

# Leveraging Intellectual Capital for Industry 4.0: An Analysis of Strategic Alignment and Organizational Readiness

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## ABSTRACT

The advent of Industry 4.0 has fundamentally transformed organizational operations by integrating advanced technologies such as artificial intelligence (AI), the Internet of Things (IoT), big data, and robotics. This paper explores the concept of organizational readiness in the context of Industry 4.0, emphasizing the critical role of Intellectual Capital (IC)—comprising human, structural, and relational capital—and its strategic alignment with organizational objectives. The paper highlights the unique challenges faced by public sector organizations, including rigid bureaucratic structures and limited resources, in achieving this alignment. Despite these challenges, the strategic management of IC is crucial for fostering innovation, operational efficiency, and adaptability in public sector institutions. The proposed conceptual framework outlines how IC components can be aligned with Industry 4.0 strategies, enhancing organizational readiness and facilitating the successful adoption of emerging technologies. This research contributes to the broader discourse on public sector transformation by offering theoretical insights and practical guidance on leveraging IC to navigate the complexities of Industry 4.0. Further empirical research is necessary to validate these relationships across different public sector contexts.

**Keywords:** Industry 4.0, Organizational Readiness, Intellectual Capital, Strategic Alignment, Public Sector

## INTRODUCTION

The emergence of Industry 4.0 has fundamentally transformed the industrial landscape by integrating advanced technologies such as artificial intelligence (AI), the Internet of Things (IoT), big data, and robotics. These advancements require organizations to not only adopt new technologies but also undergo significant shifts in their organizational readiness—the preparedness of an organization's culture, processes, and workforce to effectively leverage these technologies (Voronkova et al., 2021; Bogoviz, 2020). Organizational readiness involves ensuring that all facets of the organization, from leadership to frontline employees, are aligned and prepared to support technological innovation and its integration into existing operations. In the public sector, this readiness is particularly important as government agencies seek to modernize public services and improve their efficiency, transparency, and accountability in the face of evolving citizen expectations.

Achieving organizational readiness is closely linked to the management of Intellectual Capital (IC), which comprises three main components: human capital, structural capital, and relational capital (Voronkova et al., 2021; Chowdhury et al., 2019). Human capital, including the skills, expertise, and competencies of employees, is crucial in fostering innovation and problem-solving abilities within organizations. Structural capital, which encompasses organizational processes, culture, and systems, supports operational efficiency, while relational

capital involves the external networks and partnerships that organizations maintain with stakeholders. The strategic alignment of these elements of IC with an organization's long-term goals is critical for enhancing organizational readiness for Industry 4.0, ensuring that the organization's resources are directed toward achieving competitiveness and operational success (Dalwai & Salehi, 2021). For the public sector, aligning IC with strategic objectives enables public institutions to foster innovation in public service delivery, improve internal efficiencies, and respond to societal needs effectively.

Despite the recognized importance of IC and strategic alignment for organizational readiness, many organizations struggle with aligning their resources with the demands of Industry 4.0. Misalignment can result in significant barriers to achieving organizational readiness, such as a lack of coordination between workforce capabilities, organizational structures, and external partnerships (Soewarno & Tjahjadi, 2020; Pirogova et al., 2020). These challenges are particularly pronounced in the public sector, where bureaucratic structures and resource constraints can hinder effective alignment. Addressing these gaps requires a framework that helps organizations strategically leverage their IC to achieve organizational readiness. This paper proposes such a conceptual framework, illustrating how human, structural, and relational capital can be strategically aligned with Industry 4.0 objectives. By examining the interplay of these elements, this framework provides both theoretical insights and practical guidance for organizations, including public sector entities, to enhance their organizational readiness for successful transformation (Mulyadi & Panggabean, 2017; Nasution, 2023).

## LITERATURE REVIEW

### Industry 4.0: An Overview

Industry 4.0 represents a significant evolution in production and organizational processes, characterized by the integration of advanced technologies such as cyber-physical systems, big data, artificial intelligence (AI), robotics, and the Internet of Things (IoT) (Sudrajat, 2021). This digital transformation enhances agility, efficiency, and innovation within organizations, fundamentally reshaping their operational frameworks and interactions with external stakeholders (Keco et al., 2023). The adoption of these technologies necessitates profound changes in organizational culture, processes, and workforce capabilities (Lyu, 2024). In the public sector, these transformations are equally critical as government entities strive to modernize service delivery, enhance operational transparency, and meet the increasing expectations of citizens for efficient, technology-driven public services (Mariani & Bianchi, 2023).

The readiness of organizations to embrace Industry 4.0 technologies is closely tied to their intellectual capital and strategic alignment capabilities (Kvashina et al., 2021). Organizations that cultivate a culture of continuous learning and adaptability are better positioned to leverage advancements associated with Industry 4.0 effectively (Christensen & Lægheid, 2020). This readiness is essential not only for private enterprises but also for public sector organizations, where the integration of technology must align with public accountability, regulatory frameworks, and societal needs (Xu & Tang, 2020). Research underscores that strategic alignment is crucial for the successful integration of Industry 4.0 technologies, ensuring that technological deployments are consistent with the organization's broader objectives (Molchanova, 2020). In the public sector, achieving this alignment can be particularly challenging due to bureaucratic structures and resource limitations; however, it remains vital for enhancing operational efficiency and addressing the evolving expectations of citizens (Bondarenko et al., 2020).

