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Research on the Impact of Digital Innovation and Digital Transformation on Technological Innovation in Information Security Enterprises

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Abstract

With the rapid advancement of digital technologies, information security enterprises face unprecedented challenges and opportunities. Against this backdrop, this study focuses on information security enterprises, examining how digital innovation and digital transformation influence technological innovation through digital disruption. It aims to reveal the impact mechanisms of digital innovation, digital transformation, and digital disruption on technological innovation within information security enterprises by investigating the interactions and influence pathways among these variables. Drawing upon dynamic capability theory, the technology-organization-environment (TOE) framework, digital disruption theory, and the digital transformation maturity model, a theoretical model was constructed to capture the relationships among digital innovation, digital transformation, digital disruption, and technological innovation. This study collected 446 valid samples from Chinese information security enterprises through questionnaire surveys. Empirical analyses included reliability and validity assessments, correlation tests, difference tests, and structural equation modeling (SEM). The findings reveal that both digital innovation and digital transformation significantly and directly promote technological innovation within information security enterprises. Furthermore, digital disruption plays a crucial mediating role between these two factors and technological innovation. This research not only enriches theoretical studies on digital innovation and transformation pathways in the information security field but also provides practical guidance for enterprises to achieve technological innovation during digital transformation. Additionally, it offers a reference basis for government and industry regulators in formulating relevant policies, demonstrating significant theoretical value and practical significance.

Keywords: Digital Disruption, Digital Innovation, Digital Transformation, Information Security Enterprises, Technological Innovation.

Introduction

Since the mid-twentieth century, information technology-particularly digital technologies such as the Internet, cloud computing, big data, artificial intelligence, and blockchain-has evolved continuously, profoundly transforming the operational logic of society and reshaping the development trajectories of enterprises (1). As a key force in safeguarding national cyberspace security and protecting corporate data assets, the core competitiveness of information security enterprises increasingly relies on the enhancement of digital capabilities and the advancement of security technologies. Guided by China's "Digital China" and "Cyber Power" strategies, enterprise digitalization is accelerating, and the development quality of information security enterprises has become increasingly dependent on the integration of digital capability building and technological innovation. Within this context, digital innovation (DI) has emerged as a critical driver of technological progress, encompassing not only the research, development, and application of emerging technologies but also systematic reforms in products, processes, organizational structures, and business models (2, 3). In parallel, digital transformation (DT) entails the comprehensive restructuring of an enterprise's technical architecture, organizational culture, and operational model around customer value and the digital ecosystem (4). It extends beyond the mere adoption of new technologies to encompass fundamental changes in corporate management mechanisms, capability systems, and value logic (VL) (5, 6). Extensive studies have demonstrated that DT can substantially improve innovation efficiency in domains such as security governance, response speed, and threat identification (7). Moreover, digital disruption (DD) has emerged as

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a structural force for change, dismantling traditional industry boundaries, redefining competitive rules, and reshaping technological trajectories (8). Existing research has analyzed the impact of digital innovation or digital transformation on corporate technological innovation from multiple perspectives. For instance, Yoo *et al*., and Chesbrough indicate that enhancing a company's digital capabilities facilitates the generation and iteration of new products (9, 10); Some authors in past emphasize the role of agile management mechanisms in boosting research and development efficiency (11). However, existing literature has inadequately addressed how these factors systematically influence technological innovation in information security enterprises, as well as the potential mediating role of digital disruption in these relationships. A systematic analysis in the information security industry, which is heavily reliant on digital technologies, is significantly lacking. On one hand, while existing literature has explored the relationship between digital transformation at the enterprise level and technological innovation (4), it has primarily focused on sectors such as manufacturing, retail, or finance, lacking systematic research on information security enterprises. On the other hand, information security enterprises exhibit higher research and development intensity and shorter technology lifecycles compared to other industries. They also face persistent pressures regarding data sensitivity and compliance requirements (e.g., zero-trust architecture and security control baselines) (12, 13). These characteristics differ significantly from those of other sectors, suggesting that the mechanisms through which digital transformation (DT) drives technological innovation in the information security industry may be more complex. Therefore, this study aims to address this gap in the literature by further examining how information security enterprises achieve technological innovation (TI) through digital disruption within the context of digital innovation and digital transformation.

To further enhance theoretical explanatory power, this study builds upon the dynamic capabilities theory (14), the technology-organization-environment (TOE) framework (15), and the digital disruption theory (8). This study incorporates the digital transformation maturity model to elucidate how enterprises achieve continuous innovation through perception, integration, and reconstruction at different developmental stages (16).

Based on this, this study constructs a theoretical model for information security enterprises that integrates digital innovation, digital transformation, digital disruption, and technological innovation (Figure 1). Further research into the relationships among various variables and their causal pathways will analyze the impact mechanisms of digital innovation and digital transformation on digital disruption. This study will also validate the mediating role of digital disruption in driving technological innovation within information security enterprises, comprehensively revealing the pathway mechanisms through which digital innovation and digital transformation propel technological innovation. Concurrently, the following research hypotheses are proposed for empirical testing.

H1: Digital innovation has a significant positive effect on technological innovation.

H2: Digital transformation has a significant positive effect on technological innovation.

