

Delivering Software and AI Sustainable Performance: A Stagewise CB-SEM Pathways Approach

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ABSTRACT

The Pakistan Government has directed its' software industry, and its over 3000 registered software and AI (SAI) houses, to expand global, and to maintain the industry's competitiveness both domestically and internationally. This research delineates pathways that can raise the net sustainable performance of Pakistan SAI houses whilst driving this industry's ongoing dynamically advancing digital global intelligences. Literature supported constructs, and a theoretically developed relational framework model are used to CB-SEM model and interpret how Pakistan's software houses as an industry may consider optimizations across their network of rapid-action SAI capabilities approaches. Model robustness is confirmed against composite, hybrid, and full parameter complex CB-SEM modelling approaches. Key deliverance pathway solutions are highlighted as possible best deliverance options towards advancing existing sustainable performance outcomes.

Keywords: Competencies, actioning, capabilities, competitiveness, sustainable performance, knowledge creation, software development.

INTRODUCTION

Today Pakistan has over 5,109 IT/SAI company registrations primarily based in Lahore, Karachi, and Islamabad/Rawalpindi, and over 3000 registered SAI houses delivering competitive international and domestic digital business solutions. These Pakistan Software Export Board (PSEB) registered SAI houses are continually increasing (*source* <https://moitt.gov.pk/>; <https://www.trade.gov/country-commercial-guides/pakistan-computer-software>). These SAI houses have competencies that allow them to create code, develop innovative new initiatives, incorporate their combined collective knowledge, aggressively pursue new competitiveness approaches, strategize to solve SAI risks, remain digitally autonomous and unique. These registered SAI houses remain under tight competitive pressure from freelance unregistered SAI developers within Pakistan, but they remain sizeable, internationally sought after, profitable, and collectively are one of the world's largest high-end SAI solutions providers. Across 2022 this Pakistan business sector revenue exceeded US\$1.5B, and between July 2022 and March 2023, IT/SAI exports totalled US\$1.94B compared to US \$1.95B during the same period the previous fiscal year (International Trade Administration Pakistan Country Commercial Guide 2025).

The Government of Pakistan through its PSEB promotes development of SAI with 100% equity ownership, income tax exemption, 100% profits repatriation, 1 year tax holiday, accelerated depreciation, internet merchant bank accounts special technology zones, and high-speed internet connectivity. By April 2023, 197M telecom subscribers (83.2% of population) engaged via high-speed broadband and mobile devices. Pakistan places great emphasis on aggressively pursuing new IT educational institutions and new SAI curriculums and so consistently improves its local human resource pool.

Today, Pakistan SAI houses pursue new initiatives and are international and domestic capabilities providers. They transform their possessed or acquired digital competencies into new networked actioning capabilities solutions. This involves exploitable operational abilities in combination with new digital assimilation abilities to create new packages of SAI solutions. These in-turn capture and focus into delivering ongoing sustainable performance situations.

Hence this study asks, 'can Pakistan's SAI houses astutely deliver sustainable performances?' and so achieve their government's desire to be one of the top five SAI digital solutions providers internationally. The study pursues SAI house developer understanding around how their firm generates, or refines, their latest digital SAI approaches towards actioning and delivering ongoing digital product version and/or new ideas and/or real-time connectivities. It captures at least five Likert scale [strongly disagree (1) to strongly agree (5)] developer responses per construct. This quantitative data set is then developed and assessed using Amos 28.0 CB-SEM and seeks quantitative causal reflective assessment of competing ways to advance the SAI house's sustainable performance.

LITERATURE REVIEW

The literature supported construct and item measure development, and the theoretical- developed framework modelling relevant to this study is contained in a previous ICEB 2022 paper (Ali *et al.* 2022). The literature presents a theoretical framework designed to achieve sustainable performance outcomes within Pakistan's software industry. The framework synthesizes a range of competencies and capabilities, including digital autonomy, aggressive competitiveness, collective knowledge, digital creativity, and strategic risk management. These are linked to actioning capabilities such as transformational abilities, assimilation abilities, strategic operational abilities, and new acquisitions.

