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The Effect of Digital Transformation on Startups' Innovation Performance: The Chain-Mediating Roles of Big Data Capabilities, Internet of Things and Organizational Agility

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Abstract

Digital transformation is recognized as a key driver of high-quality development in firms and a critical tool for shaping innovation-oriented models. However, existing studies have not fully examined the specific mechanisms through which it affects firm innovation performance, and perspectives on this matter remain divergent. Some studies argue that digital transformation can improve innovation performance, while others point to its negative effects and fail to clearly explain the precise role of big data capabilities, the Internet of Things (IoT), and organizational agility in this process. Therefore, drawing on the dynamic capabilities theory of the organization and systems engineering theory, this study employs the logical "Strategy–Behavior–Performance" framework to systematically investigate the process through which digital transformation enhances the innovation performance of startups by promoting big data capabilities, IoT capabilities, and organizational agility. Through empirical analysis of data collected from 203 questionnaires completed by CEOs, senior and middle managers, and IT experts from 15 Iranian startups, this study reveals the serial mediation effects of big data capabilities, IoT capabilities, and organizational agility, confirming the key role of all three factors in the digital transformation process. The findings indicate that digital transformation significantly improves the innovation performance of startups, and the triple mediation effects of big data capabilities, IoT capabilities, and organizational agility are important links in

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its influence mechanism. These results not only provide empirical support for the theoretical model of digital transformation but also offer practical guidance for startups in formulating strategies and optimizing resource allocation in the digital era.

Keywords: Digital Transformation, Innovation Performance, Big Data Capabilities, Internet of Things, Organizational Agility.

Introduction

In recent decades, digital technologies such as big data, the Internet of Things (IoT), and artificial intelligence have created a wave of fundamental change in the global economy, often referred to as the "Digital Revolution" (Gimenez-Fernandez et al., 2020). This transformation has turned the digital economy into a driving engine for countries' economic growth. According to a report by the China Academy of Information and Communications Technology, in 2020, the digital economy of 47 countries reached USD 32.6 trillion, accounting for 43.7% of their GDP (Xu et al., 2024). At the firm level, a report by the United Nations Industrial Development Organization (UNIDO, 2022) shows that manufacturing companies with a high level of digitalization outperform others in indicators such as sales, profit, employment, and innovation. The nature of digital transformation goes beyond merely adopting technology; it means reinventing business models, processes, and organizational culture through the integration of new technologies to enhance efficiency, flexibility, and innovation (Hanelt et al., 2021). This transformation is not only a strategic pillar for developing the digital economy but has also become a driving force for improving quality, enhancing productivity, and enabling economic transformation in firms (Dong & Netten, 2017). Through deepening digital transformation, organizations can redesign their business models, improve market and product strategies, and enhance their innovative capacities (Adomako et al., 2021; Nambisan, 2017). This transformation has also increased firms' competitiveness and strengthened their leading role in the digital economy (Scuotto et al., 2017). However, research conducted to date has not reached a theoretical consensus on the impact of digital transformation on firms' innovation performance. One group of studies emphasizes its positive impact, arguing that digital transformation facilitates the innovation process by reducing information costs, improving resource integration capabilities, and enhancing operational efficiency (Arias-Pérez & Vélez-Jaramillo, 2022). The pathways of influence include integration into innovation networks (Dong & Netten, 2017), enhancement of information technology capabilities (Augustsson et al., 2019), improvement of human capital (Lenka et al., 2017), reduction of financial constraints (Kim et al., 2011), and increase in organizational flexibility (Li et al., 2018). In contrast, another group of studies points to negative or non-linear effects of digital transformation. Overemphasis on technology may lead to neglecting customer needs (Gebauer et al., 2020), and heavy investment in digitalization can be accompanied by delayed effects and managerial costs (Rachinger et al., 2018). Some studies have shown that beyond a certain tipping point of digitalization, the benefits diminish and even approach zero (von Briel et al., 2018; Vial, 2019). In such conditions, information overload and incompatibility of human resources with new technologies prevent the firm from adapting quickly to the competitive environment (Wamba et al., 2017).