Overall, the successful adoption of Industry 4.0 technologies necessitates a multifaceted approach that encompasses technological integration, strategic alignment, and workforce development. This approach is equally important for both private and public sector entities (Magna & Maulana, 2022). The digital transformation journey in public administration is not merely about technology; it involves rethinking how services are delivered, improving citizen engagement, and ensuring that digital initiatives are inclusive and equitable (Sihombing, 2024). As governments worldwide increasingly prioritize digital transformation, understanding the implications of these changes on public service delivery becomes essential for creating effective and responsive governance frameworks (Stoyanova, 2023).

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## Intellectual Capital and Its Components

Intellectual Capital (IC) has emerged as a critical resource for organizations, particularly within knowledge-driven economies, where it encompasses three primary components: human capital, structural capital, and relational capital. These components collectively facilitate innovation and help organizations maintain competitive advantages in an increasingly complex business environment (Yilmaz, 2023; Rahman & Mohtar, 2019). Human capital, which refers to the knowledge, skills, and competencies of employees, is particularly vital for fostering innovation and enhancing problem-solving capabilities within organizations (Yilmaz, 2023; Arsawan, 2019). In the context of Industry 4.0, the significance of human capital is heightened as employees are required to develop digital literacy and technical expertise to effectively engage with emerging technologies (Li, 2023; Tran et al., 2022). Continuous learning and adaptability are essential attributes in this landscape, enabling organizations to leverage new technological advancements effectively. This is especially pertinent in the public sector, where reskilling employees is crucial for the successful implementation of digital transformation initiatives (Rahman & Mohtar, 2019; Alfarra, 2019).

Structural capital, which includes organizational processes, systems, and intellectual property, plays a pivotal role in supporting operational efficiency and innovation (Yilmaz, 2023; Rahman & Mohtar, 2019). In the context of Industry 4.0, structural capital must be adaptable and responsive to technological changes, allowing organizations to integrate new technologies seamlessly without disrupting existing operations (Li, 2023; Tran et al., 2022). This adaptability is essential for organizations aiming to thrive in rapidly evolving environments, as it enables them to capitalize on new opportunities while maintaining operational integrity (Yilmaz, 2023; Rahman & Mohtar, 2019). In the public sector, structural capital is instrumental in the digitization of services and operations, necessitating the modernization of outdated systems and processes to meet the increasing demands of digital governance and public accountability (Yilmaz, 2023; Rahman & Mohtar, 2019).

Relational capital, which encompasses the external relationships and networks that organizations maintain with stakeholders, is equally important (Yilmaz, 2023; Rahman & Mohtar, 2019). Strong relational capital facilitates partnerships and collaborations that are crucial for successful Industry 4.0 initiatives. These relationships provide access to cutting-edge technologies, market insights, and resources that can enhance an organization's innovative capabilities (Yilmaz, 2023; Rahman & Mohtar, 2019). In the public sector, relational capital is vital for fostering collaborations with technology providers, research institutions, and other governmental bodies, enabling public organizations to adopt and implement new technologies more effectively, thereby improving service delivery and operational efficiency in the context of digital transformation (Yilmaz, 2023; Rahman & Mohtar, 2019).

In summary, the effective management and development of intellectual capital—comprising human, structural, and relational components—are essential for organizations aiming to achieve sustainable competitive advantages in today's knowledge-driven economy. The integration of these elements not only fosters innovation but also enhances an organization's ability to adapt to the challenges posed by Industry 4.0 (Yilmaz, 2023; Rahman & Mohtar, 2019). For the public sector, managing intellectual capital effectively is equally crucial, as government institutions increasingly face pressures to innovate, improve service efficiency, and respond to the demands of digital transformation while maintaining public trust and accountability (Yilmaz, 2023; Rahman & Mohtar, 2019).

## Strategic Alignment and Organizational Performance

Strategic alignment is a fundamental concept that denotes the extent to which an organization's resources, processes, and intellectual capital are synchronized with its strategic objectives. In the context of Industry 4.0, this alignment is increasingly crucial as organizations channel their intellectual capital—comprising human, structural, and relational capital—toward initiatives that foster digital transformation and innovation. The successful alignment of these resources is vital for organizations to achieve their goals and enhance their readiness for technological changes, as emphasized by Henderson and Venkatraman (Ferreira & Franco, 2017). This alignment is not merely a static condition; it necessitates ongoing adaptation of resources and

capabilities to effectively respond to the dynamic environment characteristic of Industry 4.0 (Ferreira et al., 2021; Sucena, 2023). This is particularly pertinent in the public sector, where organizations must reconcile public service missions with the imperatives of technological innovation.

Research indicates that strategic alignment significantly enhances organizational performance, innovation, and agility. Organizations that adeptly align their resources and strategies are better positioned to react to environmental changes and manage technological disruptions, thus maintaining a competitive edge (Kuzior et al., 2022; Ghlichlee & Goodarzi, 2022). For instance, entities with a high degree of alignment can utilize new information technologies more creatively, optimize IT expenditures, and achieve superior performance outcomes (Al-Tal & Emeagwali, 2019). In the public sector, achieving this alignment presents unique challenges due to the complexities of balancing innovation with public accountability, budget constraints, and regulatory compliance. Nevertheless, studies have demonstrated that public sector organizations that successfully align their strategic objectives with digital transformation initiatives can realize substantial improvements in service delivery, operational efficiency, and citizen engagement (Curado et al., 2011; J6ia & Malheiros, 2009).

The process of achieving and sustaining strategic alignment in rapidly evolving environments like Industry 4.0 is fraught with challenges. Effective communication and collaboration across various organizational levels are essential to ensure that resources and strategies remain aligned (Bilorus et al., 2018; Andersen et al., 2007). In the public sector, this alignment is often complicated by hierarchical structures and rigid processes, which can impede the pace of digital transformation. Furthermore, the dynamic nature of strategic alignment necessitates that organizations continuously evaluate and adapt their alignment strategies to remain relevant amidst technological advancements and market fluctuations (Baikuni et al., 2023). For public sector organizations, this ongoing adaptation is critical to ensuring that their intellectual capital is effectively leveraged to meet both technological and societal objectives.