The framework model (Figure 1) integrates several key competencies critical for success in the software industry. Digital autonomy refers to a firm's capacity for independent decision-making and innovation in digital environments (Hakala, 2013). Aggressive competitiveness involves actively challenging rivals and developing differentiated performance capabilities (Ajamieh *et al.* 2016). Collective knowledge emphasizes the importance of shared knowledge and collaborative learning within organizations (Nonaka & Konno, 1998). Digital creativity highlights the importance of creative thinking and innovation in digital contexts (Sherif & Xing, 2006). Strategic risk management involves assessing and managing risks associated with new ventures and market entries (Dai *et al.* 2014).

These competencies are supported by actioning capabilities that enable firms to effectively utilize these competencies. Transformational abilities involve refining and developing routines to combine prior and newly acquired resources (Zahra & George, 2002). Assimilation abilities refer to the processes that allow firms to examine and appreciate information gained from external sources (Zahra & George, 2002). Strategic operational abilities involve the coordination and execution of strategic initiatives (Todorova & Durisin, 2007). New acquisitions capabilities focus on identifying and gathering external resources to enhance performance (Zahra & George, 2002).

Theoretical Framework

The proposed framework is grounded in resource-based view (RBV) and knowledge-based view (KBV) of the firm. The RBV suggests firm competitive advantage arises from unique resources which are valuable, rare, inimitable, and non-substitutable (Barney, 1991). This aligns with the theoretical framework's emphasis on developing a suite of competencies and capabilities that are difficult for competitors to replicate. The theoretical framework integrates competencies including digital autonomy, aggressive competitiveness, collective knowledge, digital creativity, and strategic risk management, which collectively form the foundation for sustainable competitive advantage (Nonaka & Konno, 1998).

The KBV further supports the theoretical framework highlighting knowledge as a critical resource for achieving competitive advantage. The framework's focus on collective knowledge and digital creativity reflects importance of knowledge creation and sharing in driving innovation and performance (Nonaka & Konno, 1998). Further, actioning capabilities within the theoretical framework including transformational abilities and assimilation abilities, remain essential for effectively utilizing and integrating knowledge resources.

The theoretical framework draws on absorptive capacity – the firm's ability to recognize, assimilate, transform, and utilize external knowledge (Zahra & George, 2002). This reflects the theoretical framework's emphasis on new acquisitions capabilities and strategic operational abilities, which enables firms to acquire and leverage external resources to enhance their performance.

The theoretical framework establishes a networked coalescing suite of constructs that can deliver sustainable performance outcomes. This is based on the resource-based view of the firm, which suggests that a firm's performance is determined by its unique resources and capabilities that are valuable, rare, inimitable, and non-substitutable (Barney, 1991). The framework also draws on the knowledge-based view, which emphasizes the importance of knowledge as a critical resource for achieving competitive advantage (Nonaka & Konno, 1998).

The theoretical framework proposes that by developing and integrating these competencies and capabilities, firms can enhance their sustainable performance outcomes (SPO). SPO represents the ability of a firm to maintain superior performance over competitors by utilizing its resources and capabilities in a way that is difficult for competitors to replicate (Barney, 1991).

This theoretical framework has several practical implications for firms in Pakistan's software industry. First, it highlights the importance of developing a range of competencies and capabilities that can be integrated to achieve sustainable performance outcomes. Second, it emphasizes the need for firms to continuously invest in and develop these competencies and capabilities to maintain their competitive advantage. Third, it suggests that firms should focus on building a networked coalescing suite of constructs that can work together to deliver sustainable performance outcomes.

In conclusion, this theoretical framework provides a comprehensive approach for firms in Pakistan's software industry to achieve sustainable performance outcomes. By integrating a range of competencies and capabilities, firms can enhance their sustainable competitive advantage and maintain superior performance over competitors.