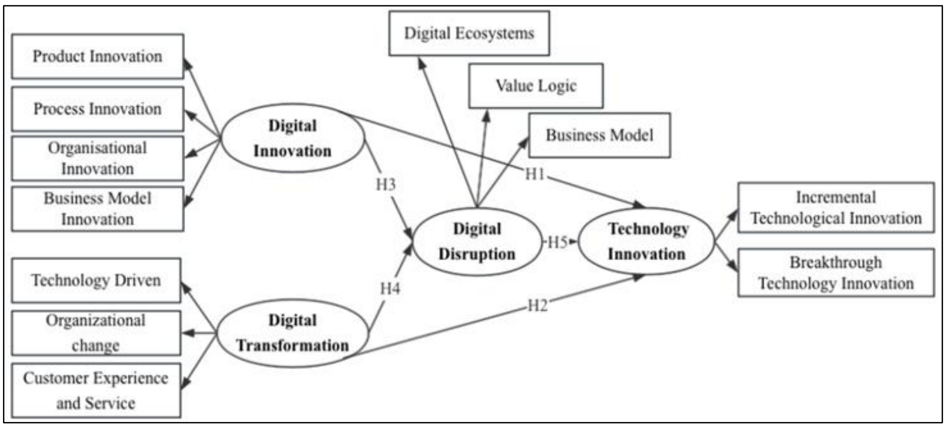

Figure 1: Conceptual Model Framework

H3: Digital innovation has a significant positive effect on digital disruption.
H4: Digital transformation has a significant positive effect on digital disruption.
H5: Digital disruption has a significant positive effect on technological innovation.
H6: Digital innovation indirectly influences technological innovation through the mediating effect of digital disruption.
H7: Digital transformation indirectly influences technological innovation through the mediating effect of digital disruption.

The composition of the core variables within this theoretical framework is as follows:

Digital innovation (DI) refers to a firm's application of digital technologies to innovate in products, processes, organizational structures, and business models (2), conceptualized across four dimensions: product innovation (PDI), process innovation (PI), organizational innovation (OI), and business model innovation (BMI). PDI leverages digital technologies to deliver intelligent, personalized solutions (2). PI enhances operational efficiency through technological advancements, while OI transforms structures and cultures to accelerate the adoption and scaling of digital technologies (17). BMI integrates these innovations, extending DI's reach and impact (18).

Digital transformation (DT) encompasses technology-driven (TD), organizational change (OC), and customer experience and service (CES) dimensions. TD drives transformation via the adoption of big data, cloud computing, AI, and IoT to optimize processes, products, and business models (1). OC enables transformation through structural, cultural, and skill adjustments (11). CES focuses on enhancing the customer journey, personalizing services, and improving interactions to foster loyalty and satisfaction (19). The dependent variable "Technological Innovation (TI)" comprises two dimensions: Incremental Technological Innovation (ITI) and Breakthrough Technological Innovation (BTI) (20). Within information security enterprises, technological innovation is influenced by the combined effects of digital innovation, digital transformation, and digital disruption.

Digital disruption (DD), the mediating variable, consists of digital ecosystems (DE), value logic (VL), and business model (BM) (21). DE fosters collaboration, resource integration, and value creation, while VL redefines value realization processes, allowing DD to permeate operations. Novel business models enable firms to leverage digital technologies to capture new market opportunities and gain a competitive advantage.

Methodology

Data Collection and Sample Design

This study adopts a quantitative research methodology to examine the mechanisms through which digital innovation (DI) and digital transformation (DT) influence technological innovation (TI) via digital disruption (DD). A structured questionnaire survey and statistical analysis were employed. Data were collected through stratified random sampling, with stratification criteria including age, gender, position, and company size, to ensure both representativeness and balance of the sample. The questionnaire utilized a five-point Likert scale and was subjected to pre-testing prior to formal distribution to enhance both reliability and validity. The final dataset was analyzed using Structural Equation Modeling (SEM) to assess direct and mediating effects between the variables. The significance of the mediating effects was verified through the bootstrapping method.

This study primarily focuses on Chengdu, Sichuan Province-a region with a high concentration of information security enterprises, while also covering eastern and central China to enhance the sample's regional representativeness. The survey participants include managers and technical personnel from information security companies, spanning different age groups (20-55 years old), corporate levels, and job categories, ensuring the sample's diversity and representativeness.

A stratified random sampling strategy was employed, with stratification criteria including age, gender, education level, position, company size, and company location. The sample size was determined using Yamane's formula for finite populations (22):

$$N = \frac{n}{1+n\ (e)^{2}} \qquad [1]$$

Note: Where N represents the required sample size, n is the population size, and e denotes the margin of error, typically set at 0.05 or 0.1.

Based on an estimated population of approximately 50,000 information security professionals in Chengdu and a 5% margin of error (e = 0.05), the calculated minimum sample size was approximately 397. To account for an expected 80% response rate, at least 497 questionnaires were distributed (23-25).

All items in the survey questionnaire employed a 5-point Likert scale (1 = Strongly Disagree, 5 = Strongly Agree) to capture respondents' subjective evaluations (26). The scale was localized and revised based on existing mature scales relevant to the information security industry context. A total of 39 items were used to measure the four core variables and their 12 dimensions. Prior to the formal survey, a pretest was conducted to ensure reliability and validity. Feedback from the pretest was used to revise the wording and structure of the scale, ensuring clarity and applicability of the measurements.

Data Analysis Methods

Data analysis employed software such as SPSS and AMOS, utilizing the following primary analytical methods:

Descriptive Statistics: Summarized sample characteristics and the distribution patterns of key variables, examined data for outliers or skewness, and provided foundational assessments for subsequent analysis.

Reliability and Validity Testing: Assessing internal consistency and construct validity using Cronbach's α coefficient and KMO test.

Confirmatory Factor Analysis (CFA): Evaluating model fit and the convergent/discriminant validity of latent variables.

Correlation Analysis: Exploring relationships between variables using Pearson correlation.

