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Beyond Digital Transformation: A Hybrid SEM–System Dynamics Explanation of Institutional Resilience in Higher Education

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Abstract

The digital transformation of universities is more often than not described in terms of adopting new digital technologies. Using new integrated systems is assumed to lead to improved operational efficiencies. Such changes may be described as digital transformations; however, they may be little more than minor incremental improvements. These incremental digital technologies will not bring about major resilience or the ability to cope with radical changes. Most of the published studies consider the impact of the changes and improvements in a linear manner and are mostly concerned with the technological aspects. This study overcomes this deficit by conceptualizing resilience as an evolving and capability mediated organizational outcome. Building on both the Resource-Based View and Dynamic Capabilities Theory, this study uses a hybrid PLS-SEM-System Dynamics approach to study resilience in the Saudi higher education system. Survey responses from 327 academics and administrators formed the foundation of this study. Empirically supported relationships were translated into an exploratory dynamic simulation. The results show that the maturity of digital transformation does not directly impact institutional resilience. Rather, it is mediated by organizational agility and innovation capability. From a transformation standpoint, digital competence is the primary upstream driver; however, from a resilience standpoint, funding stability has a direct impact. In terms of the capability-based view, the simulation shows that the adaptation of organizational structures that accompanies the development of resilience can occur gradually. This study contributes to the literature in two ways. First, it challenges the technology-based deterministic approaches to the adoption of digital technologies in higher education. Second, it uses a combination of variance-based and systematic approaches to provide a deeper insight into the development of adaptive and resilient capabilities in higher education.

Keywords: Digital transformation; Institutional resilience; Organizational agility; Innovation capability; Post-secondary education.

1. Introduction

Higher education institutions (HEIs) face rapid changes due to the confluence of disruptive technologies, (unpredictable) financing, changing demographics, shifting geopolitical landscapes, and uncertainty surrounding the needs and wants of stakeholders. HEIs have evolved from focusing on the short-term problems and challenges that affect the day-to-day operations of the institution, to the ability to sense and respond to changes, and to alter different aspects of the HEI and maintain various levels of performance over the long-term. Resilience is no longer about responding defensively to threats and challenges, but is a core strategic capability (Duchek, 2020; Hillmann & Guenther, 2021). Concurrent with this, the digital age has influenced all HEI activities (governance, teaching, learning, research, administration, and the management of knowledge) as well as all HEI activities related to planning and policy implementation (García-Morales et al., 2021; Verhoef et al., 2021; Vial, 2019).

Digital transformation involves all aspects of HEI activities, including teaching and learning. It is a common misperception that simply converting teaching and learning to digital formats is a form of digital transformation. HEIs may become less resilient if digital transformation is not approached from the perspective of changing HEI governance, (strategic) decision-making, competencies, routines, and way of doing and thinking about (cot/st) value (Bharadwaj et al., 2013; Svahn et al., 2017; Warner & Wäger, 2019). Digital transformation may create an over reliance on technology, unmanageable complexity, and a sharp break and disconnect in HEI governance, especially given competing HEI stakeholder interests, bureaucratic structures, and professional autonomy, as well as management styles of low to no control, that are inherent in the HEI system. This is particularly true for the modern university system with its decentralized structures.

While some studies report a positive correlation between digital transformation and resilience, some studies argue that that correlation is not direct (Awad & Martín-Rojas, 2024; He et al., 2023; Zhang et al., 2021). The positive effects of digital transformation are contingent on the ability of institutions to leverage the digital assets into agility, innovation, and a learning culture. According to Resource-Based View (RBV), digital transformation is a digital organizational resource that represents a competitive advantage and supports an organization's transformation (Barney, 1991; Limani et al., 2019). From a Dynamic Capabilities Theory perspective, this is the ability of organizations to identify opportunities in the evolving marketplace and strategically modify their resources and routines in an uncertain environment

(Teece, 2007). Therefore, it is more accurate to say that institutional resilience is the combination of several capabilities rather than the result of advanced organizational technology.

Another shortcoming of the existing studies is that they rely heavily on static models. Although cross-sectional structural models shed some light on the relationships between latent variables of an organization, they only capture a moment in a process that may take a long time to complete. Resilience at the institutional level is unlikely to be the result of technology and digital transformation initiatives. Instead, it is likely the result of accumulating capabilities, modifying behaviors, and learning from resource constraints.

Thinking in systems enables us to conceptualize universities as large corporate systems in which the evolution of capabilities and outcomes may be influenced by accumulation, time lag, delay, saturation and feedback among other variables (Davis et al., 2007; Sterman, 2000). Integration of Partial Least Squares Structural Equation Modeling (PLS-SEM) and System Dynamics allows the empirical determination of structural relationships and the exploration of the likely future effects of these relationships beyond the boundaries of current systems.

Saudi higher education is an appropriate context in which to analyze these relationships. Within the context of Saudi Vision 2030, universities have received increased digital funding, restructuring of management, and demands to modernize and enhance the innovative, effective, and sustainable operation of the organization. However, uneven digital funding, organizational preparedness, supportive leadership, and financial resources may limit the potential of universities to actualize digital funding in the creation of sustainable institutional resilience. Thus, the context of Saudi Arabia can be used to study the digital evolution in an almost fully changed large scale governmental educational system (Alenezi, 2021).

In this context, the study focuses on the role of digital transformation maturity in enhancing institutional resilience in Saudi Arabian higher education and whether having organizational agility and innovation capability may provide the additional explanatory factors of this relationship. Furthermore, the study focuses on the factors of digital maturity, leadership, and policy funding as supportive conditions of resilience. The study expects to use PLS-SEM to study the relationships, while System Dynamics will be used to study the changes of the relationships over time under various institutional preparedness scenarios.

2. Literature Review and Hypotheses Development

2.1 Digital Transformation and Institutional Resilience

Digital transformation is no longer simply a technological change but an organization-wide transformation that encompasses not only strategy but also the design of the institution, changes in governance, learning, and the development of organizational capabilities (Bharadwaj et al., 2013; Verhoef et al., 2019; Vial, 2019). For higher education institutions, digital transformation is much more than technology adoption; it is about the extensive transformation of the education system, organizational processes and structures, governance, the management of knowledge, and the routines and practices of the organization to improve the institution's preparedness for the future (Bond et al., 2018, 2021; Branch et al., 2020; García-Morales et al., 2021; Xiao, 2019). Digital transformation is increasingly perceived in the education and higher education sectors as a driver of competitive advantage and a differentiator for frameworks of governance, decision-making, and the agility of the organization and system within an ecosystem of knowledge-intensive education (Carmo et al., 2025; UNESCO, 2025).

Despite the instrumental and positive role digital transformation plays in organizational resilience and adaptability, many studies document its effects using deterministic frameworks (He et al., 2022; Zhang et al., 2021). Earlier works on transformation document systems of automation, technological advancement, streamlined processes, and digital infrastructures as direct contributors to resilience (Bharadwaj et al., 2013; Sebastian et al., 2018). While most of the aforementioned works focus on the positive effects of digital transformation, recent studies have expressed concern that digital transformation can lead to increased rigidity, coordination and governance issues, an over-reliance on technology, and institutional complexity in the presence of underdeveloped organizations' adaptive capabilities (Bharadwaj et al., 2013; Kwiotkowska, 2024a; Sebastian et al., 2018; Svahn et al., 2017).