In response to this theoretical gap, the present study focuses on successful Iranian startups to examine the impact of digital transformation on innovation performance. Utilizing the theoretical framework of "Strategy–Behavior–Performance," this study analyzes the mechanisms through which digital transformation exerts its influence and explains the mediating role of three key big data capabilities, IoT, and organizational agility in this process. Furthermore, this research demonstrates that big data, IoT, and organizational agility not only act as mediating mechanisms in transmitting the effect of digital transformation to innovation but also sequentially influence each other and affect the relationship between digital transformation and performance. On one hand, big data analytical capabilities and IoT enable organizations to identify hidden patterns in complex data and improve innovative decision-making (Mikalef et al., 2017). On the other hand, organizational agility, as the ability to respond quickly and implement changes effectively, plays a vital role in exploiting innovation opportunities (Puriwat & Hoonsopon, 2021; Xu et al., 2024).

In this regard, this study seeks to answer three main questions:

1. Does digital transformation facilitate or hinder innovation performance in firms?
2. Through what mechanisms does digital transformation affect firms' innovation performance?
3. Through what sequential pathway and with what roles of big data capabilities, IoT capabilities, and organizational agility does digital transformation affect firms' innovation performance?

To answer these questions, the present paper is organized as follows: Section 2 reviews the theoretical foundations and research background and presents the research hypotheses; Section 3 presents the conceptual framework; Section 4 is dedicated to the research methodology and statistical population; Section 5 analyzes the empirical findings; and finally, Section 6 discusses the results, concludes, and provides practical recommendations for managers and policymakers.

Literature Review

In the era of digital transformation, organizations have faced fundamental changes in structure, processes, and business models. This transformation has not only redefined the role of technology in innovation management but has also introduced new technological capabilities such as big data, the Internet of Things, and organizational agility as key factors in enhancing innovation performance. Given the complexity of the competitive environment and the speed of market changes, understanding the relationships between digital transformation and innovation, especially through mediating capabilities, has become increasingly important. This section reviews the theoretical literature related to the main components of the research to lay the groundwork for developing hypotheses and the conceptual model.

Digital transformation, by redefining organizational structures and enhancing information infrastructures, has paved the way for improving innovation performance in

firms. This transformation increases flexibility and intra-organizational synergy (Lokuge et al., 2019), reduces information asymmetry and facilitates innovative decision-making (Baregheh et al., 2009), and enhances market responsiveness through big data and cloud computing (Zhao et al., 2023). By shifting from traditional structures to network models, digital transformation increases the speed of innovation implementation (Corallo, 2007), reduces operational costs (Hess et al., 2016), and strengthens an organizational culture based on learning and risk acceptance (Hoorani et al., 2023).

Hypothesis 1: Digital transformation significantly increases the innovation performance of startups.

Big data capabilities go beyond simple data storage and include the organization's ability to effectively collect, analyze, interpret, and utilize data in decision-making and learning processes (Gebauer et al., 2020). These capabilities play an important role in enhancing innovation performance by improving market analysis, predicting customer behavior, and increasing the speed and quality of managerial decisions (Mikalef et al., 2019). Through leveraging big data, firms have increased their ability to absorb and combine external knowledge (Surbakti, 2022) while improving the processing and effective use of internal data (Garmaki et al., 2023). Developing these capabilities expands the scope and diversity of the organization's knowledge resources (Baesens et al., 2016), reduces the cognitive distance with the market, and facilitates the integration of interdisciplinary knowledge. Furthermore, employing tools such as cloud computing and machine learning algorithms has significantly increased the speed and accuracy of data analysis (Su et al., 2022) and strengthened the data-driven decision-making platform in organizations (Ly, 2023). In such conditions, firms can more quickly identify hidden market patterns, timely recognize innovative opportunities, and shorten the product and service development cycle (Xu et al., 2024).

Hypothesis 2: Big data capabilities mediate the impact of digital transformation on the innovation performance of startups.

The Internet of Things, through the intelligent connection of physical objects to the digital space, has enabled real-time data collection and analysis (Mashat et al., 2024). This technology facilitates more accurate understanding of customer behavior (Li et al., 2022), advanced analysis and system modeling (Irannezhad & Faroqi, 2023), and the creation of new markets (Abdel-Basset et al., 2018). Its combination with artificial intelligence and big data enhances organizational agility and user experience, leading to more complex innovations (Mashat et al., 2024).

Hypothesis 3: The Internet of Things mediates the impact of digital transformation on the innovation performance of startups.