Differential Analysis: Employed one-way ANOVA to examine whether significant differences exist in core variables across different demographic or organizational characteristics, identifying potential control variables or stratification effects.

Structural Equation Modeling (SEM) Analysis: Tested causal pathways between theoretical constructs and overall structural relationships.

Mediating Effect Testing: Utilized Bootstrapping methods for mediation analysis to estimate mediating effects, validating the mediating pathways of digital disruption.

Results

Descriptive Statistics

In this study, a total of 526 questionnaires were distributed, of which 446 were returned and deemed valid, yielding a valid response rate of 84.79%. This rate meets the sampling adequacy requirements of the study. The demographic characteristics of the survey respondents are presented in Table 1.

Table 1: Statistics on Basic Information of Respondents

Type	Indicator	Frequency	Percentage
Gender	M	297	66.6
	F	149	33.4
Age	<20	34	7.6
	20-30	171	38.3
	31-40	143	32.1
	41-50	87	19.5
	>50	11	2.5
Education Level	High school and below	13	2.9
	College	82	18.4
	Undergraduate	249	55.8
	Master's degree and above	102	22.9
Enterprise size	ME	72	16.1
	SME	155	34.8
	MSE	130	29.1
	LE	64	14.3
	ELE	25	5.6
Location	Eastern	102	22.9
	Central	73	16.4
	Western	271	60.8
Positions	General Employee	67	15

Type	Indicator	Frequency	Percentage
	Technical Staff	182	40.8
	Technical Developer	103	23.1
	Middle management	66	14.8
	Top Management	28	6.3
	Total	**446**	**100**

From a gender perspective, male respondents accounted for approximately twice the number of female respondents, reflecting the male-dominated nature of the information security workforce. Regarding age, respondents aged 20 to 40 comprised 70.4% of the sample, highlighting the industry's trend toward a younger workforce, which aligns with government initiatives emphasizing cybersecurity and the growing demand for skilled talent. In terms of educational background, 78.7% of respondents held a bachelor's degree or higher (55.8% with a bachelor's degree and 22.9% with a master's degree or above), indicating the sector's demand for highly qualified professionals. Concerning enterprise size, 63.9% of respondents were from small and medium-sized enterprises, 19.9% from large and super-large enterprises, and 16.1% from micro-enterprises, consistent with the market structure where small and medium-sized enterprises predominate. Geographically, 60.8% of respondents were from western China, consistent with the study's regional sampling strategy. Regarding job roles, technical personnel accounted for 40.8%, technical developers for 23.1%, and middle managers for 14.8%, indicating a reasonable distribution that reflects the workforce composition in information security enterprises. Overall, the sample encompasses diverse characteristics including gender, age, education level, enterprise size, region, and job position. It largely aligns with the data trends presented in the "2024 Cybersecurity Industry Talent Development Report" released by the AnHeng Research Institute (27), demonstrating strong diversity and representativeness. The analyzed participant information is summarized in Table 2.

Table 2: Statistical Analysis of Basic Information of Interviewees

		Gender	Age	Educational Level	Enterprise Size	Location	Position
N	Valid	446	446	446	446	446	446
	Missing	0	0	0	0	0	0
Average Value		1.33	2.71	2.99	2.59	2.38	2.57
Standard Deviation		.472	.948	.728	1.092	.833	1.105
Skewness		.706	.246	-.436	.390	-.806	.532
Standard Error of Skewness		.116	.116	.116	.116	.116	.116
Kurtosis		-1.508	-.543	.122	-.481	-1.080	-.443
Standard Error of Kurtosis		.231	.231	.231	.231	.231	.231
Minimum		1	1	1	1	1	1
Maximum		2	5	4	5	3	5

The standard deviation, skewness, and kurtosis values presented in Table 3 indicate that the respondents' basic information conforms to a normal distribution, satisfying the assumptions required for this study. The descriptive statistics for the 12 dimensions examined in this research are summarized in Table 3.

The results indicate that the mean values for all dimensions in this study range from 3.1 to 3.8, reflecting an overall above-average level. This suggests that the surveyed information security companies possess a certain foundation in digital innovation, digital transformation, digital disruption, and technological innovation, although there remains potential for further improvement. Examination of the standard deviations (0.527-1.246) reveals variation across dimensions, with process innovation exhibiting the highest standard deviation (1.246), indicating substantial performance differences among companies in this area. Skewness and kurtosis values are generally close to 0, indicating a symmetrical distribution without pronounced peaks or flatness, thereby satisfying the assumptions for subsequent statistical analyses.

Table 3: Description of Statistical Results

Dimensions	N	Minimum	Maximum	Average	Standard Deviation	Skewness	Kurtosis
PDI	446	1	5	3.344	1.137	-0.602	-1.010
PI	446	1	5	3.128	1.246	-0.169	-1.429
OI	446	1	5	3.217	1.137	-0.302	-1.177
BMI	446	1	5	3.354	1.209	-0.549	-1.124
TD	446	1	5	3.224	1.072	-0.362	-0.969
OC	446	1	5	3.274	1.113	-0.476	-1.171
CES	446	1	5	3.243	1.090	-0.450	-0.857
DE	446	1	5	3.348	1.084	-0.512	-0.798
VL	446	1	5	3.315	1.009	-0.488	-0.579
BM	446	1	5	3.531	1.099	-0.757	-0.631
BTI	446	1	5	3.613	0.979	-0.393	-0.711
ITI	446	2	5	3.792	0.527	-0.206	0.085
DI	446	1	5	3.261	0.974	-0.533	-1.290
DT	446	1	5	3.247	0.875	-0.419	-1.047
DD	446	1	5	3.398	0.880	-0.853	-0.329
TI	446	2	5	3.702	0.629	-0.326	-0.634