Recent studies from institutions of higher education have shown that fragmented digital ecosystems, a lack of digital skills, insufficient integration across institutions, and low levels of strategic alignment have caused non-adaptive learning outcomes despite significant investments in technology. Many of these problems are still faced by universities (Limanovskaja & Davidavičienė, 2025). The problems faced by universities are further complicated by the bureaucratic nature of governance and the aforementioned problems that create barriers to adaptive change (Alenezi, 2021; Rughani et al. 2025). Because of this, digital transformations should not be seen as a resilience factor. They should be viewed more as an enabling channel in the development of adaptive capabilities, and in the processes of organizational learning and renewal (Kwiotkowska, 2024b; Nurhayati & Astono, 2024; Warner & Wäger, 2018).

2.2 Dynamic Capabilities and Adaptive Capability Development

When considering the need for organizations to adapt in the face of environmental volatility and rapid technological changes, the relevance of Dynamic Capabilities Theory becomes apparent (Teece, 2017, 2025). Unlike the traditional resource-based view, Dynamic Capabilities Theory is concerned with the ability of an organization to identify changes in the environment, opportunistic changes, and the ability to reconfigure resources, as well as competencies in the process (Eisenhardt & Martin, 2000; Teece, 2017).

The capability to innovate and be agile provide higher education institutions a competitive advantage that results in increased adaptive capacity.

It has been suggested that organizational agility encompasses an organization's ability to respond to changes in the environment, adapt and reform the practices of the organization, and create and preserve equilibrium in the face of disruptive occurrences (He et al., 2022; Awad & Martín-Rojas, 2024; J. Zhang et al., 2021). Agility contributes toward an organization's capability to innovate, allowing organizations to create flexible solutions and process modifications, and to initiate new strategies and learn from challenging and disruptive experiences (Saunila, 2020; Wang & Ahmed, 2007; J. Zhang et al., 2025).

More recently, some researchers have recognized adaptive capabilities as factors that help explain why some organizations become more resilient as a result of their digital transformation (Awad & Martín-Rojas, 2024; Nurhayati & Astono, 2024; Warner & Wäger, 2018). Therefore, it can be suggested that the more advanced an organization becomes in its digital transformation, the more agile and innovative the organization will be, and the more resilient the organization will become.

2.3 Systems Thinking and Institutional Resilience

Most of the existing literature on resilience relies on static, variance-based approaches and suggests either an attribute of an organization that is persistent, or an immediate response to disruption (Duchek, 2019; Lengnick-Hall et al., 2011). However, the development of resilience in higher education systems is dynamic, recursive, nonlinear, temporally contingent, and the like. With systems thinking, universities can be viewed as complex adaptive systems with recursive adaptation in which delayed responses, feedback are dominant, and path dependency are present (Holland, 2006; Liu et al., 2022; Sterman, 2000).

In such systems, the outcomes of the organization flow from the combined effects of technology, institutional governance, learning, and the environment, rather than from isolated, linear relationships (Davis et al., 2007; Khan et al., 2019). In this situation, institutional resilience must be perceived as an emergent system's property caused by learning that is

adaptive and reinforced by feedback that is coupled with delayed adaptation (Duchek, 2019; Khan et al., 2019). This happens over time. Therefore, the use of static analysis methods alone will not explain the development of resilience in higher education systems. Structural Equations Modeling (SEM) provides robust structural explanations for latent organizational relationships, but lacks recursive adaptation, delayed accumulation, and the behavior of temporal systems (Hair et al., 2021).

2.4 Leadership Support and Funding Stability

Leadership support is vital for the mobilization of resources, the determination of the institutional goals and direction, and the development of the ability of the organization to respond to changes and uncertainty caused by technological innovation (M. Zhang et al., 2024). It is suggested that leadership support has a positive relationship with the maturity of digital transformation.

Along with leadership support, stability of funding is an essential resource for institutional continuity and organizational flexibility, as well as the management of resources for the development of adaption capabilities (Barney, 1991; Dasuki et al., 2025; Peteraf et al., 2013). The stability of financing allows institutions the capacity to invest in innovation, digital, and organizational learning infrastructures, which results in greater adaptability in changing environments. Therefore, funding stability is an effective predictor for the resilience of an institution. As a result, the following hypotheses are proposed:

H1: Digital competence has a positive impact on the maturity of digital transformation.

H2: Digital transformation maturity has a positive impact on innovation capability.

H3: Digital transformation maturity has a positive impact on institutional resilience.

H4: Digital transformation maturity has a positive impact on organizational agility.

H5: Funding stability has a positive impact on institutional resilience.

H5a: Funding stability has a positive impact and moderates the relationship between innovation capability and institutional resilience.

H5b: Funding stability has a positive impact and moderates the relationship between Organizational agility and institutional resilience.

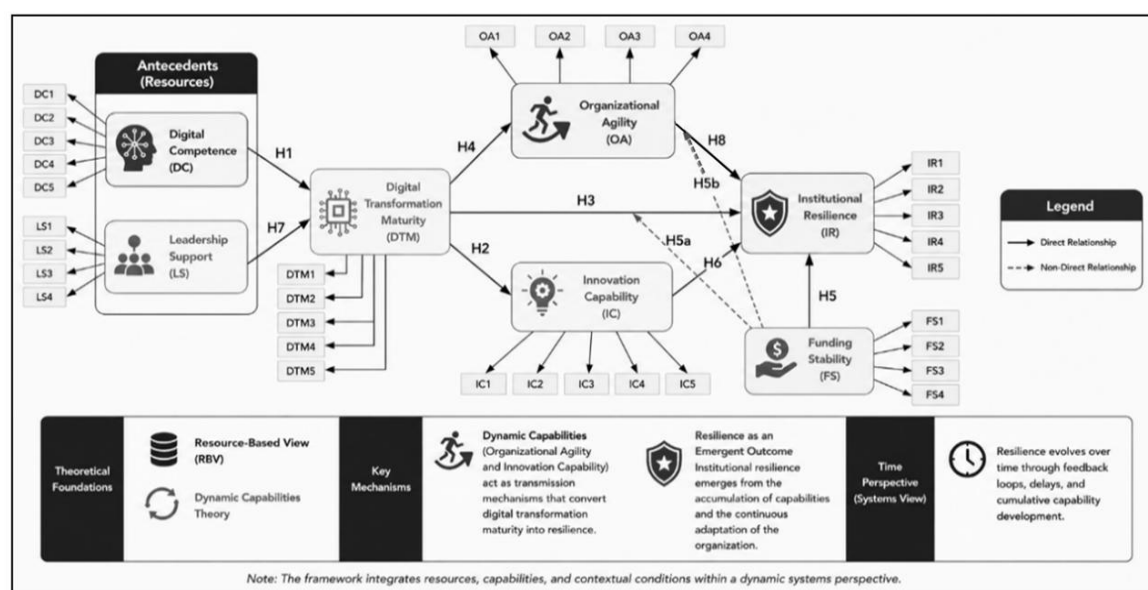
H6: Innovation capability has a positive impact on institutional resilience.

H7: Leadership support has a positive impact on digital transformation maturity.

H8: Organizational agility has a positive impact on Institutional resilience.

2.5 Conceptual Model

The framework brought together the Resource-Based View (RBV) with Dynamic Capabilities



Theory and systems thinking to illustrate the resilience development of higher education institutions during the digital transformation process (Stermann, 2000; Teece, 2017). The model positions digital competence and the presence of digital transformation-supporting leadership as the threshold of digital transformation maturity, with organizational agility and the ability to innovate as the most important adaptive capabilities. In the framework, resilience is conceptualized as capability-related and adaptive, and it is assumed to emerge from continuous learning and sub-optimality building. Funding stability is also considered to be an institutional phenomenon of resilience. As illustrated in Figure 1, the framework assumes that resilience is a characteristic that emerges from the integration of digital transformation, adaptive capabilities, and components of a complex higher education system.