Organizational agility refers to a firm's ability to respond quickly, effectively, and flexibly to environmental and internal changes (Su et al., 2022). Digital transformation, by leveraging technologies such as cloud computing and artificial intelligence, has

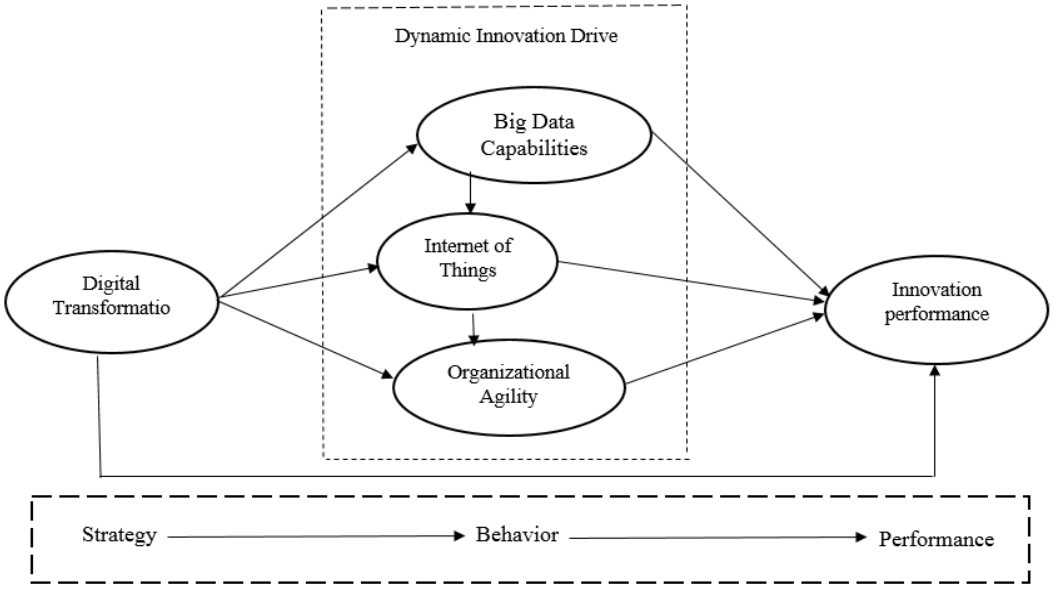
transformed traditional organizational structures into dynamic and flexible networks (Ly, 2023) and, through updating strategies and optimizing processes, has increased organizations' capacity to respond to changes (Zhu & Li, 2023). At the external environment level, organizational agility enables faster access to resources, identification of opportunities, and acceleration of innovation processes (Mihardjo et al., 2020). Internally, structural flexibility, facilitating coordination between units, and accelerating managerial decision-making reduce the time to achieve innovation (AlNuaimi et al., 2022; Bogarin, 2022) and ultimately strengthen the competitive ability and performance sustainability of firms (Xu et al., 2024).

Hypothesis 4: Organizational agility mediates the impact of digital transformation on the innovation performance of startups.

Digital transformation, by enhancing big data capabilities, IoT capabilities, and organizational agility, has made innovation processes more efficient. These technologies enable rapid analysis of market data and target innovation based on customer needs (Surbakti, 2022). Strengthening data processing and organizational flexibility reduces resource incompatibility and facilitates effective internal integration (Hyun et al., 2023; Dubey et al., 2019). By leveraging these technologies, firms identify demand changes and optimize supply chain decision-making (Rialti et al., 2019). Organizational structure has become flatter and responsiveness to the environment has increased (Medeiros & Macada, 2022), leading to the formation of an open innovation culture and the integration of internal and external knowledge (Xu et al., 2024).

Hypothesis 5: Digital transformation has a positive impact on firms' innovation performance through the serial mediation of big data capabilities, IoT capabilities, and organizational agility.

Figure 1. Conceptual Model of the Research



Regarding the concepts of digital transformation, IoT, big data, and organizational agility, several studies have been conducted. Table 1 summarizes these studies that are relevant to the present research

Table 1. Empirical Literature Review

No.	Researchers (Year)	Title	Results and Findings
1	Lu et al. (2025)	Can digital transformation help reduce corporate financial redundancy?	Digital transformation reduces financial redundancy in manufacturing firms by improving internal control, reducing opportunistic behavior, and decreasing information asymmetry; non-state-owned and growing firms benefit the most.
2	Wei & Shen (2025)	The impact and mechanism of digital transformation on manufacturing firm performance	Digital transformation enhances the performance of manufacturing firms through three pathways: increasing sales, reducing production costs, and fostering differentiated innovation; large and non-state-owned firms benefit more.