Table 4: Reliability Test for Each Variable

Variables	Cronbach's α	Item Count
Digital Innovation	**0.928**	13
Product Innovation	0.888	4
Process Innovation	0.908	3
Organizational Innovation	0.877	3
Business Model Innovation	0.858	3
Digital Transformation	**0.88**1	10
Technology Driven	0.831	3
Organizational Change	0.894	4
Customer Experience and Service	0.809	3
Digital Disruption	**0.895**	10
Digital Ecosystems	0.809	3
Value Logic	0.880	4
Business Model	0.869	3
Technological Innovation	**0.857**	6
Breakthrough Technological Innovation	0.882	3
Incremental Technological Innovation	0.838	3

Reliability Test

The reliability of each section of the questionnaire was tested separately, and the results are shown in Table 4. The results are presented in the table. All variables and their respective dimensions exhibited Cronbach's alpha coefficients greater than 0.80, indicating high internal consistency of the questionnaire. This demonstrates that the research data possess a strong reliability foundation, suitable for subsequent structural equation modeling and path analysis.

KMO and Bartlett's Test of Sphericity

The results of the KMO and Bartlett tests are shown in Table 5.

Table 5: KMO and Bartlett's Test

Variables	KMO	Bartlett's Test of Sphericity		
		Approximate Chi-Square	df	Sig.
DI	0.921	3899.442	78	0.000
DT	0.873	2279.955	45	0.000
DD	0.891	2402.297	45	0.000
TI	0.822	1385.825	15	0.000

The test results indicated that the KMO values for all four variables exceeded 0.8. According to Kaiser's criteria (28), a KMO value greater than 0.9 is considered "very suitable", while a value between 0.8 and 0.9 is regarded as "suitable". This suggests that the sample data are appropriate for factor analysis. Moreover, the Bartlett's test of sphericity was highly significant (Sig. = 0.000), indicating sufficient correlations among the variables and further confirming the suitability of the data for factor analysis.

Confirmatory Factor Analysis (CFA)

The model obtained through confirmatory factor analysis using AMOS for the four variables-digital innovation, digital transformation, digital disruption, and technological innovation shown in Figure 2. The model fit indices are presented in Table 6. According to the structural equation model fit indices (29), all fit indices meet the recommended standards, indicating that the model exhibits overall good fit.

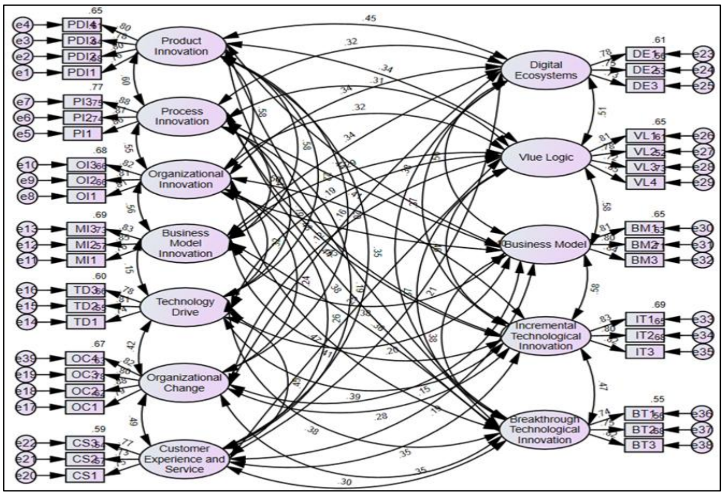

Figure 2: Confirmatory Factor Analysis Model

Table 6: Model Fit Indicators

Indicator	X^2/df	GFI	AGFI	NFI	TLI	CFI	RMSEA
DI	1.369	0.973	0.959	0.979	0.993	0.994	0.029
DT	1.323	0.983	0.970	0.982	0.994	0.995	0.027
DD	1.400	0.982	0.968	0.982	0.992	0.995	0.030
TI	1.381	0.992	0.978	0.992	0.996	0.998	0.029
Reference Value	<2	>0.9	>0.9	>0.9	>0.9	>0.9	<0.05
Achievement of Standards	Criteria Met	Criteria Met	Criteria Met	Criteria Met	Criteria Met	Criteria Met	Criteria Met

Table 7: Results of Convergent Validity Analysis for Each Variable

Variables	Measurement Items	Estimate	S.E.	C.R.	P	CR	AVE
DI	PDI	0.844				0.880	0.648
	PI	0.779	0.081	12.659	***		
	OI	0.801	0.075	12.562	***		
	BMI	0.794	0.079	11.732	***		
DT	TD	0.729				0.782	0.545

	OC	0.715	0.132	8.363	***		
	CES	0.770	0.140	8.274	***		
	DE	0.766					
DD	VL	0.759	0.091	10.063	***	0.828	0.617
	BM	0.829	0.105	10.079	***		
TI	BTI	0.655				0.742	0.595
	ITI	0.872					