Figure 1. Proposed Conceptual Framework

3. Materials and Methods

3.1 Participants and procedures

This research combines the Partial Least Squares Structural Equation Modelling (PLS-SEM) and System Dynamics (SD) techniques, following the principles of the hybrid variance-systems methodology, in order to investigate the role of digital transformation to the enhancement of institutional resilience in higher education. It also seeks to overcome a number of challenges of traditional fixed analytical methods in understanding complex adaptive systems in organizations within the context of contemporary higher education (Davis et al., 2007; Holland, 2006; Liu et al., 2022; Stermann, 2000). More emphasis has been placed on the need to study

digital transformation and the resilience of organizations using integrated systems thinking from dynamic rather than static and variance-based methods (Duchek, 2019; Khan et al., 2019; Verhoef et al., 2019; Vial, 2019).

While PLS-SEM shows great promise for analyzing latent-variable relationships and causal predictors, it is limited in addressing time-dependent phenomena, including the accumulation of recursive adaptation, delayed responses, and feedback-influenced changes in organizational resilience (Hair et al., 2021; Ringle et al., 2020). On the other hand, System Dynamics is able to capture time-developed structures of feedback-based balancing and reinforcing in the evolution of organizations and the path-dependent adaptation of stocks (Stermann, 2000). Thus, the combination of SEM and SD improves the analysis of structural causality and time-varying behavioral systems and co-evolving organizations (Davis et al., 2007). The methodological fusion employed in this research is aligned with several publications encouraging the joint application of variance-based methods and systems-based methods in the global context of digital transformation, resilience and the development of adaptive capacities in complex institutional contexts (Kowalski et al., 2024; Teece, 2007; Warner & Wäger, 2018).

Recent organizational studies have noted that resilience develops through a combination of capabilities, organizational learning, and recursive adaptation. This is in contrast to the traditional, linear relationship view (Awad & Martín-Rojas, 2024; Duchek, 2019; Lengnick-Hall et al., 2011). To model the relationships of interest, this study adopted a Partial Least Squares Structural Equation Modeling (PLS-SEM) approach. PLS-SEM is appropriate for research directed toward the development of new theories and hypotheses in the area of prediction and for the analysis of relatively intricate, structurally inter-related systems and relationships (e.g., mediations) and small sample sizes (Hair et al., 2021; Henseler et al., 2016). It is also highly appropriate for analysis based on atypical data and complex organizational frameworks, involving multiple endogenous constructs, circularity, indirectness, and moderation (Sarstedt et al., 2022). In comparison with covariance-based SEM, this study focuses on predictive reasoning and the development of capabilities for organizational adaptability instead of replicating strict covariances (Hair et al., 2019; Richter et al., 2016).

SEM has its limitations, particularly in understanding the evolutionary nature of resilience via delayed adaptation, institutional learning, and the feedback system in institutional evolution (Davis et al., 2007; Sterman, 2000). Therefore, the co-evolution of capabilities in Higher Education Institutions (HEIs) was examined using System Dynamics to capture the effects of temporal compounding, nonlinear dynamics, and reinforcing feedback (Papachristos, 2019). With this methodological combination, it is possible to think of institutional resilience not as a

static case of organizational outcome, but as an emergent outcome of a system whereby capability is co-evolved through the adaptation of an organization and the dynamic response of the system over time (Duchek, 2019; Khan et al., 2019; Liu et al., 2022).

3.2 Population, Sampling, and Data Collection

Using a comprehensive snowball sampling approach, the study surveyed 2,147 faculty, administrators and management-level staff involved in aspirant higher education institutions in Saudi Arabia, including administration staff who have impacted and participated in the digital transformation and decision-making processes of their respective institutions. Data were collected using an online survey created by the authors for the research study. The online survey was sent out to participants in the broader work of vision 2030 for higher education in Saudi Arabia. The dataset was scrutinized before computational analysis. This included verifying missing values, outlier detection and visual inspection for normality (Hair et al., 2021). Straight-lining, unthoughtful completion and inconsistent responses were regarded as causes for exclusion. After data cleaning, the final sample consisted of 327 participants. The final sample size satisfied multiple methodological criteria. First, the sample size exceeded the population size recommendation by Krejcie and Morgan (1970). Second, it exceeded the minimum threshold for analyzing PLS-SEM based on the 10-times rule (Hair et al., 2019). Third, the statistical analysis indicated that the sample size was appropriate to discern medium or large effects in a complex structural model (Cohen, 1992). The demographic characteristics of respondents adequately represented the vast majority of the participants (Table 1).

Table 1. Demographic characteristics (N = 327)

Items	Characteristics	Frequency	Percentage (%)
Gender	Male	172	52.6%
	Female	155	47.4%
Experience	< 5 years	11	3.4%
	5–10 years	48	14.7%
	11–15 years	126	38.5%
	16–20 years	92	28.1%
	> 20 years	50	15.3%
University Type	Public	221	67.6%
	Private	106	32.4%
Digital	Early Stage	132	40.4%
Transformation Stage	Developing	115	35.2%
	Advanced	80	24.5%
Current Position	Dean	12	3.7%

Deputy Dean	20	6.1%
Head of Department	46	14.1%
Faculty Member	195	59.6%
Administrative Staff	54	16.5%

3.3 Instrument Development and Measurement Model

The measurement tool was constructed from validated scales of digital transformation, organizational resilience, innovation, agility, and dynamic capability. Seminal studies on these concepts provided the basis of the measurement scales and their constructs (see Table 2). Items were designed to be context specific to the higher education domain and to the research objectives. The survey was composed of reflective multi-item constructs that used a five-point Likert scale, of which the endpoints were strongly disagree (1) and strongly agree (5), respectively. Each of the constructs was measured across the digital divide of leadership, competency, maturity, agility, capability, resilience, and stability. To establish the instrument's construct validity, experts in higher education administration, digital transformation, and organizational theory reviewed the instrument, along with researchers having expertise in the quantitative domain. Items were assessed for relevance, clarity, and appropriateness (Haynes et al, 1995). Cross-lingual validation was done to ensure the English version of the instrument was semantically equivalent to the Arabic version. In accordance with Brislin's (1970) protocol, the survey was independently translated to Arabic and back to English to confirm linguistic equivalence and conceptual accuracy. The instrument was then finalized for the measurement of institutional resilience within the higher education sector in Saudi Arabia.

Table 2. Sources of Item Adaptation and Anchor Measurement for each Construct

Construct	Items	Representative anchors	source	Adaptation note
Leadership Support	LS1–LS4	Alnuaimi et al. (2024); Tenggono et al. (2024).		Adapted to the university's strategic governance context and data-driven leadership.
Digital Competence	DC1–DC4	Limani et al. (2019); Valdivia-Salazar et al. (2025)		It focuses on faculty, staff, and continuous digital learning capabilities.
Digital Transformation	DTM1–DTM5	Bravo-Jaico et al. (2025); Alfrević et al. (2025)		It is adapted to integration, automation, strategies, and infrastructure renewal.
Maturity				
Organizational Agility	OA1–OA4	Zhang et al. (2024); Teece (2025)		It is operationalized as the speed and flexibility of response and reconfiguration.

Innovation Capability	IC1–IC4	Wang and Jia (2025); Zhang et al. (2025).	Adapting to new program development, digital initiative support, and proactive technology adoption is also important.
Institutional Resilience	IR1–IR5	Gull et al. (2023); Wang & Jia (2025)	Framed as stability, recovery, risk management, quality continuity, and organizational stability.
Funding Stability	FS1–FS3	Custom items informed by higher-education finance and resilience literature	It may be retained as a contextual construct; consider adding a fourth item on budget predictability, for example.