No.	Researchers (Year)	Title	Results and Findings
3	Simeon Ebhota et al. (2024)	Examining the impact of digital transformation, budgeting, and budget control on the financial performance of SMEs	In SMEs, digital transformation strengthens customer experience, big data analysis, and budget control, with financial productivity playing a moderating role.
4	Li et al. (2023)	Examining the impact of digital transformation on firm innovation performance	Digital transformation promotes innovation, increases competitiveness, and creates innovative business models in digital-oriented industrial firms.
5	Songkajorn et al. (2022)	Organizational strategic intuition, the role of knowledge-based dynamic capabilities and digital transformation	Digital capabilities improve organizational performance by facilitating knowledge acquisition and storage; digital transformation mediates the development of strategic intuition.
6	Li et al. (2022)	Dynamic capabilities of digital technology and their effects on firm performance: Evidence from the COVID-19 pandemic	Digital technologies enhance operational agility and investment by creating dynamic capabilities, strengthening the competitive advantage of manufacturing firms.
7	Gaglio et al. (2022)	Effects of digital transformation on innovation and productivity: South African manufacturing SMEs	In South African small firms, digital technologies have increased customer interactions, product development, and productivity.
8	Sadeghi baloee et al. (2024)	The impact of digital readiness dimensions on digital innovation performance moderated by employee digital competence	Digital readiness enhances digital innovation performance with the moderating role of employee digital competence; employee skills play a key role.
9	Yalpanian et al. (2024)	Analyzing the impact of digital transformation technologies on business performance improvement using advanced text analysis methods	Advanced text analysis shows that digital transformation leads to data-driven decision-making, increased productivity, and improved customer experience in businesses.

No.	Researchers (Year)	Title	Results and Findings
10	Rouhani & Keshavarz (2024)	The impact of digital transformation on innovation performance with the mediating role of innovation factors	Digital transformation significantly enhances the innovation performance of distribution companies through innovative awareness and investment in R&D.

Methodology

This research is applied in terms of purpose and descriptive-survey in terms of nature. Its aim is to investigate the causal relationships between digital transformation, technological capabilities, and innovation performance in Iranian startups. The statistical population includes CEOs, senior and middle managers, and IT experts in 15 active Iranian startups. Due to the lack of access to a complete sampling frame, convenience sampling was used. According to Kline (2011), the minimum sample size for structural equation modeling is 200. To compensate for potential non-response, 250 questionnaires were distributed, and ultimately 203 usable questionnaires were collected. The data collection tool was a researcher-made questionnaire designed based on indicators and items extracted from valid studies. The questionnaire consists of 28 questions in five main sections: digital transformation, big data capability, Internet of Things, organizational agility, and innovation performance. Responses were measured on a five-point Likert scale (from strongly disagree to strongly agree). To ensure the accuracy and validity of the research results, the technical characteristics of the questionnaire were evaluated in two sections: validity and reliability, using various criteria. Questionnaire validity was assessed and confirmed through content and construct validity. For content validity, the questionnaire was reviewed by professors and experts, and after review, three questions were removed. Construct validity was measured using structural equation modeling with convergent and discriminant validity. To determine convergent validity, the Average Variance Extracted (AVE) index was used, and for discriminant validity, the square root of AVE was used. The AVE for all variables was above 0.5, indicating high validity. Additionally, the reliability of the questionnaire was measured using Cronbach's alpha and composite reliability. Given that Cronbach's alpha for all variables was above 0.70 and the overall alpha of the questionnaire was 0.79, it can be concluded that the research instrument has desirable reliability. Table 2 shows the number and source of questionnaire items, Cronbach's alpha, composite reliability, and AVE for each variable.