Strategic alignment is a multifaceted and dynamic process that is essential for organizations striving to thrive in the era of Industry 4.0. By effectively aligning their resources, processes, and intellectual capital with their strategic goals, organizations can enhance their performance, innovation, and agility, thereby positioning themselves for long-term success in a rapidly changing landscape. For public sector organizations, achieving strategic alignment not only facilitates operational efficiency but also enhances public service outcomes and improves the citizen experience. As these organizations navigate the complexities of Industry 4.0, maintaining strategic alignment will be pivotal in successfully integrating technological advancements while fulfilling their core public service missions.

### **Organizational Readiness for Industry 4.0**

Organizational readiness is a multifaceted construct that plays a pivotal role in the successful adoption and implementation of new technologies, particularly in the context of Industry 4.0. This concept encompasses various dimensions, including technological, cultural, and human capital readiness, which collectively influence an organization's ability to embrace digital transformation. As noted by Ghobakhloo (2018), readiness is not merely about having the right technology in place; it also involves the organizational culture and the preparedness of the workforce to engage with new processes and systems. Hanafiah et al. (2020) further elaborate that organizational readiness is crucial for facilitating change, emphasizing that a supportive culture and skilled human capital are essential for navigating the complexities of technological advancements, especially in complex environments like the public sector, where organizations must balance innovation with public service missions and regulatory compliance.

In the realm of Industry 4.0, organizational readiness extends beyond technological preparedness. It includes the capability of employees to adapt to innovations, the flexibility of organizational structures, and the alignment of strategic goals with digital transformation initiatives. Studies have shown that organizations exhibiting high levels of readiness are better positioned to integrate new technologies, adapt their business

models, and maintain a competitive edge (Arlbjørn et al., 2019; Selim et al., 2022). In the public sector, the alignment of readiness is particularly challenging due to rigid bureaucratic structures and often limited resources. For instance, Monshizadeh et al. (2023) highlight that firms with robust readiness frameworks can leverage Industry 4.0 technologies to enhance operational efficiency and customer value. In contrast, public organizations lacking such readiness frequently face significant barriers such as employee resistance and misalignment between strategic objectives and technological capabilities (Saad et al., 2021; Ribeiro et al., 2022).

Moreover, the literature underscores that readiness is a critical predictor of successful Industry 4.0 implementation, both in the private and public sectors. Organizations that proactively assess and enhance their readiness across various dimensions are more likely to achieve successful outcomes in their digital transformation efforts (Lee & Meng, 2021; Ansari et al., 2023). For example, Hanafiah et al. (2020) conducted a systematic literature review identifying key dimensions of Industry 4.0 readiness, emphasizing the need for organizations to improve their technological capabilities and foster a culture that embraces change. In the public sector, this is particularly relevant, as research shows that governmental organizations must align their technological initiatives with public accountability and regulatory compliance (Ghobakhloo, 2018). By aligning strategic goals with digital initiatives and ensuring organizational readiness, public sector organizations can enhance service delivery and efficiency while navigating the challenges of technological adoption.

Conversely, organizations with low levels of readiness face numerous challenges, including inefficient processes and a lack of alignment between strategic goals and technological capabilities. This misalignment often results in wasted resources and missed opportunities for innovation (Saghafian et al., 2021; Saleh & Ijab, 2022). For instance, Ribeiro et al. (2022) found that many companies in Brazil's construction industry reported low readiness levels for adopting Industry 4.0 technologies, which hindered their ability to compete effectively. Similarly, public sector organizations often struggle with aligning their strategic objectives with technological capabilities due to tight budgets and slower adoption rates. This highlights the critical importance of addressing readiness as a foundational element of any digital transformation strategy. Without adequate preparation and alignment, both private and public organizations risk falling behind in an increasingly competitive and technology-driven landscape.

## Theoretical Grounding

The interaction between intellectual capital and organizational readiness in the context of Industry 4.0 is an area that requires further exploration. Intellectual capital, comprising human, structural, and relational capital, has been shown to significantly contribute to an organization's competitive advantage (Sari et al., 2023; Cortellazzo et al., 2019). However, the specific mechanisms through which intellectual capital influences organizational readiness for digital transformation, particularly in the context of Industry 4.0, remain under-researched. This gap is critical as organizations increasingly face the challenges posed by rapid technological advancements and the need for strategic alignment to effectively leverage these changes.

Strategic alignment is essential for organizations to integrate their intellectual capital with their digital transformation objectives. Research suggests that effective leadership plays a pivotal role in fostering this alignment, as leaders can influence organizational culture and readiness for change (Azieva, 2021; Putra, 2019). Transformational leadership has been particularly linked to enhanced organizational readiness by motivating employees and fostering an environment conducive to change (Sia et al., 2021; Xie et al., 2022). This highlights that organizations must focus not only on technological readiness but also on aligning their human and structural capital with strategic goals to ensure successful digital transformation. By doing so, leaders can effectively guide their organizations through the complexities of Industry 4.0.

Moreover, organizational readiness has often been narrowly defined in terms of technological preparedness, neglecting the broader dimensions of readiness that include human and relational aspects (Sun et al., 2023;

Sazonov & Sazonova, 2023). Studies have highlighted the importance of fostering a culture of innovation and adaptability, which are crucial for leveraging digital capabilities effectively (Gfrerer et al., 2020; Adiwijaya, 2023). This underscores the need for a comprehensive framework that integrates intellectual capital, strategic alignment, and organizational readiness, providing both theoretical insights and practical guidance for organizations navigating the complexities of Industry 4.0. Such an integrated framework would ensure that all dimensions of readiness are addressed, leading to more holistic organizational transformation.