3.4 Assessment of Common Method Bias

To counteract potential common method bias (CMB) from survey respondents providing self-reported data, several steps were undertaken both procedural and statistical (Podsakoff et al., 2003). From a procedural point of view, respondents were accorded assurance of anonymity and confidentiality to mitigate both evaluation apprehension and social-desirability bias. Also, construct ambiguity and item order effects were prevented by meticulously structuring the survey items (Podsakoff et al., 2003). Harman's single-factor test showed that the first factor explained less than half of the variance overall, suggesting that common method bias was unlikely to threaten the validity of findings (Podsakoff et al., 2003). Evidence of minimal common method bias was also provided by the full collinearity variance inflation factor (VIF) scores falling below the threshold value of 3.3 (Kock, 2015).

4. Results

4.1 Measurement Model Assessment

The assessment model confirmed psychometric standards applicable to PLS-SEM evaluation (Hair et al., 2021; Henseler et al., 2016). All indicator loadings exceeded the accepted threshold of 0.70 (Table 3). Lower loading items (less than 0.6) were eliminated from the survey (appendix 1), indicating a high level of indicator reliability. Also, internal consistency for all constructs was satisfied with composite reliability (CR) and Cronbach's alpha values of 0.70, and Average Variance Extracted (AVE) scores were greater than 0.50, which suggests acceptable convergent validity (Fornell & Larcker, 1981).

Table 3. Results of the Measurement Model

Items	FL	CA	CR_a	CR_c	AVE
	> 0.7	> 0.7	> 0.7	> 0.7	> 0.7
<i>Digital Competence</i>					

1	DC1	0.897	0.946	0.947	0.959	0.823
2	DC2	0.918				
3	DC3	0.93				
4	DC4	0.885				
5	DC5	0.906				
<i>Digital Transformation Maturity</i>						
1	DTM1	0.854	0.889	0.892	0.919	0.694
2	DTM2	0.867				
3	DTM3	0.86				
4	DTM4	0.75				
5	DTM5	0.827				
<i>Financial Sustainability</i>						
1	FS1	0.869	0.867	0.891	0.908	0.711
2	FS2	0.786				
3	FS3	0.867				
4	FS4	0.848				
<i>Innovation Capability</i>						
1	IC2	0.812	0.78	0.792	0.858	0.603
2	IC3	0.723				
3	IC4	0.733				
4	IC5	0.832				
<i>Institutional Resilience</i>						
1	IR1	0.845	0.829	0.855	0.879	0.593
2	IR2	0.774				
3	IR3	0.735				
4	IR4	0.759				
5	IR5	0.734				
<i>Leadership Support</i>						
1	LS2	0.922	0.921	0.924	0.95	0.864
2	LS3	0.926				
3	LS4	0.94				
<i>Organizational Agility</i>						
1	OA1	0.821	0.71	0.708	0.838	0.633
2	OA2	0.757				
3	OA3	0.808				

Discriminant validity was evaluated using the heterotrait-monotrait ratio (HTMT). Most HTMT scores, reported in Table 4, were below the conservative threshold of 0.85. All HTMT scores remained below the threshold of 0.90. This threshold is generally accepted for exploratory and

conceptually linked organizational constructs (Franke & Sarstedt, 2019; Henseler et al., 2015). The highest HTMT score was 0.894. High HTMT scores could indicate some of the other adaptive capability constructs have some level of conceptual integration. Our measurement model was adequate for assessing reliability, convergent and discriminant validity, as required for structural model analysis.

Table 4. Discriminant According to HTMT Result

Constructs	1	2	3	4	5	6	7	8	9
DC									
DTM	0.875								
FS	0.214	0.292							
IC	0.739	0.812	0.365						
IR	0.493	0.455	0.370	0.526					
LS	0.894	0.766	0.168	0.627	0.529				
OA	0.806	0.848	0.259	0.894	0.547	0.789			
FS x IC	0.124	0.203	0.325	0.132	0.076	0.134	0.179		
FS x OA	0.124	0.210	0.307	0.187	0.070	0.102	0.161	0.768	

4.2 Structural Model Assessment

The structural model was evaluated using bootstrapping with 5,000 resamples in SmartPLS 4. Before performing hypothesis testing, collinearity diagnostics indicated that all inner VIF values were below the conservative threshold of 3.3, concerning multicollinearity and the presence of significant common method bias (Kock, 2015). Detailed structural results can be found in Table 5. The structural relationships are illustrated in Figure 2.

The analysis of the structural relationships indicates that digital competence has a positive and significant effect on digital transformation maturity ($\beta = 0.742$, $t = 14.51$, $p < 0.001$) and therefore, is the major driver of transformation in this model. Additionally, the maturity of digital transformation positively and significantly influences both organizational agility ($\beta = 0.675$, $t = 19.79$, $p < 0.001$) and innovation capability ($\beta = 0.686$, $t = 21.56$, $p < 0.001$).

On the other hand, the direct effect of digital transformation maturity and institutional resilience was not significant ($\beta = 0.095$, $t = 1.23$, $p = 0.219$). Therefore, we can say that digital transformation does not ensure resilient performance. Rather, the resilient performance is ensured through the adaptive processes of the organization. In the case, both, organizational agility ($\beta = 0.208$, $t = 2.866$, $p = 0.004$) and innovation capability ($\beta = 0.175$, $t = 2.767$, $p = 0.006$) have significant and positive effects on institutional resilience and, therefore, play a

major role as capability-based transmission mechanisms through which resilient performance is enabled.

Additionally, a direct effect of funding stability on institutional resilience ($\beta = 0.238$, $t = 4.841$, $p < 0.001$) was observed. Therefore, we can say that financial stability enables resilient performance of an organization.

Leadership support does not relate to the degree of digital transformation maturity ($\beta = 0.075$, $t = 1.342$, $p = 0.180$). Furthermore, funding stability did not provide statistical evidence for moderating the relationship between agility, IC, and institutional resilience. The interaction effects of $FS \times OA \rightarrow IR$ ($\beta = 0.075$, $p = 0.292$) and $FS \times IC \rightarrow IR$ ($\beta = 0.001$, $p = 0.989$) were not significant; therefore, it can be stated that, in funding stability, the moderating effect is more likely to impact resilience than the relationship between internal capability development.

This model showed moderate to strong explanatory power. As indicated in Table 5, coefficient of determination (R^2) values ranged from 0.279 for institutional resilience to 0.649 for digital transformation maturity. Therefore, it showed a strong explanatory power. In addition, all Q^2 values exceeded zero, thus demonstrating satisfactory predictive relevance for the endogenous constructs (Shmueli et al., 2019).