Table 2. Number and Source of Questionnaire Items, Cronbach's Alpha, Composite Reliability, and AVE Results

Variable	Digital Transformation	Big Data Capability	Internet of Things	Organizational Agility	Innovation Performance
Source	Hess et al., 2016	Akter et al., 2016	Asad et al., 2024	Bekos et al., 2025	Mashat et al., 2024; Hsu & Yu, 2012; Akter et al., 2016
Items	6	6	5	6	5
Cronbach's Alpha	0.89	0.93	0.86	0.92	0.88
Composite Reliability	0.95	0.96	0.94	0.95	0.91
AVE	0.77	0.81	0.73	0.75	0.63

As shown in Table 3, the square root values of AVE are higher than the minimum acceptable level (0.5), so the research variables have discriminant validity. Discriminant validity is acceptable when the numbers on the main diagonal are greater than the values below them. Since the square root values of AVE are greater than the correlation of each variable with others, it can be said that the variables have validity and their discriminant validity is confirmed.

Table 3. Discriminant Validity Results Based on Fornell-Larcker Criterion

Construct	Digital Transformation	Big Data Capability	Internet of Things	Organizational Agility	Innovation Performance
Digital Transformation	**0.88**				
Big Data Capability	0.74	**0.9**			
Internet of Things	0.69	0.71	**0.85**		
Organizational Agility	0.72	0.68	0.66	**0.87**	
Innovation Performance	0.61	0.59	0.51	0.39	**0.79**

Given the perceptual nature of the data and their collection through a single-source questionnaire, the possibility of common method bias was considered. To reduce this bias, the questionnaire was distributed anonymously through multiple channels (email, social networks, and messaging apps), and the order of items was arranged to avoid uniform responses. Additionally, Harman's single-factor test was conducted, and the

results showed that the first factor explained about 37% of the total variance; therefore, common method bias did not significantly affect the research results.

Findings

Demographic analysis of respondents showed that 80% were male and 20% female. The most common education level was bachelor's degree (about 62%), and the majority of individuals were in the 30-40 age range with 6-10 years of work experience. In terms of job position, 79.8% were IT experts, 17.7% were middle and senior managers, and only 2.5% were CEOs or company presidents.

Data normality was assessed by examining skewness and kurtosis indices, and the results showed that these indices for all variables were within the range of ±2. Accordingly, the data were deemed suitable for analysis using structural equation modeling. In the next step, LISREL software was used to fit the conceptual and measurement models. The chi-square to degrees of freedom ratio was 2.79, which is less than the standard value of 3, indicating a good model fit. All other fit indices are presented in Table 4, and based on standard values, the final model is confirmed and accepted.

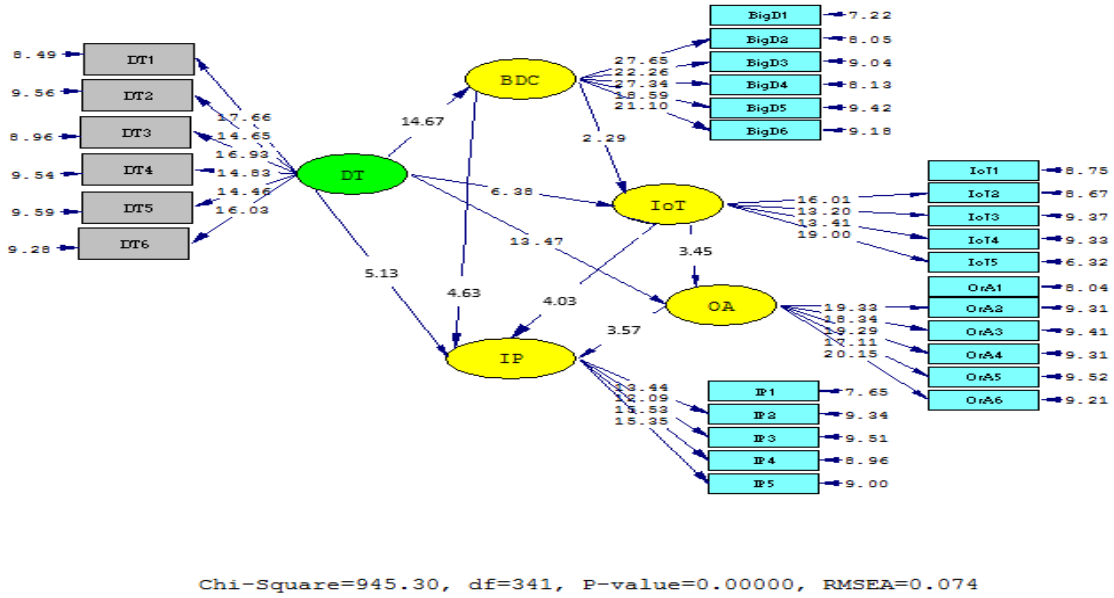
The coefficient of determination (R^2) values for all endogenous constructs in the study ranged from 0.56 to 0.73, which, according to common criteria in the present study (Chen, 1998), are evaluated as acceptable to good and indicate the model's adequate ability to explain the variance of dependent variables.