Table 8: Distinguished Validity Analysis Test

Dimensions	PDI	PI	OI	BMI	TD	OC	CES	DE	VL	BM	BTI	ITI
PDI	**.816**											
PI	.605**	**.876**										
OI	.581**	.566**	**.840**									
BMI	.590**	.523**	.566**	**.818**								
TD	.397**	.388**	.439**	.392**	**.790**							
OC	.438**	.385**	.440**	.384**	.457**	**.826**						
CES	.516**	.441**	.432**	.417**	.462**	.473**	**.766**					
DE	.464**	.376**	.408**	.392**	.375**	.372**	.390**	**.765**				
VL	.377**	.350**	.367**	.358**	.349**	.281**	.363**	.490**	**.806**			
BM	.457**	.436**	.426**	.413**	.376**	.333**	.349**	.535**	.555**	**.831**		
BTI	.520**	.501**	.521**	.489**	.477**	.429**	.459**	.441**	.476**	.569**	**.845**	
ITI	.405**	.349**	.394**	.363**	.395**	.298**	.349**	.328**	.299**	.277**	.333**	**.799**

Note: The bolded data values in the upper right corner are the square root of the AVE values

Convergent Validity: The results of the convergent validity analysis of each research variable are shown in Table 7. All standardized factor loadings for the latent variables were significant ($p < 0.001$) and exceeded 0.70. Composite reliability (CR) values were above 0.70, and the average variance extracted (AVE) exceeded 0.50, indicating that the scale demonstrates good convergent validity.

Discriminant Validity: The results of the discriminant validity test are shown in Table 8.

The results indicate that the AVE values for all dimensions exceed 0.50, and the square roots of the AVE values are greater than the correlation coefficients between the dimensions. The measurement model satisfies internationally recognized evaluation criteria for goodness of fit, convergent validity, and discriminant validity, providing a reliable foundation for subsequent structural equation modeling (SEM) analysis.

Correlation Analysis

To further examine the relationships among the variables, Pearson correlation analysis was employed to assess the associations between the four variables: digital innovation, digital transformation, digital disruption, and technological innovation. The results are presented in Table 9. The analysis results indicate that all variables exhibit significant positive correlations ($p < 0.01$), demonstrating strong linear relationships among them.

Table 9: Correlation Test for Each Variable

	DI	DT	DD	TI
DI	1			
DT	.638**	1		
DD	.590**	.534**	1	
TI	.671**	.623**	.620**	1

Note: ** indicates a significant correlation at the 0.01 level (two-tailed)

Difference Analysis

To examine demographic differences in digital innovation (DI), digital transformation (DT), digital disruption (DD), and technological innovation (TI), one-way analysis of variance (ANOVA) was conducted, with a significance threshold of $p < 0.05$. The results indicated no significant gender differences across the four core variables. Significant differences, however, were observed in other demographic categories, as detailed below:

Age Differences: The results of the analysis of age-related differences across the variables are summarized in Table 10.

Table 10: Analysis of Differences in Variables by Age

	<20 M±SD	20-30 M±SD	31-40 M±SD	41-50 M±SD	>50 M±SD	F	P
DI	2.89±1.14	3.25±0.947	3.43±0.916	3.22±0.96	2.71±1.254	3.283	0.011
DT	3±0.962	3.28±0.861	3.32±0.837	3.24±0.869	2.57±1.08	2.699	0.030
DD	3.07±1.014	3.4±0.924	3.55±0.731	3.34±0.893	2.93±1.091	3.155	0.014
TI	3.59±0.735	3.66±0.61	3.85±0.593	3.67±0.605	2.98±0.629	6.264	0.000

Significant differences were observed among age groups for digital innovation (p = 0.011), digital transformation (p = 0.030), digital disruption (p = 0.014), and technological innovation (p < 0.001). Specifically, younger and middle-aged respondents scored higher on digital innovation and technological innovation, suggesting a greater level of engagement and active participation in driving corporate digital transformation and technological innovation.

Educational Attainment Differences: The results of the analysis of differences across educational attainment levels for each variable are shown in Table 11 below.

Table 11: Analysis of Differences in Variables by Education Level

	High School and Below	College	Undergraduate	Master's Degree and Above	F	P
	M±SD	M±SD	M±SD	M±SD		
DI	2.71±1.133	3.13±0.95	3.22±0.989	3.54±0.873	4.994	0.002
DT	2.85±1.078	3.13±0.86	3.24±0.882	3.42±0.82	2.728	0.044
DD	2.88±1.011	3.27±0.919	3.39±0.873	3.58±0.815	3.555	0.014
TI	3.35±0.763	3.54±0.62	3.7±0.629	3.87±0.571	5.835	0.001

Significant differences were observed across educational attainment groups for all four core variables (p < 0.05), with respondents holding a master's degree or higher scoring the highest, and those with a high school diploma or lower scoring the lowest. These results suggest that educational attainment is closely associated with both the perception and application of digital capabilities and technological innovation.

Enterprise Size Differences: The results of the analysis of differences in each variable across different enterprise sizes are shown in Table 12 below.

Table 12: Analysis of Differences in Variables by Enterprise Size

	ME M±SD	SME M±SD	MSE M±SD	LE M±SD	ELE M±SD	F	P
DI	3.08±1.009	3.24±0.973	3.27±0.987	3.31±0.938	3.74±0.778	2.191	0.069
DT	3.1±0.918	3.21±0.871	3.22±0.873	3.35±0.853	3.76±0.67	3.073	0.016
DD	3.27±0.974	3.36±0.872	3.38±0.88	3.48±0.833	3.89±0.617	2.548	0.039
TI	3.47±0.648	3.66±0.594	3.73±0.636	3.87±0.581	4.03±0.624	5.914	0.000

Significant differences across enterprise sizes were observed for digital transformation (p = 0.016), digital disruption (p = 0.039), and technological innovation (p < 0.001), in addition to digital innovation. Large and extra-large enterprises scored significantly higher than small and medium-sized enterprises in terms of digital transformation and technological innovation, reflecting the influence of scale advantages on resource allocation and innovation capabilities. These findings indicate that enterprise size plays a significant role in shaping the processes of digital transformation and technological innovation.