To address these research gaps, this paper draws on several established theories. The Resource-Based View (RBV) posits that an organization's resources, particularly intangible assets such as intellectual capital, are critical drivers of competitive advantage (Barney, 2001). In the context of Industry 4.0, organizations with well-developed intellectual capital are better positioned to leverage technological innovations effectively (Ali & Johl, 2023; Dhanapal, 2023). Additionally, Strategic Alignment Theory provides a framework for understanding how organizations can align their intellectual capital with strategic goals, enhancing operational efficiency and responsiveness to market changes (Samarasinghe & Medis, 2020; Dhanapal, 2023). The concept of Dynamic Capabilities further complements this theoretical framework by emphasizing the need for organizations to continuously adapt and innovate, maintaining a competitive edge in dynamic environments (Green et al., 2008; Fürstenau et al., 2014). Together, these theories offer a robust foundation for understanding how intellectual capital can be strategically aligned to drive success in the era of Industry 4.0.

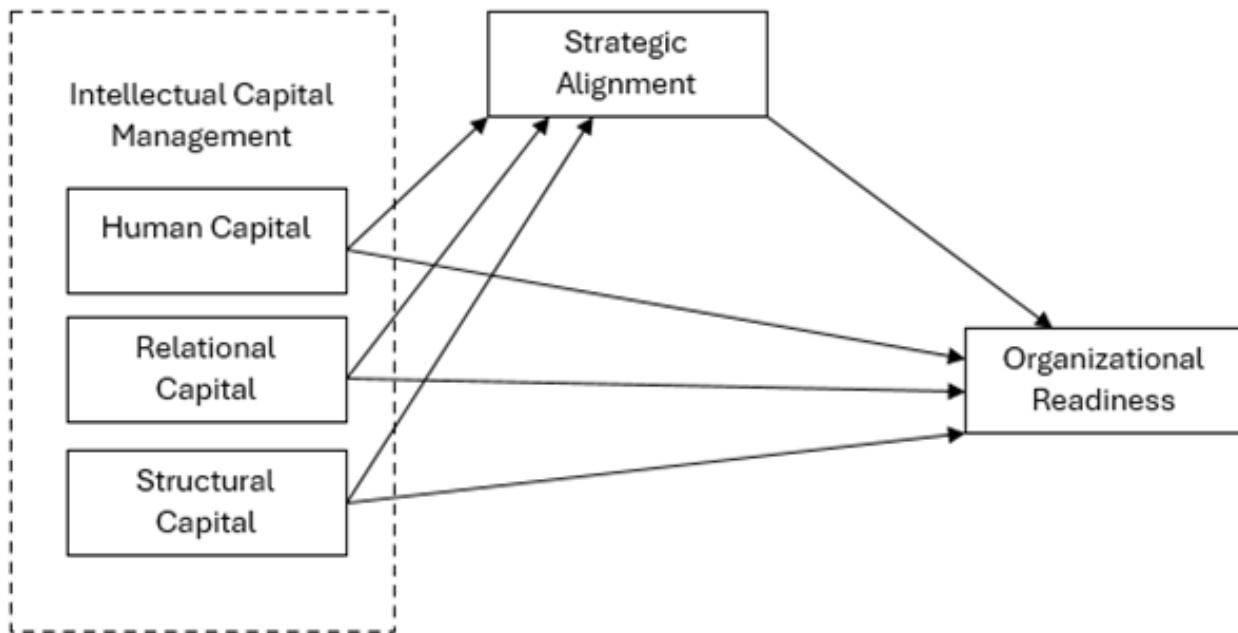
## CONCEPTUAL FRAMEWORK

The public sector's adaptation to the technological shifts of Industry 4.0 presents unique challenges compared to the private sector. Public organizations often operate under stringent regulations, limited resources, and must balance their public service missions with the pursuit of innovation and efficiency. Successful implementation of Industry 4.0 initiatives in the public sector relies heavily on the strategic alignment of intellectual capital—human, structural, and relational capital—with organizational goals. This alignment is essential to fostering organizational readiness, allowing public institutions to navigate the complexities of digital transformation and technological adoption effectively.

As depicted in Figure 1, the framework indicates that human capital, encompassing the skills, knowledge, and expertise of public servants, plays a crucial role in adopting new technologies and fostering innovation in public service delivery. However, public sector organizations often face barriers such as rigid employment structures, limited opportunities for reskilling, and slower digital adoption compared to the private sector. To overcome these challenges, public sector organizations must align human capital development strategies with digital transformation objectives, focusing on reskilling employees in digital literacy, data management, and automation. Similarly, structural capital, which includes organizational processes and systems, must be modernized to support the adoption of new technologies. Aligning structural capital with Industry 4.0 goals improves efficiency, reduces bureaucratic inefficiencies, and enhances transparency. Relational capital, involving networks and partnerships with external stakeholders, further supports this transformation by facilitating access to new technologies and innovations through collaboration with private sector partners, research institutions, and civil society organizations.

Tailoring this conceptual framework to the public sector context requires acknowledging the mission-driven nature of these organizations, which prioritize public service over profit. Public sector organizations must align their intellectual capital with broader governmental strategies, such as national digital transformation agendas, while navigating political and regulatory constraints. The framework assumes that public sector organizations can develop and align their intellectual capital with strategic goals, but challenges such as budget constraints, political interference, and rigid structures may pose significant barriers. Readiness levels may also vary across institutions, especially in developing regions with limited infrastructure and human capital. Despite these challenges, the framework offers guidance for public sector organizations to assess their readiness for Industry 4.0 and take targeted actions to align their intellectual capital with their strategic transformation goals.