Table 4. Inferential Statistics Results

Fit Index	Standard Value	Research Value	Fit Index	Standard Value	Research Value
χ^2/df	< 3	2.79	NFI	> 0.9	0.96
RMSEA	< 0.08	0.074	NNFI	> 0.9	0.98
RMR	< 0.088	0.058	CFI	> 0.9	0.98
GFI	> 0.8	0.85	IFI	> 0.9	0.98
AGFI	> 0.8	0.81			

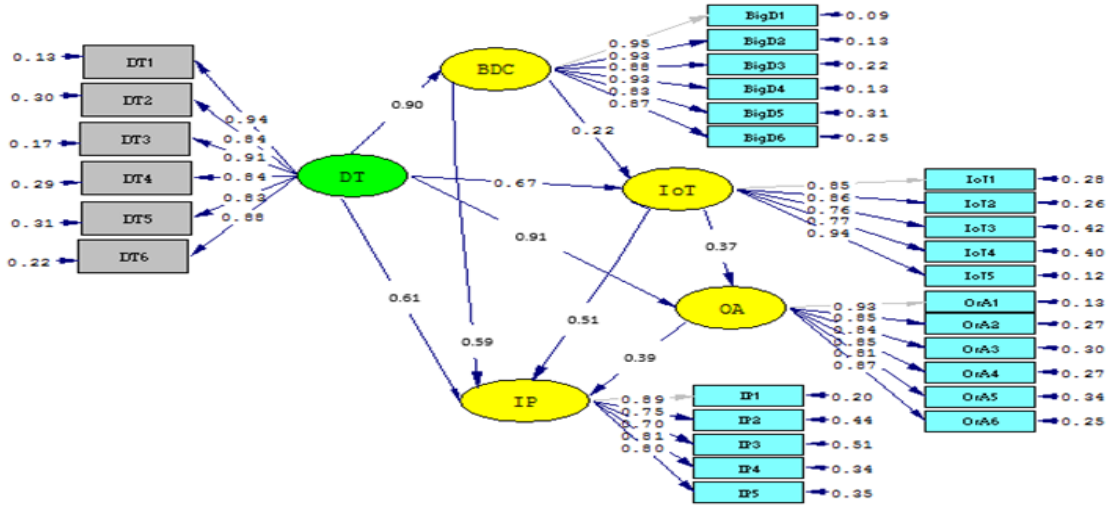
Structural equation modeling is a suitable statistical technique based on hypotheses about causal relationships between variables. Figure 2 shows the t-values, and Figure 3 shows the standardized coefficients for the research model. This model is used to examine the significance level of relationships between latent variables proposed in the research model. If the calculated t-values at the 0.05 error level are not within the range of (-1.96 to +1.96), it can be concluded that there is a significant relationship between the two latent variables under investigation.

Figure 2. Research Model in Significance State (t-values)



Chi-Square=945.30, df=341, P-value=0.00000, RMSEA=0.074

Figure 3. Research Model with Standardized Coefficient Estimates



Chi-Square=945.30, df=341, P-value=0.00000, RMSEA=0.074

According to Figures 2 and 3, the factor loadings and t-statistic values are presented in Table 5.

Table 5. Factor Loadings and t-statistic Values

Code	Factor Loading	t-value	Code	Factor Loading	t-value	Code	Factor Loading	t-value	Code	Factor Loading	t-value	Code	Factor Loading	t-value
Digital Transformation			Big Data Capability			Internet of Things			Organizational Agility			Innovation Performance		
DT1	0.94	17.66	BigD1	0.95	23.76	IoT1	0.85	16.77	OrA1	0.93	25.17	IP1	0.89	12.3
DT2	0.84	14.65	BigD2	0.93	27.65	IoT2	0.86	16.01	OrA2	0.85	19.33	IP1	0.75	13.44
DT3	0.91	16.93	BigD3	0.88	22.26	IoT3	0.76	13.20	OrA3	0.84	18.34	IP1	0.70	12.09
DT4	0.84	14.83	BigD4	0.93	27.34	IoT4	0.77	13.41	OrA4	0.85	19.29	IP1	0.81	15.53
DT5	0.83	14.46	BigD5	0.83	18.59	IoT5	0.94	19.00	OrA5	0.81	17.11	IP1	0.80	15.35
DT6	0.88	16.03	BigD6	0.87	21.10				OrA6	0.87	20.15			