METHODOLOGY

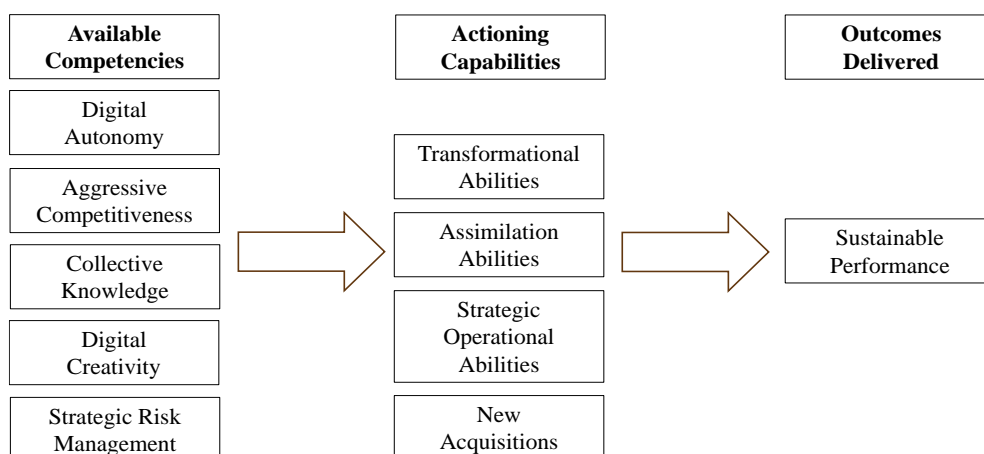
Key construct item measure references from the previous ICEB 2022 paper are summarized in Table 1. Likewise, the Figure 1 theoretically developed framework model (Ali *et al.* 2022) is also tested against a carefully developed and pilot tested online Qualtrics survey in the key Pakistan IT software house developer city of Islamabad. After adjustments to simplify and refine questions, and to correct two questions, the final Qualtrics survey was deployed. This delivered a final useable dataset provided by 182 registered SAI software house developers within Pakistan, and as expected, showed particular concentrations of developer respondents resided within five major software house cities (Karachi, Lahore, Islamabad, Faisalabad, and Rawalpindi).

After data cleaning to remove cases with excessive missing data (<10%) and then missing value average replacement plus correction to whole numbers 1 to 5), an EFA varimax principal components rotated pattern matrix solution was introduced to check for factors, and to remove cross loads, low loads below 0.3, and very poor factors. This left eleven well defined factors. These factors (now termed constructs), and their varimax EFA pattern matrix item measures, were matched against the dataset’s literature supported constructs and item measures. In each case the literature sourced, and carefully developed construct item measure questions, matched the varimax EFA pattern matrix construct solution.

Table 1 Key construct item measure references

Construct Developed	References (for italicized references - refer Ali et al .(2022) ICEB 2022 paper)
Digital Autonomy	Hakala, 2013; Huu, 2023; Yulianto et al. 2023; <i>Alshanty & Emeagwali, 2019</i>
Competitive	Zahra & Bogner, 2000; Gallivan, 2003. Xu et al. 2017; Ajamieh et al. 2016; <i>Mullens, 2018, Gauthier et al., 2021,</i>
Aggressiveness	<i>Mostafiz et al., 2021, Omisakin & Adegoke, 2022; Ameer & Khan, 2020; Alshanty & Emeagwali, 2019</i>
Collective	Nonaka & Konno, 1998; Gallivan, 2003; Ravichandran, 2005; Amin et al. 2020; <i>Cuevas-Rodríguez et al., 2014;</i>
Knowledge	<i>Nonaka et al., 2000, Arnett & Wittmann, 2014; Ichijo & Nonaka, 2007; Mahdi et al., 2019; Spraggon & Bodolica,</i>
Digital Creativity	Sherif & Xing, 2006; Chung et al. 2015; Khin & Ho, 2019; <i>Canzano & Grimaldi, 2012; Alshanty & Emeagwali, 2019; Na, K. S., Simpson, J. T., Li, X., Singh, T., & Kim, K. Y. 2007; Dess & Lumpkin, 2005; Nishimura, 2015; Bekefi</i>
Strategic Risk Management	Dai et al. 2014; <i>Lee & Roh, (2020). Alshanty & Emeagwali, 2019</i>
Transformational Abilities	Zahra & George, 2002; Amin et al 2020; Ravichandran, T. 2005; <i>Mullens, 2018, Gauthier et al., 2021, Mostafiz et al., 2021, Omisakin & Adegoke, 2022; Jansen et al., 2005; Engelman et al., 2017; Flatten et al., 2011; Lee et al., 2018</i>
Process Assimilation	Zahra & George, 2002; Gallivan, 2003; Zahra & George, 2002; <i>Jansen et al., 2005; Engelman et al., 2017; Flatten et al., 2011; Lee et al., 2018; Zahra & George, 2002; -Usman et al., 2022; Ahmed et al., 2020; Sun & Anderson, 2010;</i>
Strategic Operational	Jansen et al., 2005; Todorova & Durisin, 2007; Dai et al. 2014; <i>Engelman et al., 2017; Flatten et al., 2011; Lee et al., 2018; Scuotto et al., 2017; Zahra et al. 2009; Zahra & Hayton 2008; Engelen et al., 2014</i>
New Acquisitions	Zahra & Bogner, 2000; Zahra & George, 2002; <i>Rodríguez-Serrano & Martín-Armario, 2019; Lichtenthaler, 2016; Lee et al., 2018; Jansen et al., 2005; Engelman et al., 2017; Flatten et al., 2011</i>
Sustainable Performance	<i>Aras & Crowther, 2010; Lee et al., 2018; Mahdi et al., 2019</i>