Figure 1: Proposed Conceptual Framework



## DISCUSSION

The conceptual framework developed in this paper underscores the importance of intellectual capital—comprising human, structural, and relational capital—and its strategic alignment in fostering organizational readiness for Industry 4.0 in the public sector. Public organizations, unlike their private sector counterparts, face unique challenges in adopting Industry 4.0 technologies, including regulatory restrictions, limited resources, and the need to balance innovation with public service obligations. However, aligning intellectual capital with strategic goals provides public institutions with the capabilities to overcome these challenges and successfully navigate digital transformation. This section discusses the practical implications for public sector organizations, the barriers to achieving strategic alignment, and the broader contributions this framework makes to both theory and practice.

The framework highlights the critical role intellectual capital plays in public sector digital transformation. Aligning human capital—the skills, knowledge, and expertise of public sector employees—with Industry 4.0 strategies is essential for reskilling the workforce and equipping them to leverage advanced technologies such as AI, big data, and the Internet of Things (IoT). This alignment fosters a more adaptable and innovative public workforce capable of driving transformation in areas such as e-governance, smart cities, and data-driven services. Similarly, aligning structural capital—which includes organizational processes and systems—ensures that public institutions can integrate new technologies efficiently, leading to enhanced transparency, accountability, and service delivery. The alignment of relational capital—networks and partnerships with external stakeholders—enables public sector organizations to access new technologies and resources, accelerating their digital transformation efforts.

Despite these potential benefits, public sector organizations face significant challenges in achieving strategic alignment. Resource constraints, such as limited budgets, restrict their ability to invest in the necessary technological infrastructure and human capital development. Additionally, rigid bureaucratic structures impede the flexibility needed for digital transformation, leading to resistance to change and slowing down the alignment process. Leadership gaps further complicate matters, as public sector leaders often struggle to balance the demands of digital transformation with traditional public service missions. Furthermore, political

and regulatory constraints can disrupt alignment efforts when changes in government or policy priorities shift focus away from long-term digital transformation goals. Public sector organizations must carefully navigate these challenges to ensure their intellectual capital aligns with their strategic objectives.

The framework contributes to the broader body of research on Industry 4.0 and public sector transformation by addressing the intersection of intellectual capital, strategic alignment, and organizational readiness. It fills a gap in the literature by offering a tailored approach for public sector organizations to enhance their readiness for digital transformation. The integration of Strategic Alignment Theory and Intellectual Capital Theory provides a solid theoretical foundation for analyzing how public institutions can align their resources to achieve these goals. Additionally, the framework emphasizes the importance of dynamic capabilities, highlighting the need for public institutions to continuously adapt their intellectual capital to meet evolving technological demands. Practically, the framework offers valuable insights for public sector leaders and policymakers on how to align intellectual capital with digital transformation goals, reskill their workforce, and foster partnerships that support innovation and improved public service delivery.

## **FUTURE RESEARCH DIRECTIONS**

The conceptual framework presented in this paper provides a foundation for understanding how public sector organizations can leverage intellectual capital to enhance organizational readiness for Industry 4.0. However, empirical research is necessary to validate and refine the proposed relationships between intellectual capital, strategic alignment, and organizational readiness. Future research should focus on testing these relationships in real-world settings, particularly within the public sector, where the challenges of digital transformation are distinct. This will provide deeper insights into how public sector organizations can effectively align their intellectual capital to meet the demands of Industry 4.0. Empirical validation through both quantitative and qualitative research would help clarify the extent to which human, structural, and relational capital contribute to successful digital transformation in different public sector contexts.

Another avenue for future research involves exploring the framework in sector-specific contexts within the public sector. The public sector is diverse, encompassing services like healthcare, education, transportation, and public safety, each with unique challenges in aligning intellectual capital with Industry 4.0 goals. For example, healthcare may focus more on human capital due to its reliance on skilled personnel, while sectors like transportation might prioritize structural capital and technology integration. Understanding how intellectual capital alignment varies across different sub-sectors of the public sector would refine the framework and make it more applicable to specific areas of public service.

Cross-country comparisons could also provide valuable insights into how public sector organizations worldwide navigate digital transformation. The challenges faced by public organizations in developed economies likely differ from those in developing countries, where resource constraints and regulatory hurdles may play a more significant role. By comparing how different countries approach the alignment of intellectual capital with Industry 4.0 strategies, future research could highlight key differences in readiness levels and offer insights into best practices that can be adapted across various contexts. Such studies would also explore the role of political, cultural, and economic factors in shaping the public sector's ability to leverage intellectual capital for digital transformation.

Additionally, future research should delve deeper into the barriers to alignment that public sector organizations face. Resource constraints, rigid organizational structures, and leadership practices could all impact how intellectual capital is aligned with strategic goals. Future studies could also investigate the role of technological maturity in influencing alignment, exploring whether organizations with higher levels of technological adoption are better able to align their intellectual capital. Lastly, the relationship between innovation and intellectual capital development in the public sector offers another rich area for research, particularly in understanding how the alignment of human, structural, and relational capital contributes to fostering a culture of innovation that supports the strategic goals of Industry 4.0.