The detailed results of the data analysis are presented in Table 6. The t-statistic value of 5.13 for the path between digital transformation and innovation performance indicates that digital transformation significantly increases the innovation performance of startups. Therefore, Hypothesis 1 is confirmed. The other results presented in the table also support Hypothesis 1 and demonstrate the vital role of digital transformation, big data capability, the Internet of Things, and organizational agility in improving the innovation performance of startups.

Table 6. Detailed Results of Data Analysis

Path	Standardized Coefficient	t-statistic	Result
Digital Transformation → Innovation Performance	0.61	5.13	Digital transformation has a significant impact on innovation performance.
Digital Transformation → Big Data Capability	0.90	14.67	Digital transformation has a significant impact on big data capability.
Digital Transformation → Internet of Things	0.67	6.38	Digital transformation has a significant impact on the Internet of Things.
Digital Transformation → Organizational Agility	0.91	13.47	Digital transformation has a significant impact on organizational agility.
Big Data Capability → Internet of Things	0.22	2.29	Big data capability has a significant impact on organizational agility.
Big Data Capability → Innovation Performance	0.59	4.63	Big data capability has a significant impact on innovation

Path	Standardized Coefficient	t-statistic	Result
			performance.
Internet of Things → Organizational Agility	0.37	3.45	The Internet of Things has a significant impact on organizational agility.
Internet of Things → Innovation Performance	0.51	4.03	The Internet of Things has a significant impact on innovation performance.
Organizational Agility → Innovation Performance	0.39	3.57	Organizational agility has a significant impact on innovation performance.

To test the significance of the mediation effects (Hypotheses 2 to 5), the non-parametric bootstrap method with 5,000 replications was used. This method, without relying on the assumption of normality in the distribution of indirect effects, enables accurate estimation of the role of mediating variables. In bootstrapping, the significance of indirect effects is evaluated based on 95% confidence intervals; if zero is not contained within these intervals, the indirect effect is considered significant. The results showed that the 95% confidence intervals for the simple indirect effects of digital transformation on innovation performance through big data capabilities, the Internet of Things, and organizational agility did not include zero; therefore, Hypotheses 2 to 4 were confirmed. Additionally, the serial indirect effect of digital transformation on innovation performance through the path DT → BDC → IoT → OA → IP was also found to be significant, and Hypothesis 5 was confirmed. The detailed results are presented in Table 7.

Table 7. Results of Indirect Effects Testing Using the Bootstrap Method

Hypothesis	Path	Indirect Effect (β)	Bootstrap	Lower Bound	Upper Bound	Result
2	DT → BDC → IP	0.53	0.54	0.036	0.052	Confirmed
3	DT → IoT → IP	0.34	0.34	0.032	0.044	Confirmed
4	DT → OA → IP	0.35	0.36	0.025	0.042	Confirmed
5	DT → BDC → IoT → OA → IP	0.29	0.29	0.005	0.024	Confirmed

Discussion and Conclusion

With the global expansion of digital transformation, emerging technologies such as big data, the Internet of Things (IoT), and artificial intelligence are redefining how organizations operate, make decisions, and interact internally and externally (Gimenez-Fernandez et al., 2020). These technologies not only increase operational efficiency but also enhance innovation capabilities, flexibility, and adaptability to market changes. In this context, digital transformation, especially in developing economies, is recognized as a strategic imperative for economic restructuring and qualitative growth of firms (Xu et al., 2024; UNIDO, 2022). Drawing on the dynamic capabilities theory of the organization and systems engineering theory (Dong & Netten, 2017), and within the "Strategy–Behavior–Performance" framework, the present study demonstrated that digital transformation has a direct, strong, and significant effect on the innovation performance of Iranian startups. This empirical finding indicates that startups, through targeted investment in digital strategies, can improve innovative processes and accelerate the development of new products and services. The results align with studies by Xu et al. (2024), Kim et al. (2011), and Zhao et al. (2023), confirming that the effective integration of advanced digital technologies strengthens organizations' capacity to respond rapidly to market changes. From the perspective of dynamic capabilities theory, this finding shows that digital transformation acts as an enabling capability that helps the organization reconfigure resources and create competitive advantage. Although some studies have pointed to challenges such as information overload and resource misalignment (Rachinger et al., 2018; Appio et al., 2021), the results of this research indicate that with the simultaneous development of technological and organizational capabilities, these challenges can be managed and can even become drivers of innovation.