Source: This study.



Source: This study.

Figure 1 Theoretically developed framework model (adapted from Ali, *et al.* (2022))

Next, with factor constructs defined and literature supported, a CFA construct item measures reduction process is undertaken. The CFA dimension reduction settings are guided by all items being suitably near normal. This allows a maximum likelihood, oblim, rotational approach. The CFA stagewise removal of item measures from the construct reduces the remaining construct item measures down to between 5 or 4 or 3. This leaves each construct with all its remaining item measures having all their

residuals below 0.05. The column 2 italicized measurement items of Table 2 are the ones eliminated from the construct during the CFA dimension reduction process.

Table 2 CB-SEM dataset and modelling measurement table

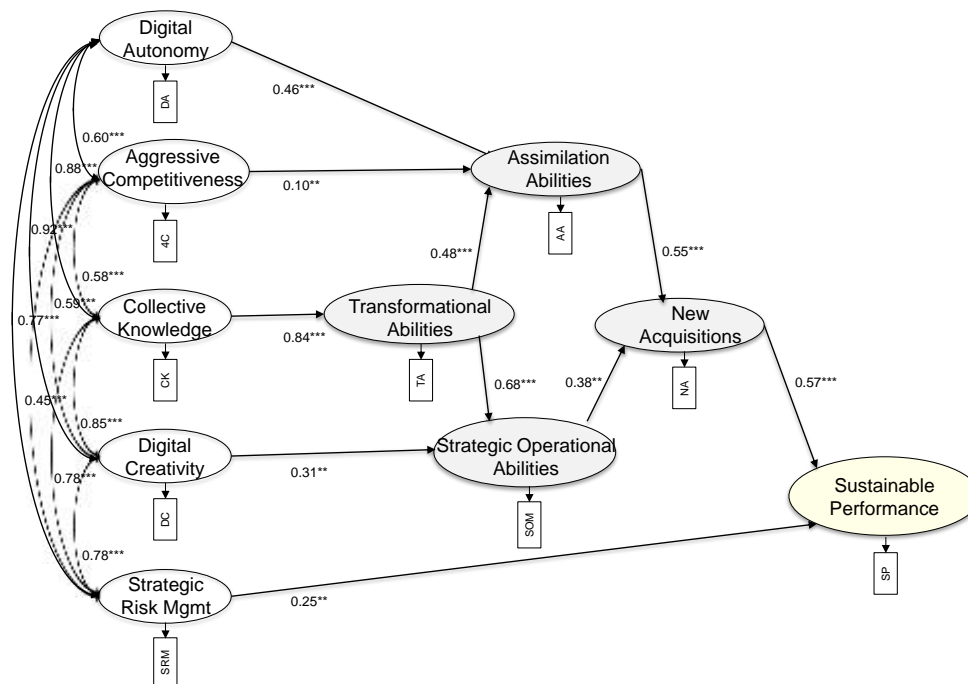
Survey ID	Construct and Item Measures (ML, 200 Bootstrap) 182 cases in dataset	Load (λ)	Av. Variance Extracted	Construct Mean	Construct Std Dev SD	Cronbach Alpha α	Composite Load SD($\sqrt{\alpha}$)	Composite Error SD $^2(1-\alpha)$	CR = $(\sum \lambda)^2 / [(\sum \lambda)^2 + \sum(1 - \lambda^2)]$
	Digital Autonomy (<i>Our company allow staff to</i>)		0.61	3.80	0.86	0.86	0.80	0.10	0.86
Q1_1	provide business ideas	0.82							
Q1_2	help develop strategic vision	0.84							
Q1_3	take part in developing business concepts	0.79							
Q1_4	pursue new self-directed opportunities	0.67							
Q1_5	<i>seek out new opportunities</i>								
	Competitive Aggressiveness (<i>Our company reacts quickly to</i>)		0.80	3.75	1.00	0.94	0.97	0.06	0.94
Q4_1	<i>developing new ideas</i>								
Q4_2	delivering new innovations	0.83							
Q4_3	offering best qualities for consumers	0.91							
Q4_4	providing best products for consumers	0.93							
Q4_5	pursuing best servicing for consumers	0.90							
	Collective knowledge (<i>Our company</i>)		0.60	3.94	0.77	0.86	0.71	0.09	0.86
Q6_1	<i>recombines ideas to solve problems or create opportunities</i>								
Q6_2	<i>absorbs, assimilates, and recombines information from different sources (internal and external)</i>								
Q6_3	frequently recombines existing knowledge to meet new demands	0.72							
Q6_4	is encouraged to share and learn from their experiences and failures	0.84							
Q6_5	combines external and internal knowledge to generate new ideas	0.81							
Q6_6	<i>knowledge grows when specialist workforce skills are shared</i>								
Q6_7	<i>turns new concepts towards reality</i>								
Q6_8	shares new ideas and/or creative thoughts	0.72							
	Digital Creativity (<i>Our company</i>)		0.60	3.74	0.80	0.81	0.72	0.12	0.85
Q2_1	hire only employs who pursue creative ideas	0.59							
Q2_2	supports staff creativity	0.87							