Table 5. Structural Model Results

Path coefficient	St. Beta	St. Error	T-t	P-v	2.50	97.50	VIF	f^2	Result	R^2	Q^2
					% LB	% UB					
DC -> DTM	0.742	0.051	14.51	0	0.639	0.837	3.283	0.478	Accept	0.649	0.645
DTM -> IC	0.686	0.032	21.56	0	0.617	0.743	1	0.891	Accept	0.471	0.404
DTM -> IR	0.095	0.077	1.23	0.219	-0.059	0.246	2.293	0.005	Rejected	0.279	0.43
DTM -> OA	0.675	0.034	19.79	0	0.597	0.733	1	0.836	Accept	0.455	0.244
FS -> IR	0.238	0.049	4.841	0	0.133	0.328	1.206	0.065	Accept		
FS x IC -> IR	0.001	0.065	0.014	0.989	-0.127	0.127	2.552	0	Rejected		
FS x OA -> IR	0.075	0.071	1.053	0.292	-0.062	0.217	2.498	0.003	Rejected		
IC -> IR	0.175	0.063	2.767	0.006	0.052	0.298	2.363	0.018	Accept		
LS -> DTM	0.075	0.056	1.342	0.18	-0.031	0.185	3.283	0.005	Rejected		
OA -> IR	0.208	0.073	2.866	0.004	0.065	0.35	2.19	0.027	Accept		

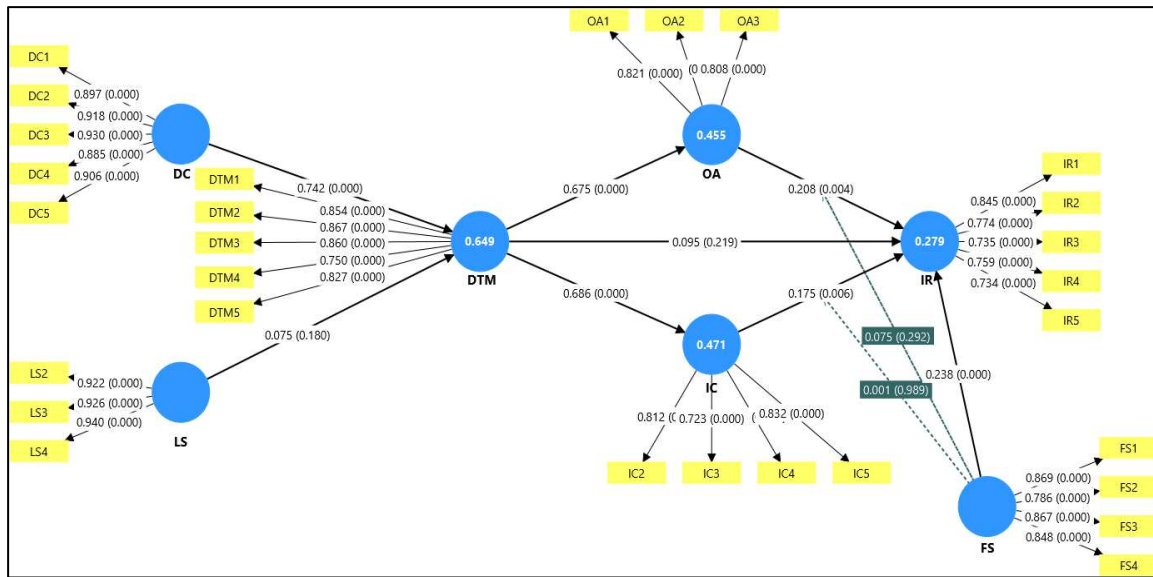


Figure 2. SEM-PLS Structural Model Results

4.3 Mediation Analysis

The results of the analysis indicate that digital transformation maturity has a positive and significant indirect impact on institutional resilience through both organizational agility ($\beta = 0.140$, $p = 0.005$) and innovation capability ($\beta = 0.120$, $p = 0.007$). Although the direct impact of digital transformation maturity on institutional resilience was found to be insignificant, the results of this study showed that full mediation was supported (Nitzl et al., 2016).

The results of this study suggest that the combination of digital transformation and the ability to address external and institutional disruptions is required for the adaptive capacity of an organization. Resilience is therefore not the result of digital transformation. The results of the study support the existing studies that suggest digital transformation is a catalyst for the development of adaptive capacity, but is not the source of resilience.

The analysis indicated notable sequential mediation effects relating to digital competence, digital transformation maturity, organizational agility, and innovation capability on institutional resilience. Specifically, the paths $DC \rightarrow DTM \rightarrow OA \rightarrow IR$ ($\beta = 0.104$; $p = 0.007$) and $DC \rightarrow DTM \rightarrow IC \rightarrow IR$ ($\beta = 0.089$; $p = 0.008$) were significant. As such, the model of adaptive capability development was established and confirmed in the order of hierarchy and processes.

The detailed mediation results are presented in Table 6.

Table 6. Mediation Analysis Results

Path coefficient	St. Beta	St. Error	T-t	2.50	97.50	P-v	Result
				%	%		
				LB	UB		
DC -> DTM -> IC	0.509	0.044	11.667	0.427	0.597	0	Accept

DTM -> IC -> IR	0.12	0.044	2.701	0.038	0.211	0.007	Accept
DC -> DTM -> IR	0.07	0.057	1.237	-0.044	0.182	0.216	Rejected
DC -> DTM -> OA	0.501	0.042	12.015	0.421	0.583	0	Accept
LS -> DTM -> IC	0.052	0.039	1.329	-0.021	0.129	0.184	Rejected
LS -> DTM -> IR	0.007	0.01	0.731	-0.005	0.032	0.465	Rejected
LS -> DTM -> OA	0.051	0.039	1.316	-0.02	0.128	0.188	Rejected
LS -> DTM -> OA -> IR	0.011	0.009	1.205	-0.005	0.03	0.228	Rejected
DC -> DTM -> IC -> IR	0.089	0.034	2.638	0.028	0.161	0.008	Accept
DC -> DTM -> OA -> IR	0.104	0.039	2.698	0.031	0.184	0.007	Accept
DTM -> OA -> IR	0.14	0.05	2.812	0.043	0.241	0.005	Accept
LS -> DTM -> IC -> IR	0.009	0.008	1.141	-0.004	0.027	0.254	Rejected

4.4 System Dynamics Analysis

Applying PLS-SEM for static causal analysis, this research deployed System Dynamics (SD) modeling to design an institutional resilience evolution framework within the higher education systems over time. SEM captures statistically meaningful relationships of structural components. In contrast, SD emphasizes temporal build-up, nonlinear, cumulative effects, and delayed feedback, that are characteristic of complex adaptive organizational systems (CAS). Thus, the SD model was developed as an addendum to the SEM findings. This methodological integration of both approaches addresses the digital transformation of institutional resilience within the dynamic capability perspective.

4.4.1 Translating SEM Results into the SD Model

The SD model was constructed from empirically verified SEM relationships, and as such captures variance in similar structures of the simulation. (Davis et al., 2007; Sterman, 2000). As stated in Table 7, causal paths in the SEM that were found to be statistically significant have been represented as causal paths in the stock-flow representation of the architecture, and those pathways that were found to be unsupported have been omitted from the resilience-growth architecture.

The results show that digital competence has the strongest positive effect on digital transformation maturity ($\beta = 0.742$, $p < 0.001$). Digital transformation maturity positively influences both organizational agility ($\beta = 0.675$, $p < 0.001$) and innovation capability ($\beta = 0.686$, $p < 0.001$) which are important adaptive capability mechanisms. Funding stability emerged as a positive influence on resilience in the model ($\beta = 0.238$, $p < 0.001$).

On the other hand, the association of digital transformation maturity with institutional resilience ($\beta = 0.095$, $p = 0.219$) is not represented in the SD model due to its absence of statistical significance. Likewise, the moderating influence of funding stability on the interaction of organizational agility, innovation capability, and institutional resilience is also not included in the model because the interaction effects could not be substantiated. The SD model generally views institutional resilience as the outcome of a cumulative adaptive system, where the dominant influence of technology is superseded by the cumulative effect of developing adaptive systems and is mediated by feedback (Duchek, 2019; Khan et al., 2019).