In the second step, the mediating role of big data capabilities, the Internet of Things, and organizational agility in transmitting the effect of digital transformation to innovation performance was examined. The results showed that each of these capabilities independently plays a mediating role, while their combination in the form of a serial pathway explains a more complete mechanism of how digital transformation affects innovation. Specifically, big data capabilities and the Internet of Things, by providing accurate data and analytical insights, create the foundation for data-driven decision-making, and organizational agility enables the conversion of these insights into innovative actions. This finding indicates that mere access to digital technologies is not sufficient for improving innovation; rather, the synergy between technological capabilities and organizational responsiveness plays a decisive role. These results are consistent with previous studies (Mikalef et al., 2019; Puriwat & Hoonsopon, 2021) as well as more recent research (Xu et al., 2024; Bogarin, 2022). Compared to studies by Dubey et al. (2019) and Peng & Tao (2022), the present study, by providing empirical evidence of a specific serial pathway, offers a more precise picture of how these

capabilities interact and demonstrates that the success of digital strategies requires the appropriate overlap and sequencing of data-driven and organizational capabilities.

Another important finding of this research is that data-driven capabilities, including big data and the Internet of Things, play a more prominent role than organizational agility in explaining innovation performance. This result suggests that in startups operating in data-driven environments, developing analytical infrastructure and smart technologies can have a more direct effect on innovation, while organizational agility plays a complementary and facilitating role. From a managerial perspective, this finding implies that prioritizing investments in digital transformation should focus initially on data-driven capabilities. From a theoretical standpoint, this finding challenges some previous results, including the study by Chen & Kim (2023), and shows that the relative weight of digital capabilities can vary depending on the organizational context and industry type. Accordingly, the present study emphasizes the need to reconsider the prioritization of digital capabilities in formulating innovation strategies, particularly in the startup ecosystem. The theoretical contributions of this research are as follows:

1. This study resolves the existing disagreements regarding the impact of digital transformation on innovation by analyzing data from 203 managers and experts across 15 Iranian startups and demonstrates that digital transformation significantly improves innovation performance.
2. By systematically combining three digital capabilities and explaining how they interact, the synergistic role of these variables in stimulating innovation has been revealed.
3. Theoretical Framework: The "Strategy–Behavior–Performance" model is introduced as a reliable framework for analyzing and designing digital strategies and extends the application scope of dynamic capabilities theory.

The managerial implications of this research include:

1. Startup managers should prioritize the development of data-driven capabilities (big data and IoT) as a strategic priority, as these capabilities create stronger pathways toward improving innovation.
2. Strengthening organizational agility is critically important, as insights derived from data only create value when rapid response mechanisms are in place.
3. Digital transformation should be implemented in an integrated and phased manner, rather than as separate projects; an integrated approach increases innovation efficiency.
4. Simplifying decision-making structures, delegating authority, and improving coordination among teams amplifies the effect of digital transformation in turbulent environments.

In addition to the common limitations of survey research, such as sampling error and non-response, this study faced two specific limitations: a) The use of cross-sectional data, which limits the ability to analyze long-term trends and cyclical effects of digital transformation. It is suggested that future research employ longitudinal data to examine

the impact of digital transformation at different stages and across various time periods. b) The focus on only three digital capabilities, while other variables such as organizational culture, employee skills, technology acceptance, and internal innovation climate could also interact with these capabilities. Future research is encouraged to examine these variables at different managerial levels and within multi-level frameworks. c) Most respondents had information technology expertise. Given the nature of the research topic, which focuses on digital transformation and technological capabilities in startups, this sample composition may reflect the central role of IT experts and specialists in the digital and innovative processes of these organizations. However, this could influence the perception and evaluation of the research variables, particularly the technological variables, and caution should be exercised in generalizing the results to other occupational groups. Therefore, it is suggested that future research more balancedly examine the perspectives of other organizational stakeholders, including non-technical managers and employees from operational units.

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