## CONCLUSION

In conclusion, this paper has presented a conceptual framework that emphasizes the strategic alignment of intellectual capital—comprising human, structural, and relational capital—as essential for enhancing organizational readiness for Industry 4.0 in the public sector. Given the unique challenges that public sector organizations face, such as resource constraints, bureaucratic structures, and leadership gaps, the alignment of intellectual capital with digital transformation goals is crucial for overcoming these barriers and successfully adopting new technologies. Human capital development through reskilling, the modernization of structural capital to integrate new technologies, and the cultivation of relational capital through external collaborations are vital to this alignment. By leveraging these forms of intellectual capital, public sector organizations can enhance their agility, efficiency, and innovation capacity, ultimately improving public service delivery in the digital era. This framework contributes to a deeper understanding of how public organizations can navigate Industry 4.0, and future empirical research will be necessary to validate these relationships across different contexts.

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## REFERENCES

1. Adiwijaya, S. (2023). The effect of transformational leadership on readiness for change mediated by organizational commitment. *Asian Journal of Economics Business and Accounting*, 23(15), 69-80. <https://doi.org/10.9734/ajeba/2023/v23i151017>
2. Alfarra, N. (2019). The role of the intellectual capital in achieving competitive advantage: a comparative study between private universities of turkey and uae. *International Journal of Humanities and Applied Social Science*, 1-16. <https://doi.org/10.33642/ijhass.v4n4p1>
3. Ali, K. and Johl, S. (2023). Driving forces for industry 4.0 readiness, sustainable manufacturing practices and circular economy capabilities: does firm size matter?. *Journal of Manufacturing Technology Management*, 34(5), 838-871. <https://doi.org/10.1108/jmtm-07-2022-0254>
4. Al-Tal, M. and Emeagwali, O. (2019). Knowledge-based hr practices and innovation in smes. *Organizacija*, 52(1), 6-21. <https://doi.org/10.2478/orga-2019-0002>
5. Andersen, K., Cooper, B., & Zhu, C. (2007). The effect of shrm practices on perceived firm financial performance: some initial evidence from australia. *Asia Pacific Journal of Human Resources*, 45(2), 168-179. <https://doi.org/10.1177/1038411107079111>
6. Ansari, I., Barati, M., Moghadam, M., & Ghobakhloo, M. (2023). An industry 4.0 readiness model for new technology exploitation. *International Journal of Quality & Reliability Management*, 40(10), 2519-2538. <https://doi.org/10.1108/ijqrm-11-2022-0331>
7. Arlbjørn, J., Jensen, K., Philipsen, K., & Haug, A. (2019). Drivers and barriers for industry 4.0 readiness and practice: a sme perspective with empirical evidence.. <https://doi.org/10.24251/hicss.2019.619>
8. Arsawan, I. (2019). Intellectual capital and innovation culture: evidence from smes performance in indonesia. *Economics Ecology Socium*, 3(4), 10-18. <https://doi.org/10.31520/2616-7107/2019.3.4-2>
9. Azieva, R. (2021). Assessing the readiness of oil and gas companies for digital transformation.. <https://doi.org/10.15405/epsbs.2021.11.244>
10. Baikuni, A., Dafik, D., Poernomo, D., & Sisbintari, I. (2023). The effect of strategic flexibility as a moderating variable in improving firm performance in microfinance institutions. *International Journal of Professional Business Review*, 8(7), e02298. <https://doi.org/10.26668/businessreview/2023.v8i7.2298>

11. Barney, J. (2001). Resource-based theories of competitive advantage: a ten-year retrospective on the resource-based view. *Journal of Management*, 27(6), 643-650. <https://doi.org/10.1177/014920630102700602>
12. Bilorus, T., Kornilova, I., Olikh, L., & Firsova, S. (2018). Methodological support for intellectual capital strategic management of the research organization. *Problems and Perspectives in Management*, 16(1), 292-308. [https://doi.org/10.21511/ppm.16\(1\).2018.29](https://doi.org/10.21511/ppm.16(1).2018.29)
13. Bogoviz, A. (2020). Perspective directions of state regulation of competition between human and artificial intellectual capital in industry 4.0. *Journal of Intellectual Capital*, 21(4), 583-600. <https://doi.org/10.1108/jic-11-2019-0270>
14. Bondarenko, S., Liganenko, I., & Mykytenko, D. (2020). Transformation of public administration in digital conditions: world experience, prospects of ukraine. *Journal of Scientific Papers Social Development & Security*, 10(2), 76-89. <https://doi.org/10.33445/sds.2020.10.2.9>
15. Chowdhury, L., Rana, T., & Azim, M. (2019). Intellectual capital efficiency and organisational performance. *Journal of Intellectual Capital*, 20(6), 784-806. <https://doi.org/10.1108/jic-10-2018-0171>
16. Christensen, T. and Lægred, P. (2020). Ict use in central government: scope, predictors and effects on coordination quality. *International Journal of Public Administration*, 45(3), 273-286. <https://doi.org/10.1080/01900692.2020.1851256>
17. Cortellazzo, L., Bruni, E., & Zampieri, R. (2019). The role of leadership in a digitalized world: a review. *Frontiers in Psychology*, 10. <https://doi.org/10.3389/fpsyg.2019.01938>
18. Curado, C., Henriques, P., & Bontis, N. (2011). Intellectual capital disclosure payback. *Management Decision*, 49(7), 1080-1098. <https://doi.org/10.1108/00251741111151154>
19. Dalwai, T. and Salehi, M. (2021). Business strategy, intellectual capital, firm performance, and bankruptcy risk: evidence from oman's non-financial sector companies. *Asian Review of Accounting*, 29(3), 474-504. <https://doi.org/10.1108/ara-01-2021-0008>
20. Dhanapal, K. (2023). Strategic implementation of industry 4.0 in manufacturing enterprises located in emerging economies: a resource partnership perspective.. <https://doi.org/10.46254/na8.20230070>
21. Ferreira, A. and Franco, M. (2017). The mediating effect of intellectual capital in the relationship between strategic alliances and organizational performance in portuguese technology-based smes. *European Management Review*, 14(3), 303-318. <https://doi.org/10.1111/emre.12107>
22. Ferreira, A., Franco, M., & Haase, H. (2021). Strategic alliances and development of intellectual capital: a study of technology-based smes. *International Journal of Organizational Analysis*, 30(6), 1644-1671. <https://doi.org/10.1108/ijoa-10-2020-2440>
23. Fürstenau, D., Schinzel, J., & Cleophas, C. (2014). Strategic information systems planning as a dynamic capability: insights from an agent-based simulation study.. <https://doi.org/10.7148/2014-0185>
24. Gfrerer, A., Hutter, K., Füller, J., & Ströhle, T. (2020). Ready or not: managers' and employees' different perceptions of digital readiness. *California Management Review*, 63(2), 23-48. <https://doi.org/10.1177/0008125620977487>
25. Ghlichlee, B. and Goodarzi, A. (2022). Strategic human resource practices and new product development performance: the mediating role of intellectual capital. *Journal of Intellectual Capital*, 24(3), 730-756. <https://doi.org/10.1108/jic-11-2020-0360>
26. Ghobakhloo, M. (2018). The future of manufacturing industry: a strategic roadmap toward industry 4.0. *Journal of Manufacturing Technology Management*, 29(6), 910-936. <https://doi.org/10.1108/jmtm-02-2018-0057>
27. Green, S., Larsen, G., & Kao, C. (2008). Competitive strategy revisited: contested concepts and dynamic capabilities. *Construction Management and Economics*, 26(1), 63-78. <https://doi.org/10.1080/01446190701656174>
28. Hanafiah, M., Soomro, M., & Abdullah, N. (2020). Industry 4.0 readiness models: a systematic literature review of model dimensions. *Information*, 11(7), 364. <https://doi.org/10.3390/info11070364>
29. Jóia, L. and Malheiros, R. (2009). Strategic alliances and the intellectual capital of firms. *Journal of Intellectual Capital*, 10(4), 539-558. <https://doi.org/10.1108/14691930910996634>