Table 7. Translation of SEM Results into the System Dynamics Model

SEM Path	SEM Result	SD Interpretation	SD Treatment
DC $\rightarrow$ DTM	$\beta = 0.742$, $p < .001$	Digital competence drives digital transformation maturity	Included
LS $\rightarrow$ DTM	$\beta = 0.075$, $p = .180$	Leadership support has weak/non-significant influence	Retained as weak contextual input
DTM $\rightarrow$ OA	$\beta = 0.675$, $p < .001$	Digital maturity builds organizational agility	Included
DTM $\rightarrow$ IC	$\beta = 0.686$, $p < .001$	Digital maturity builds innovation capability	Included
DTM $\rightarrow$ IR	$\beta = 0.095$, $p = .219$	No direct resilience effect	Excluded from IR growth
OA $\rightarrow$ IR	$\beta = 0.208$, $p = .004$	Agility contributes to resilience	Included
IC $\rightarrow$ IR	$\beta = 0.175$, $p = .006$	Innovation contributes to resilience	Included
FS $\rightarrow$ IR	$\beta = 0.238$, $p < .001$	Funding directly supports resilience	Included
FS $\times$ OA $\rightarrow$ IR	$\beta = 0.075$, $p = .292$	Moderation not supported	Excluded
FS $\times$ IC $\rightarrow$ IR	$\beta = 0.001$, $p = .989$	Moderation not supported	Excluded

4.4.2 Model Boundary Assumptions

The System Dynamics (SD) model reintegrates with Structural Equation Modeling (SEM) outcomes and demonstrates both theory and practice, with focus on internal capability-developing mechanisms of digital transformation and institutional resilience (Sterman, 2000). Therefore, the model is bound to examine the adaptation of institutions in the domain of education, without the external shock of the environment and macroeconomic changes, to retain the scope and model with precision. A ten-year simulation was used, as it is understood that emergent and adaptive capabilities represent longitudinal processes of an organization rather than multiple adjustments of Operations.

4.4.3 Stock-and-Flow Model Specification

Figure 3 illustrates a stock-and-flow model of resilient institutions composed of four core stock variables of resilience: digital transformation of institutions, organizational agility, innovation capability, and resilience of institutions (IR). The maturity of digital transformation serves as the primary capability stock in the upper tier, and is greatly influenced by digital expertise and leadership, which are intermediate adaptive capability stocks, along with organizational agility and innovation capability. Within the model, the outcome of institutional resilience is the final system state, which is the result of the integration of adaptive capabilities and continuous funding. To enhance behavioral realism and approximate the limits of adaptation, as well as the saturation of an organization and flexibility, this model includes bound growth and decay mechanisms (Sterman, 2000). For this reason, the resulting system dynamics model integrates the processes of resilience in higher education, which are late, cumulative, and dependent on the path.

$$\text{Stock}(t) = \text{Stock}(t - dt) + [\text{Growth}(t) - \text{Decay}(t)] \times dt$$

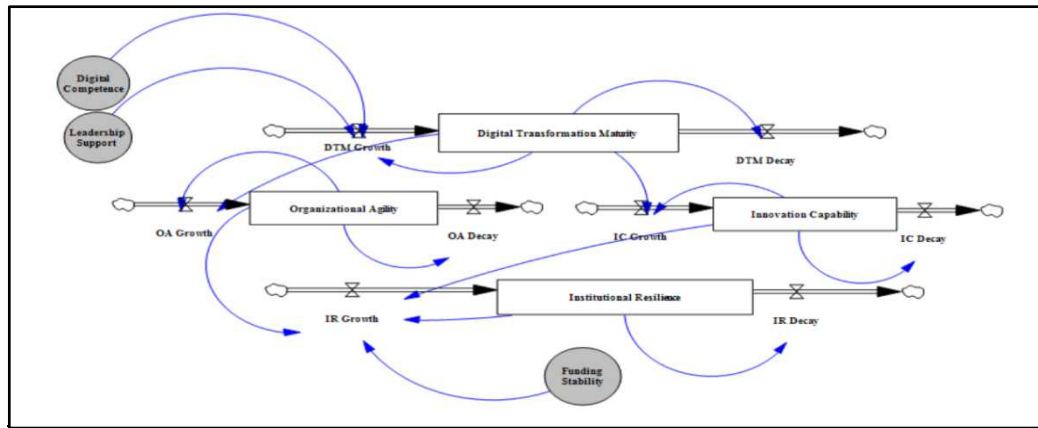


Figure 3. Stock-and-Flow Diagram

4.4.4 Model Equations

The SD model envisions a bounded stock-and-flow system where organizational capabilities gradually accumulate and atrophy over time. State variables were all normalized to a range of 0 to 1 with 0 indicating lower capability development and 1 full capability.

Digital Transformation Maturity

$$\begin{aligned} \text{DTM}(t) &= \text{DTM}(t - dt) + [\text{DTM_Growth} - \text{DTM_Decay}] \times dt \\ \text{DTM_Growth} &= (0.742 \text{ DC} + 0.075 \text{ LS})(1 - \text{DTM}) \\ \text{DTM_Decay} &= 0.030 \text{ DTM} \end{aligned}$$

Organizational Agility

$$\begin{aligned}
OA(t) &= OA(t - dt) + [OA_Growth - OA_Decay] \times dt \\
OA_Growth &= 0.675DTM(1 - OA) \\
OA_Decay &= 0.025OA
\end{aligned}$$

Innovation Capability

$$\begin{aligned}
IC(t) &= IC(t - dt) + [IC_Growth - IC_Decay] \times dt \\
IC_Growth &= 0.686DTM(1 - IC) \\
IC_Decay &= 0.025IC
\end{aligned}$$

Institutional Resilience

$$\begin{aligned}
IR(t) &= IR(t - dt) + [IR_Growth - IR_Decay] \times dt \\
IR_Growth &= (0.208OA + 0.175IC + 0.238FS)(1 - IR) \\
IR_Decay &= 0.020IR
\end{aligned}$$

These equations interpret institutional resilience as a delayed and cumulative outcome arising from certain dynamic capabilities, as opposed to being an immediate outcome of the maturity of digital transformation.

4.4.5 Initial Values and Simulation Settings

To improve the stability of the simulation and to ensure comparability among different components of the system, all model variables were constrained to a range of 0 to 1. Initial stock values were derived from the SEM findings and our theoretical considerations regarding the maturity of institutional capabilities in Saudi higher education. As seen in Table 8, the simulation was conducted with a 10-year timeframe in order to capture the long-term resilience and the cumulative nature of resilience. In order to preserve numeric stability and precision of the behavior reproduction, Euler integration was utilized with a time step of 0.05 years (Sterman, 2000). The initial values were set to the average levels of digital transformation in higher education.

Table 8. Initial Values and Simulation Settings

Variable	Initial value
Digital Transformation Maturity	0.45
Organizational Agility	0.40
Innovation Capability	0.38
Institutional Resilience	0.35
Digital Competence	0.75
Leadership Support	0.70
Funding Stability	0.68

4.4.6 Baseline Simulation Results

The baseline simulation revealed a distinct sequential and cumulative pattern for the development of an organization's adaptive capabilities during the simulation. As illustrated in Figure 4, the initial phases of the simulation show that digital transformation maturity is attributed to digital competence, which in turn, develops the organization's agility and innovation. Likewise, the gradation and accumulation of adaptive capabilities within the context of higher education explains the cumulative development of institutional resilience (Duchek, 2019; Sterman, 2000). This is in strong alignment with the SEM results, where it is stated that as part of the simulation, digital transformation maturity does not result in resilience; rather, resilience is the outcome of iterative capabilities and constructive feedback adaptations within the organization.