Position Differences: The results of the analysis of differences across various positions within enterprises for each variable are presented in Table 13.

Table 13: Analysis of Differences in Variables by Position

	General Employee M±SD	Technical Staff M±SD	Technical Developer M±SD	Middle management M±SD	Top Management M±SD	F	P
DI	2.98±0.998	3.18±0.969	3.33±0.969	3.48±0.908	3.67±0.898	4.054	0.003
DT	3.02±0.899	3.19±0.903	3.3±0.831	3.38±0.828	3.66±0.746	3.346	0.010
DD	3.23±0.953	3.4±0.918	3.35±0.813	3.51±0.851	3.75±0.662	2.077	0.083
TI	3.51±0.622	3.65±0.633	3.68±0.614	3.91±0.557	4.11±0.563	7.159	0.000

Significant differences across job positions were observed for digital innovation ($p = 0.003$), digital transformation ($p = 0.010$), and technological innovation ($p < 0.001$), with top management scoring the highest and general employees scoring the lowest, indicating a positive relationship between job hierarchy and performance in these areas. In contrast, digital disruption did not show significant differences across positions ($p > 0.05$). Overall, age, educational attainment, enterprise size, and job position were identified as key factors influencing employees' perception and engagement in digital innovation, digital transformation, and technological innovation; whereas gender and regional differences were comparatively minor. These findings provide actionable insights for talent management and organizational strategy in information security enterprises to advance digitalization and technological innovation initiatives.

Structural Equation Model Fit Test

To evaluate the fit between the theoretical model and the sample data, a structural equation model (SEM) was constructed and subjected to a fit assessment. The relevant fit indices are presented in Table 14.

Table 14: Fit Indices of the Structural Equation Model

Indicator	X^2/df	GFI	AGFI	NFI	TLI	CFI	RMSEA
Statistical Value	1.236	0.978	0.964	0.974	0.993	0.995	0.023
Reference Value	<3	>0.8	>0.8	>0.9	>0.9	>0.9	<0.08
Achievement of standards	Criteria Met	Criteria Met	Criteria Met	Criteria Met	Criteria Met	Criteria Met	Criteria Met

The results indicate that the chi-square to degrees of freedom ratio (χ^2/df) is 1.236, which is below the recommended threshold of 3, suggesting an overall good model fit. All goodness-of-fit indices are excellent, with GFI = 0.978, AGFI = 0.964, NFI = 0.974, TLI = 0.993, and CFI = 0.995, all exceeding the recommended benchmarks of 0.9 or 0.8, indicating a high level of model adequacy. The root mean square error of approximation (RMSEA) is 0.023, well below the cutoff of 0.08, further confirming the model's excellent fit according to the criteria proposed in past study (29). In summary, the structural equation model developed in this study satisfies or surpasses the recommended standards for all key fit indices, accurately reflecting the relationships among digital innovation, digital transformation, digital disruption, and technological innovation, thereby providing a robust basis for subsequent path coefficient analysis and hypothesis testing. The results of the path relationship analysis among the variables are presented in Table 15.

Table 15: Path Coefficients Test of the Structural Equation Model

Path			Estimate	S.E.	C.R.	P
DD	←	DI	0.462	0.103	3.849	***
DD	←	DT	0.330	0.122	2.671	0.008
TI	←	DI	0.342	0.037	2.672	0.008
TI	←	DT	0.418	0.045	3.092	0.002
TI	←	DD	0.412	0.033	4.214	***

Note: * indicates P < 0.05, ** indicates P < 0.01, *** indicates P < 0.001

The results show that digital innovation significantly promotes digital disruption (β = 0.462, p < 0.001), indicating that innovations in products, processes, organizations, and business models drive changes in digital ecosystems, value logic, and business models. Digital transformation also positively affects digital disruption (β = 0.330, p = 0.008), suggesting that technology adoption, organizational restructuring, and customer experience optimization facilitate enterprise digital disruption. Both digital innovation (β = 0.342, p = 0.008) and digital transformation (β = 0.418, p = 0.002) directly enhance technological innovation, while digital disruption further strengthens it (β = 0.412, p < 0.001). Overall, all hypothesized paths are supported, confirming that digital innovation and transformation promote technological innovation both directly and indirectly via digital disruption.

The standardized path coefficients are presented in Figure 3.

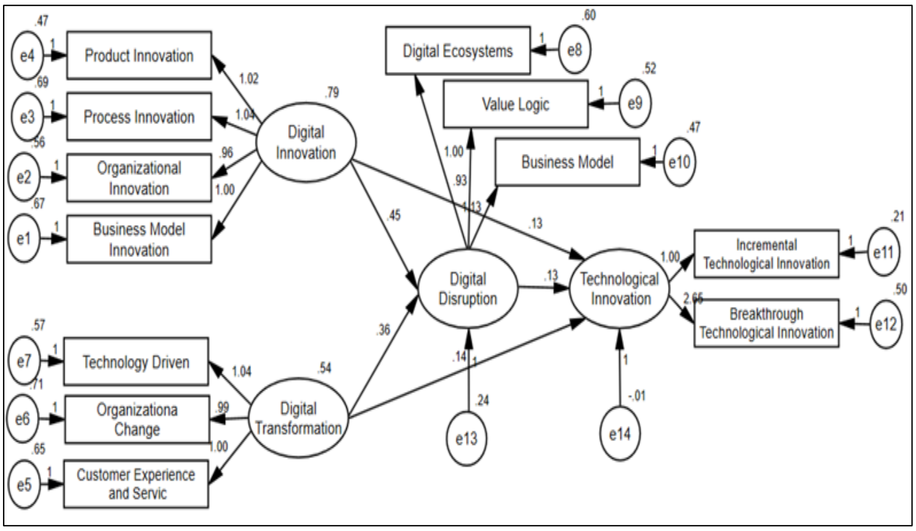

Figure 3: Structural Equation Model Diagram Results (Standardized)