30. Keco, R., Tomorri, I., & Tomorri, K. (2023). Quality evaluation of e-government services – the case of albania. *Transylvanian Review of Administrative Sciences*, (68 E), 20-33. <https://doi.org/10.24193/tras.68e.2>
31. Kuzior, A., Arefieva, O., Kovalchuk, A., Brożek, P., & Tytykalo, V. (2022). Strategic guidelines for the intellectualization of human capital in the context of innovative transformation. *Sustainability*, 14(19), 11937. <https://doi.org/10.3390/su141911937>
32. Kvashina, O., Vinokhodova, I., Belskya, O., Fadeeva, S., & Kudryavtseva, O. (2021). Public management system transformation in the conditions of digitalization. *SHS Web of Conferences*, 93, 05005. <https://doi.org/10.1051/shsconf/20219305005>
33. Lee, J. and Meng, J. (2021). Digital competencies in communication management: a conceptual framework of readiness for industry 4.0 for communication professionals in the workplace. *Journal of Communication Management*, 25(4), 417-436. <https://doi.org/10.1108/jcom-10-2020-0116>
34. Li, X. (2023). How to leverage flexibility-oriented hrm systems to build organizational resilience in the digital era: the mediating role of intellectual capital. *Journal of Intellectual Capital*, 25(1), 1-22. <https://doi.org/10.1108/jic-03-2023-0038>
35. Lyu, Y. (2024). Digital economy and institutional dynamics: striving for equitable public service in a digitally transformed era. *Frontiers in Public Health*, 12. <https://doi.org/10.3389/fpubh.2024.1330044>
36. Magna, M. and Maulana, M. (2022). Managing digital innovation as public sector transformation strategy: a case study in office of population and civil registration klaten regency., 14-28. [https://doi.org/10.2991/978-2-494069-53-4\\_3](https://doi.org/10.2991/978-2-494069-53-4_3)
37. Mariani, I. and Bianchi, I. (2023). Conceptualising digital transformation in cities: a multi-dimensional framework for the analysis of public sector innovation. *Sustainability*, 15(11), 8741. <https://doi.org/10.3390/su15118741>
38. Molchanova, S. (2020). Digital transformation in manufacturing, infrastructure and public services.. <https://doi.org/10.15405/epsbs.2020.10.03.148>
39. Monshizadeh, F., Moghadam, M., Mansouri, T., & Kumar, M. (2023). Developing an industry 4.0 readiness model using fuzzy cognitive maps approach. *International Journal of Production Economics*, 255, 108658. <https://doi.org/10.1016/j.ijpe.2022.108658>
40. Mulyadi, M. and Panggabean, R. (2017). Intellectual capital reporting: case study of high intellectual capital corporations in indonesia. *International Journal of Learning and Intellectual Capital*, 14(1), 1. <https://doi.org/10.1504/ijlic.2017.080638>
41. Nasution, U. (2023). Impact of size, leverage, profitability, age and independent commissioners on intellectual capital disclosure. *Value Jurnal Manajemen Dan Akuntansi*, 18(2), 401-416. <https://doi.org/10.32534/jv.v18i2.4356>
42. Pirogova, O., ПЛОТНИКОВ, В., Макаров, И., & Grafov, A. (2020). The impact of digitalization on the intellectual capital formation and use (case of service enterprises). *E3s Web of Conferences*, 217, 06009. <https://doi.org/10.1051/e3sconf/202021706009>
43. Putra, R. (2019). The impact of transformational leadership and job satisfaction on readiness to change with learning organizations as intervening variables. *Economica*, 8(1), 1-11. <https://doi.org/10.22202/economica.2019.v8.i1.3587>
44. Rahman, I. and Mohtar, S. (2019). Relationship between performance and intellectual capital on government sector organization in malaysian. *International Journal of Academic Research in Business and Social Sciences*, 9(11). <https://doi.org/10.6007/ijarbss/v9-i11/6624>
45. Ribeiro, D., Coutinho, A., Sátyro, W., Campos, F., Lima, C., Contador, J., ... & Gonçalves, R. (2022). The dawn readiness model to assess the level of use of industry 4.0 technologies in the construction industry in brazil. *Construction Innovation*, 24(2), 515-536. <https://doi.org/10.1108/ci-05-2022-0114>
46. Saad, S., Bahadori, R., & Jafarnejad, H. (2021). The smart sme technology readiness assessment methodology in the context of industry 4.0. *Journal of Manufacturing Technology Management*, 32(5), 1037-1065. <https://doi.org/10.1108/jmtm-07-2020-0267>
47. Saghafian, M., Laumann, K., & Skogstad, M. (2021). Stagewise overview of issues influencing organizational technology adoption and use. *Frontiers in Psychology*, 12. <https://doi.org/10.3389/fpsyg.2021.630145>

