency—rapidly assimilating new technologies and codifying them in internal documentation. Knowledge dissemination occurs primarily through internal knowledge bases and informal interpersonal communication among staff members.

In contrast, solution-oriented service organizations engage in more comprehensive, client-centered knowledge-accumulation practices. They systematically build and maintain customer databases and repositories of successful case implementations, organizing them into both industry-specific and customer-specific knowledge artifacts. These organizations place particular emphasis on observation and inductive reasoning, transforming experiential insights into organizational knowledge. Internally, this knowledge supports product innovation, consulting practices, and continuous service improvement. Externally, it serves as a foundation for marketing and customer engagement strategies, with documented success stories functioning as powerful tools to build credibility and foster trust among prospective and existing customers.

6.3. Efficiency vs. customer insight

Functional IT service providers emphasize efficiency, while solution-based providers emphasize a thorough understanding of customer needs. Functional services focus on the verification and implementation of Information technologies. These providers leverage their technical expertise to deliver services that align with predefined customer requirements. In doing so, they maintain close coordination with customers to ensure service delivery aligns with the specified needs and expectations.

By comparison, solution-based IT service providers adopt a more immersive and consultative approach. They assign qualified personnel to work directly at the customer's site, enabling a deeper understanding of the customer's operational context and underlying challenges. Through close collaboration and ongoing dialogue, these organizations co-develop

customized solutions that address complex, context-specific problems, thereby enhancing the strategic value of the service engagement.

6.4. Repetition-based vs. collaboration-based learning

Functional IT service providers accumulate problem-solving knowledge through repetition, while solution-based providers do so through collaboration. Functional providers primarily rely on the repetition of service delivery processes to internalize knowledge and accumulate experiential insights. This learning often stems from the deployment of standardized products or services across multiple customers within similar industry contexts, enabling the gradual refinement of service practices and operational efficiency.

Solution-based IT service providers, however, engage in a more analytical and consultative process, working closely with customers to diagnose complex, and often problems. Through iterative interaction and collaborative inquiry, they assist customers in articulating their needs and subsequently develop tailored solutions that are contextually grounded and strategically aligned.

6.5. Broad IT provision vs. deep customer engagement

Functional IT service providers maintain relationships by sharing new IT knowledge, while solution-based providers assign a dedicated point of contact to key customers. Functional providers strengthen relational ties by organizing regular technical forums and educational training sessions. These activities serve as platforms for knowledge dissemination while providing opportunities to reinforce professional connections and sustain ongoing dialogue with customers.

Alternatively, solution-based IT service providers adopt a more personalized and customer-specific approach to relationship management. They designate dedicated personnel to interact with key or strategically significant customers, fostering close, trust-based relationships. This ongoing engagement enables the service provider to remain attuned to evolving customers' needs and to respond proactively with customized, value-added solutions.

Based on the above five findings, this study summarizes the key distinctions in capability building between functional and solution-based IT services. Amidst the rapid advancements in Industry 4.0 technologies, IT service providers—of functional or solution-based services—that understand domain knowledge and customer usage scenarios can introduce these technologies to customers' sites more quickly. Furthermore, for functional IT service providers, offering success stories from industry peers alongside technical solutions will likely help maintain customer relationships.

7. Conclusions

This study examined how IT service providers in Taiwan assist businesses in driving Industry 4.0, considering the influence of regional industrial policies and cultural factors. The important findings are obtained from the above research:

(1) Six key organizational capabilities: to support the development of Industry 4.0, IT service organizations should cultivate human resource management capability, knowledge absorption and co-creation capability, IT application capability, collaborative partnership capability, problem-solving and continuous improvement capability, and relationship-building and maintenance capability.

(2) Differences in service delivery: the emphasis on specific capabilities varies by service provider model. Solution-based services emphasize continuous interaction and value co-creation, whereas functional services prioritize rapid, efficient fulfillment of customer requirements.

(3) Limitations and future research: given the constraints of the current study, several areas below for future exploration are identified.

- Comparative studies: conducting research in other manufacturing hubs to establish a robust foundation for the universal nature of service delivery models.
- Customer involvement: previous research on machine tools in Taiwan has shown that varying levels of customer involvement yield distinct types of customer value [25]. Whether the same applies to IT service providers' role in driving Industry 4.0 for businesses warrants further investigation.
- Customer perspective: examining the difficulties and required organizational capabilities during digital transformation from the customer's point of view to provide a more realistic outlook.

Conflicts of Interest

The authors declare no conflict of interest.

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