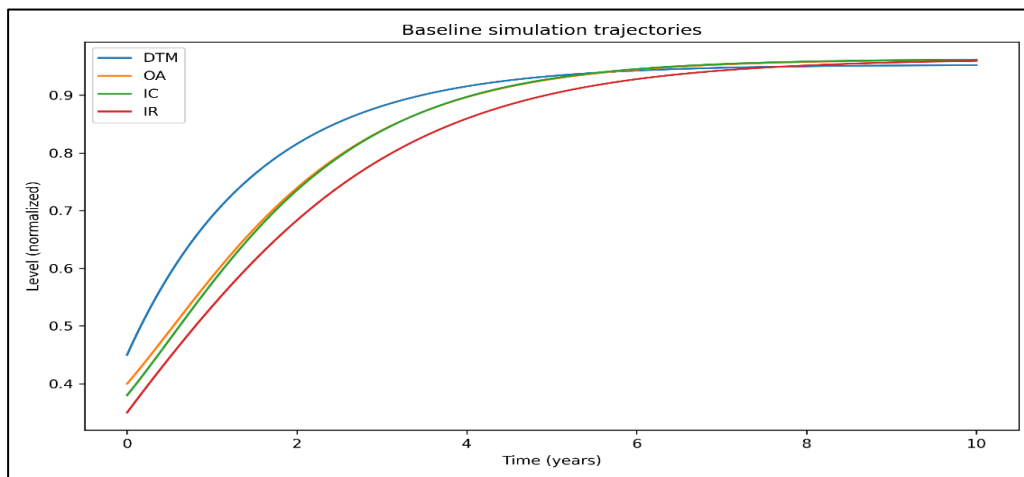


Figure 4. Baseline Simulation Trajectories

4.4.7 Scenario Analysis

Table 9 outlines five scenarios, referred to as baseline, high digital competence, low digital competence, high funding stability, and high digital competence–high funding stability, respectively, to identify the critical leverage points for resilience. Figure 5 demonstrates the results of the scenarios, which indicate that the development of digital competence accelerates the pathway for adaptive capability formation that includes the digital transformation of the organization, as well as agility and innovation. In contrast, funding stability improves institutional resilience in a direct and immediate manner, and has less of an effect on the development of the lower-level capabilities. The scenario that included high digital competence and high funding stability showed the greatest improvement in resilience over the simulation period. This suggests that the formation of a resilient adaptive trajectory involves the concurrent development of digital competence and funding stability (Duchek, 2019; Kowalski et al., 2024; Warner & Wäger, 2018).

Table 9. Design of Scenarios

Scenario	Digital Competence	Funding Stability	Purpose
Baseline	0.75	0.68	Current system condition
High DC	0.90	0.68	Test digital competence improvement
Low DC	0.50	0.68	Test system vulnerability
High FS	0.75	0.90	Test funding improvement
High DC + High FS	0.90	0.90	Test combined policy intervention

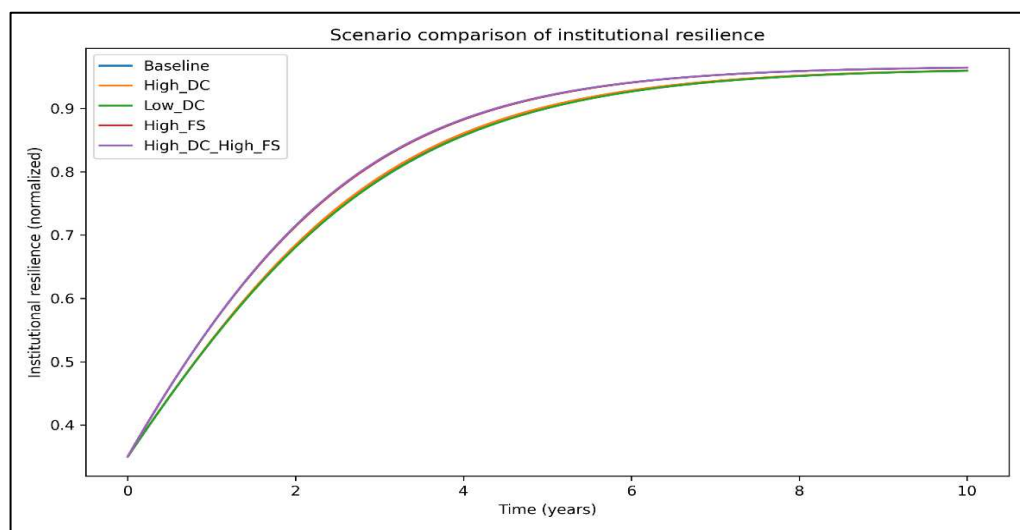


Figure 5. Comparison of Scenarios and Institutional Resilience

Results of the scenario analyses suggest that within the system, the presence of digital competence is the main system-transforming leverage point, as it improves the system's pathway for the development of its adaptive capabilities. Conversely, funding stability is a system-transforming leverage point that "directly" stabilizes the system and, in the short term, contributes to the system's resilience outcomes. From a systems-oriented perspective, the results of the scenario analyses confirm that the articulation of institutional resilience is the result of the accumulation of capabilities and the subsequent adaptive reconfiguration of the organization, rather than the application of a few isolated technological solutions.

4.4.8. Analysis of Sensitivity

To examine the behavioral and directional stability of the proposed system-dynamics (SD) model, a sensitivity analysis was conducted for various parameter configurations. Variations of digital competence predominantly affected the upper segments of the capability-development pathway, whereas funding stability exerted more immediate and pronounced effects on

institutional resilience. In the baseline scenario, the final measure for institutional resilience was set at 0.9597, while the scenario that depicted both high digital competence and high funding stability resulted in the measure of institutional resilience at 0.9645. In the absence of digital competence, the accumulation of capabilities slowed, and the development of resilience was equally slowed. The results of the scenario analyses confirmed the robustness and directional clarity of the model. The detailed results of the sensitivity analysis are presented in Table 10.

Table 10. Results from the Sensitivity Analysis

Scenario	DC	FS	Final DTM	Final OA	Final IC	Final IR	Δ IR vs Baseline	% Δ IR vs Baseline
Baseline	0.75	0.68	0.9523	0.9613	0.9620	0.9597	0.0000	0.000%
High DC	0.90	0.68	0.9598	0.9618	0.9624	0.9598	0.0001	+0.009%
Low DC	0.50	0.68	0.9289	0.9598	0.9605	0.9595	-0.0002	-0.024%
High FS	0.75	0.90	0.9523	0.9613	0.9620	0.9645	+0.0048	+0.496%
High DC + High FS	0.90	0.90	0.9598	0.9618	0.9624	0.9645	+0.0048	+0.501%

4.4.9 Validation of the SD Model

Like the other methods, the validation of the SD model followed the guidelines set forth by Sterman (2000) for a combination of verification, validation, and testing of informal consistency, plausibility, and structural and behavioral consistency. The SD model was built by following the SEM framework, and in the absence of empirical data for the SEM model, a consistency check was done for the variance-based model and dynamic simulation models. To ensure dimensional consistency, stock variables were restricted to a range of 0–1, and growth and decay mechanisms were incorporated to mitigate extreme behaviors. Testing for behavioral validity was satisfactory as simulated paths were consistent with the theory suggesting the development of resilience is a delayed process. The testing of sensitivity and extreme conditions suggested directional stability within both constraining and enabling institutional environments, confirming the robustness and validity of the SEM–SD model.

4.4.10. Integrated SEM–SD Interpretation

The combined use of SEM and SD fosters a deep understanding of the variation and progression of the resilience of institutions in the context of higher education undergoing digital transformation. SEM identifies structural relationships among the variables that are statistically significant. In contrast, SD is more suited for explaining the recursive relationships over time

through the feedback-oriented adaptive processes (Davis et al., 2007; Sterman 2000). According to the results, institutional resilience is not an outcome of the technology itself; rather, it is the result of the gradual and mediated by capabilities institutional digital transformation. Digital transformation is extended by the capability of digital competence, which further develops the maturity of the digital transformation and the capacity of the organization to be agile and innovative, which are the key resources in the adaptation for the development of resilience. Just from the integrative perspective, the institutional resilience is redefined as the emergent state of the combination of the capabilities and the dynamic character of the organization adapted to its environment.