Hypothesis Path Testing

The proposed hypotheses were tested as follows: **H1:** Digital innovation positively affects technological innovation (β = 0.342, P = 0.008, C.R. = 2.719), supporting H1. **H2:** Digital transformation positively affects technological innovation (β = 0.418, P = 0.002, C.R. = 3.165), supporting H2. **H3**: Digital innovation significantly promotes digital disruption (β = 0.462, P < 0.001, C.R. = 3.849), supporting H3. **H4:** Digital transformation positively impacts digital disruption (β = 0.330, P = 0.008, C.R. = 2.671), supporting H4. **H5:** Digital disruption significantly enhances technological innovation (β = 0.412, P < 0.001, C.R. = 4.405), supporting H5. Overall, H1-H5 are empirically supported, confirming the significant positive relationships among digital innovation, digital transformation, digital disruption, and technological innovation.

Table 16: Mediation Effect Test Results

Parameter	Estimate	Lower	Upper	P	R^2
DI - DD - TI (Indirect effect)	.190	.061	.364	.003	0.390
DT - DD - TI (Indirect effect)	.136	.027	.311	.017	0.390
DI - TI (Direct effect)	.342	.079	.601	.018	0.515
DI - TI (Total effect)	.532	.217	.818	.003	0.563
DT - TI (Direct effect)	.418	.134	.701	.008	0.515
DT - TI (Total effect)	.553	.230	.852	.002	0.563

Mediating Effect Analysis

The Bootstrap method was employed to examine the mediating role of digital disruption in the effects of digital innovation and digital transformation on technological innovation. The results are summarized in Table 16.

H6: The mediating effects of digital disruption were tested using the Bootstrap method. The results indicate that digital innovation indirectly influences technological innovation through digital disruption (β = 0.190, 95% CI [0.061, 0.364], P = 0.003), with a direct effect of 0.342 (P = 0.018) and a total effect of 0.532 (P = 0.003; R^2 = 0.563), supporting H6. **H7:** Digital transformation exerts a significant indirect effect on technological innovation via digital disruption (β = 0.136, 95% CI [0.027, 0.311], P = 0.017), with a direct effect of 0.418 (P = 0.008) and a total effect of 0.553 (P = 0.002; R^2 = 0.563), supporting H7.

These findings demonstrate that both digital innovation and digital transformation not only directly enhance technological innovation in information security enterprises but also exert significant indirect effects through digital disruption, underscoring the pivotal mediating role of digital disruption in the innovation process.

Discussion

This study confirms the significant positive impact of digital innovation and digital transformation on technological innovation in information security enterprises, and further reveals that digital disruption plays a crucial mediating and amplifying role in this pathway. Theoretically, this finding is supported by the Dynamic Capability Theory (14), the TOE framework (15), and disruption theory (8). Digital innovation enhances firms' sensing and experimenting capabilities, while digital transformation boosts technological output capacity through organizational restructuring and process reengineering. Digital disruption amplifies these conversion efficiencies by reshaping ecosystems and business models, enabling strategic investments to translate more rapidly and effectively into technological innovation outcomes (8, 30).

Comparisons with prior research reveal both alignment and subtle differences. On one hand, consistent with findings by previous researchers that digitalization promotes organizational and technological innovation (2, 4); this study reconfirms the positive effects of digital initiatives within the cybersecurity industry context. On the other hand, this study emphasizes the moderating role of industry context: within information security enterprises, the technology-driven dimension contributes more strongly to technological innovation, while organizational change plays a relatively minor role. This finding contrasts with several studies in manufacturing or service industries (where organizational change carries greater weight in certain environments), suggesting that industry characteristics-such as high research and development intensity, rapid technological iteration, and stringent regulation reshape the relative importance of digital elements (13, 31). Specific alignments and divergences are detailed in Table 17 below.

Table 17: Fits and Differences with Existing Research

Issue	This Study Found	Established Literature Consensus	Differences and Extensions
DI→T I	Significant positive effect (β = 0.342) .	Digital Innovation can catalyze security technology breakthroughs (5).	After subdividing into the four dimensions of product, process, organization, and business model, it is found that process and business model innovations contribute more to breakthrough innovations, which broadens the perspective of the “three-part model” of Fichman *et al.* (3).
DT→TI	Positive and significant (β = 0.418) and stronger direct effect.	Vial views digital transformation as a comprehensive capability reinvention (4).	In the context of information security, the technology-driven dimension exerts the greatest influence, indicating that the security industry relies more heavily on

			underlying IT capabilities. This contrasts with the conclusion in general manufacturing, where “organizational transformation” carries greater weight.
DI/DT→DD	Both paths are significant, Digital Innovation has a greater impact (β = 0.462 vs. 0.330).	Skog *et al.* emphasize innovation as the “first mover” of disruption (8).	This confirms innovation's “pioneering” role over transformation, while also highlighting transformation's compensatory function, corroborating the findings of Verhoef *et al.* (30).
DD→TI	B = 0.412, disruption acts as an amplifier.	Kane *et al.* demonstrate that Digital Disruption can reshape security posture (6).	Digital disruption acts as an amplifier in technological innovation pathways. Quantitative results indicate it enhances explanatory power by 17.3%, further refining Kane *et al.'s* discussion on disruptive effects (6).