48. Saleh, N. and Ijab, M. (2022). Industrial revolution 4.0 (ir4.0) readiness among industry players: a systematic literature review. *Artificial Intelligence and Applications*, 1(2), 70-85. <https://doi.org/10.47852/bonviewaia2202336>
49. Samarasinghe, K. and Medis, A. (2020). Artificial intelligence based strategic human resource management (aishrm) for industry 4.0. *Global Journal of Management and Business Research*, 7-13. <https://doi.org/10.34257/gjmbgrvol20is2pg7>
50. Sari, D., Pratama, N., & Nurcahyo, R. (2023). Digital transformation capability maturity framework for digital audit readiness in public sector (case study).. <https://doi.org/10.46254/af04.20230109>
51. Sazonov, A. and Sazonova, M. (2023). Development of a model for the transformation of agriculture in the digital economy. *E3s Web of Conferences*, 390, 03001. <https://doi.org/10.1051/e3sconf/202339003001>
52. Selim, S., Doğan, R., & Doğan, M. (2022). Analysis of the factors affecting firms' industry4.0readiness levels. *Pamukkale University Journal of Engineering Sciences*, 28(4), 613-624. <https://doi.org/10.5505/pajes.2021.98036>
53. Sia, S., Weill, P., & Zhang, N. (2021). Designing a future-ready enterprise: the digital transformation of dbs bank. *California Management Review*, 63(3), 35-57. <https://doi.org/10.1177/0008125621992583>
54. Sihombing, T. (2024). Digital technology adoption for village public administration—evidence from indonesia. *Journal of Infrastructure Policy and Development*, 8(4). <https://doi.org/10.24294/jipd.v8i4.3444>
55. Soewarno, N. and Tjahjadi, B. (2020). Measures that matter: an empirical investigation of intellectual capital and financial performance of banking firms in indonesia. *Journal of Intellectual Capital*, 21(6), 1085-1106. <https://doi.org/10.1108/jic-09-2019-0225>
56. Stoyanova, M. (2023). Digital transformation as a prerequisite for region`s convergence. *E3s Web of Conferences*, 452, 05019. <https://doi.org/10.1051/e3sconf/202345205019>
57. Sucena, A. (2023). The effect of intellectual capital and strategic partnerships in construction companies. *European Conference on Knowledge Management*, 24(2), 1288-1293. <https://doi.org/10.34190/eckm.24.2.1477>
58. Sudrajat, G. (2021). The acceleration of digital transformation in the ministry of finance: what are the driven factors?. *Iapa Proceedings Conference*, 45. <https://doi.org/10.30589/proceedings.2021.514>
59. Sun, X., He, Z., & Qian, Y. (2023). Getting organizational adaptability in the context of digital transformation. *Chinese Management Studies*, 18(2), 550-574. <https://doi.org/10.1108/cms-06-2022-0222>
60. Tran, N., Thu, N., Huan, N., & Trung, N. (2022). Human capital, digital transformation, and firm performance of startups in vietnam. *Management*, 26(1), 1-18. <https://doi.org/10.2478/manment-2019-0081>
61. Voronkova, O., Stepanenko, O., Balamirzoev, N., Makarenko, S., & Nurumov, A. (2021). Development of the intellectual capital of an enterprise as a competitive advantage in production management. *Economic Annals-Xxi*, 188(3-4), 134-140. <https://doi.org/10.21003/ea.v188-16>
62. Xie, X., Zhang, H., & González-Tejero, C. (2022). How organizational readiness for digital innovation shapes digital business model innovation in family businesses. *International Journal of Entrepreneurial Behaviour & Research*, 29(1), 49-79. <https://doi.org/10.1108/ijeb-03-2022-0243>
63. Xu, C. and Tang, T. (2020). Closing the gap or widening the divide: the impacts of technology-enabled coproduction on equity in public service delivery. *Public Administration Review*, 80(6), 962-975. <https://doi.org/10.1111/puar.13222>
64. Yilmaz, A. (2023). The relation between intellectual capital and digital transformation: a bibliometric analysis. *International Journal of Innovation Science*, 16(2), 244-264. <https://doi.org/10.1108/ijis-08-2022-0145>