5. Discussion

The findings suggest that the impact of digital transformation maturity on institutional resilience in higher education is mediated by organizational agility and innovation capability. This contradicts technology-deterministic thinking, which asserts that a higher level of resilience can be achieved by investing in infrastructure, automation, and advanced technologies (Verhoef et al., 2021; Vial, 2019). This result supports technology resources that integrate the ability of institutions to strategically reconfigure adaptive capabilities and learning to generate innovation practices (Ellström et al., 2022; Teece, 2007, 2018; Warner & Wäger, 2019).

The links established between institutional resilience and both organizational agility and innovation capability support the described capability-mediated process. Agility represents a university's ability to respond rapidly and evolve processes in order to ensure ongoing operational integrity. Innovation capability refers to a university's ability to create new solutions and practices in the context of evolving circumstances. (Zhang et al., 2024). The existence of strong indirect effects shows that digital competence represents a higher-order resource that strengthens digital transformation maturity and adaptive capability in a resource-based view. As a result, digital competence is a strategic resource for higher education institutions, rather than an operational resource (Barney, 1991; Limani et al., 2019).

The degree of leadership support did not account for a large portion of the variance for digital transformation maturity. This finding should not be misinterpreted as downplaying the role of leadership. Rather, it suggests that leadership commitment alone is not enough for universities with distributed authority, procedural and organizational complexity, and decentralized decision-making. The case is best made for strategic direction being transformed into

coordinated governance as well as allocation of resources and overall institutional implementation. This framework is in line with the limited role of leadership in complex public organizations with a fragmented governance structure (Mackillop & Downe, 2023).

Funding stability predicted institutional resilience, however, did not moderate the relationships of organizational agility or innovation capability with resilience. Financial stability therefore should be interpreted as a direct institutional stabilizer and not as complement to adaptive capabilities. Stable resources provide universities with the opportunity to maintain their operational activities and to absorb disruption, and agility and innovation serve the goal of capability building with different mechanisms. This findings supports the Resource-Based View and the importance of stable resources for institutional continuity and strategic adaptation in higher education (Barney, 1991; Marginson, 2018).

The System Dynamics framework suggests that, over time, resilience can be constructed through the support of digital transformation maturity and the building up of agility and innovation capability. Scenario results further indicated that digital competence influences agility and innovation capability-building in a sequenced pathway, while funding stability has a supportive role in resilience building. This simulation illustrates, rather than validates, the proposed concept of a prolonged institutional adaption (Duchek, 2020; Sterman, 2000).

The integrated data indicates that resilient universities use digital resources to develop flexible, innovative, and learning-oriented organizational practices, whereas the use of advanced technologies does not necessarily contribute to resilience. Therefore, sustainable institutional resilience involves the combined development of digital competences, adaptive capacity, and stable resources, going beyond a dependence on technology.

6. Theoretical Implications

This research adds to the literature on the deterministic view of technology and institutional resilience by illustrating that there is no direct link between the maturity of digital transformation and resilience. Instead, the impact of digital transformation occurs on resilience via organizational agility and the capability to innovate, with adaptive capabilities serving as the bridges that connect digital resources to resilient institutional outcomes.

This research adds to extant resilience literature by illustrating that the value of technology is realized only when it is integrated into organizations and institutional cultures that are positionally responsive (Duchek, 2020; Hillmann & Guenther, 2021). In addition, resilience is best understood via adaptation, learning, and reconfiguration of resources, and organizational agility and the capability to innovate serve as the adaptive mechanisms. From a Resource-Based

View, digital competence is a strategic institutional resource that is positioned to better support the transformation and development of organizational capabilities (Barney, 1991; Peteraf et al., 2013; Teece, 2007, 2018).

The methodological approach of this research links the variance-based structural analysis to a dynamic simulation. PLS-SEM identifies the structural associations and indirect connections between the component constructs, and System Dynamics provides an exploratory representation of the possibility of the cumulation of capability and delayed adaptation over time. This marriage of the two theories provides an integrative framework for process modelling that complements the static analysis and modelling frameworks formed by the principals of cross-sectional research (Hair et al., 2021; Sterman, 2000).

The study frames universities as adaptive systems as opposed to fixed administrative units. University resilience is created through digital competence, adaptive capacity, organizational learning, and consistent resources. This systems approach illustrates how universities address digital disruption and persistent environmental uncertainty.

7. Practical Implications

It is important for universities to go beyond traditional methods for digitalization. When combined with the aforementioned strategies, universities should prioritize organizational learning and flexibility, adaptive governance, and innovation. This approach would enable universities to leverage technology to develop new ways of working.

Digital competence should be developed as an organizational strategic capability. Continuous digital training for academic leaders and faculty and strengthening digital readiness, cross-unit learning, and the effective use of new technologies should be prioritized by universities.

Organizational agility and innovation require flexible governance, quicker decision-making, collaboration across units, and the institution's endorsement of the aforementioned strategies. This would allow universities to respond to disruption and maintain their operations in uncertain situations.

Funding stability should be seen as a long-term resilience building strategy and not short-term support for modernization of the infrastructure. Predictability in funding allows for ongoing digital transformation and innovation. This suggestion is particularly pertinent to Saudi universities as they have the potential to achieve the goals outlined in Vision 2030, through the planned collaboration of technology, institutional readiness, and transformative governance.

8. Conclusion, Limitations, and Future Research

The institution of Saudi Higher Education has the potential for digital transformation; however, this study highlighted that this potential will not result in the automatic development of institutional resilience. Digital transformation maturity builds resilience predominantly through an organization's agility and the organization's ability to innovate. Digital competence plays a role in building transformation maturity and the stability of funding directly builds resilience. Therefore, resilience is an adaptive learning and flexible innovation outcome with an organization's stable resources. The System Dynamics simulation suggests that resilience is built cumulatively and will not be instantaneous due to a technology investment.

These conclusions should be interpreted in light of the study's cross-sectional design. Although the simulation added a temporal perspective, the empirical data do not show how skills and resilience actually change through time. Therefore, longitudinal and especially panel studies are required to address delayed impacts and mutual relationships and the changes in institutional resilience at different levels of digital transformation.

The study is limited to Saudi higher education institutions in the frame of Vision 2030. Possible diversity in governance, institutional culture, funding systems and national policy may limit the findings. Future studies may address resilience at institutional, departmental, and managerial, and team as well as individual levels within the context of comparative research.

In addition, the author treated digital transformation as an institutional-wide phenomenon without describing different technologies. Future research may address if artificial intelligence, generative AI, cloud computing, predictive analytics, blockchain, and intelligent automation do indeed have differential impacts on building capabilities and resilience.

The System Dynamics model also relies on various initial conditions and other parameters such as decay rates and system boundary definitions. Future studies should allow for the introduction of longitudinal data, perform expert-based calibrations and historical validations, and perform larger parameter sensitivity tests. Endogenous feedback mechanisms may also be included, as well as the introduction of specific disruption scenarios. SEM, when integrated with System Dynamics, or with agent-based modeling or other approaches, may help build a more complete picture of institutional adaptation and resilience in the context of digital transformation of higher education.

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Informed Consent Statement: H.A. conceived and designed the study, developed the theoretical framework and methodology, collected and analyzed the data, conducted the PLS-SEM and System Dynamics modeling, interpreted the findings, prepared the figures and tables, and drafted and critically revised the manuscript. The author read and approved the final manuscript.

Data Availability Statement: The anonymized dataset supporting the findings of this study is provided in the Supplementary Information accompanying this article.

Conflicts of Interest: The author declares no conflicts of interest.

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