Furthermore, treating digital disruption as an intermediate variable and quantifying it fills a gap in existing literature where the “disruption” mechanism has been insufficiently quantified. This study demonstrates that digital disruption manifests not only through technological substitution but, more significantly, by reshaping ecosystems, transforming value logic, and innovating business models. These changes alter resource allocation and value realization pathways, thereby amplifying the contribution of digital innovation/transformation to technological innovation (6, 8). Considering industry-specific characteristics, this study finds that information security enterprises exhibit high research and development intensity, short technology iteration cycles, and significant regulatory pressure during digitalization. This discovery supplements existing general industry research.

This study theoretically supplements and expands existing literature. First, it addresses the academic concern regarding insufficient research on the relationship between enterprise-level digital transformation and technological innovation, particularly within the industry context of information security enterprises characterized by high research and development intensity, short technology lifecycles, and significant compliance pressures. In the past, one researcher empirically demonstrates that digital transformation significantly enhances innovation capabilities and strengthens corporate risk tolerance (32), validating the critical role of digital pathways in innovation contribution mechanisms. Second, findings reveal that digital disruption exerts amplifying and mediating effects on the influence of digital innovation and digital transformation on technological innovation-aspects rarely systematically quantified in existing literature-thus enriching empirical tests of disruptive mechanisms. Researchers (33) highlighted that the core security challenges and restructuring mechanisms inherent in digital transformation provide contextual reference for understanding digital disruption. Finally, this study combines dynamic capability theory with the TOE framework to emphasize the systemic impact of digital initiatives on corporate innovation pathways, offering a new interpretive perspective for future research.

At the practical level, this study offers three key insights for the digitalization and innovation strategies of information security enterprises. First, companies should establish a synergistic mechanism linking “innovation-transformation-disruption”, integrating continuous improvement of products and processes with breakthrough innovations in organizational structures and business models to form an innovation strategy that balances incremental and disruptive approaches. Second, enterprises must proactively enhance cyber defense capabilities and customer value creation through digital transformation, exploring emerging business models such as

"Security-as-a-Service". This approach aligns with Stefani's (34) proposal to integrate digital transformation strategies with cybersecurity risk management frameworks, thereby improving overall quality and security during digitalization. Third, information security enterprises should leverage policy and regulatory support to further strengthen organizational agility and dynamic capabilities. This will enhance their ability to respond to rapidly evolving threat landscapes and market demands, thereby sustaining competitive advantage.

Conclusion

This study investigates how digital innovation and digital transformation affect technological innovation via digital disruption, with a focus on information security enterprises. Empirical analysis of 446 valid samples reveals: Both digital innovation and digital transformation exert significant direct positive effects on technological innovation, confirming the pivotal role of digital resources and transformation initiatives in driving corporate innovation; Digital disruption plays a significant mediating role, amplifying the effects of digital innovation and transformation while reshaping the value logic and business models of information security. Technological innovation in information security enterprises follows two paths: "incremental optimization and breakthrough transformation", which rely on both ongoing technical refinement and the introduction and application of emerging technologies. These findings illustrate that the digital journey of information security enterprises is not merely about efficiency gains but is directly linked to their capabilities in defending against cyberattacks, pioneering new business models, and accelerating innovation velocity.

At the theoretical level, this study addresses gaps in existing literature regarding the relationship between enterprise-level digital transformation and technological innovation, highlighting the unique characteristics of information security enterprises-such as high research and development intensity, short technology lifecycles, and significant regulatory pressures. Simultaneously, by integrating dynamic capability theory, the TOE framework, digital disruption theory, and the digital transformation maturity model, the study deepens our understanding of the interplay between digital innovation, digital transformation, digital disruption, and technological innovation. At the practical level, the study offers three key insights for information security enterprises: First, establish a "innovation-transformation-disruption" synergy mechanism to develop a technology strategy portfolio that balances incremental and breakthrough approaches. Second, enhance cyber defense capabilities and customer value creation through digital transformation, actively exploring new business models such as "Security-as-a-Service". Third, with policy and regulatory support, enterprises must strengthen organizational agility and dynamic capabilities to enhance sustained innovation capacity in rapidly changing environments.

Although this study contributes both theoretically and practically, certain limitations remain. First, the research data primarily originates from Chinese information security enterprises, potentially affecting the cross-regional generalizability of the findings. Second, the methodology relies heavily on questionnaire surveys and structural equation modeling, without sufficiently integrating longitudinal data and case studies to reveal the dynamic evolution of variables. Future research may explore two avenues: First, expanding cross-industry and cross-national comparative studies to further validate the applicability of the research model. Second, integrating longitudinal data with multi-method designs to delve into the interactive mechanisms among digital innovation, digital transformation, and technological innovation across different time periods and varying policy and technological contexts.

Abbreviations

CES: Customer Experience and Service, DD: Digital Disruption, ELE: Super-large Enterprises, ITI: Incremental Technological Innovation, LE: Large-sized Enterprises, ME: Micro-enterprises, MSE: Medium-sized Enterprises, OC: Organizational Change, PDI: Product Innovation, SME: Small Enterprises, VL: Value Logic.

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Author Contributions

All authors participated in the conception and design of the study.

Conflict of Interest

No conflict of interest exists.

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The author(s) used OpenAI's ChatGPT to edit and refine the wording of the Introduction. All outputs were reviewed and verified by the author.

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