Q2_3	pushes workforce to be creative	0.87							
Q2_4	<i>implements new advances to production processes</i>								
Q2_5	delivers new innovative services to consumers	0.72							
	Strategic Risk Mgmt (<i>Our company supports new project ideas that</i>)		0.59	3.74	0.77	0.81	0.69	0.11	0.81
Q5_1	balance risk against financial rewards	0.78							
Q5_2	successfully manage associated risks	0.84							
Q5_3	bring unexpected beneficial opportunities	0.68							
Q5_4	<i>offer exploitable possibilities</i>								
Q5_5	<i>deliver efficient opportunities</i>								
	Transformational Abilities (<i>Our company</i>)		0.54	3.89	0.84	0.90	0.80	0.07	0.89
Q10_1	reacts to changing market demands for new software products	0.750							
Q10_2	continually refines the developing new products								
Q10_3	employees share practical experiences	0.785							
Q10_4	structurally uses its collected knowledge insights	0.874							
Q10_5	successfully links existing knowledge with new innovations/ideas	0.872							
	Process Assimilation Abilities (<i>Our Company</i>)		0.84	3.95	0.77	0.90	0.73	0.06	0.90
Q9_1	identifies new opportunities to provide quick service to customers	0.847							
Q9_2	emphasizes cross-departmental support to help solve problems	0.815							
Q9_3	employees collaborate regularly to communicate ideas and concepts.	0.806							
Q9_4	applies its acquired information and knowledge	0.819							
Q9_5	proactively responds to changing market demands	0.715							
	Strategic Operatioanl Abilities (<i>Our Company</i>)		0.70	3.92	0.85	0.87	0.80	0.09	0.81
Q11_1	<i>successfully exploit information&knowledge into software development</i>								
Q11_2	effectively utilizes knowledge in new software products	0.897							
Q11_3	effectively applies knowledge into new services	0.851							
Q11_4	<i>applies new knowledge to reengineer software</i>								
Q11_5	exploits its knowledge to development of prototypes	0.759							
	New Acquisitions (<i>To acquire new knowledge, our company</i>)		0.62	3.77	0.84	0.82	0.77	0.13	0.83
Q8_1	has routines to exploit new knowledge	0.65							
Q8_2	<i>pursues relevant strategic industrial intelligence information</i>								
Q8_3	motivates employees to embrace new information sources within industry	0.86							
Q8_4	inspires employees to seek for information beyond our industry	0.84							
Q8_5	<i>regularly seeks customers' feedback</i>								
	Sustainable Performance (<i>Our company</i>)		0.69	3.59	0.88	0.90	0.84	0.08	0.90
Q7_1	overall performance last financial year was superior to competitors	0.79							
Q7_2	<i>has gained strategic advantages over its rivals</i>								
Q7_3	<i>progressively increases its market share each year</i>								
Q7_4	has better combined capabilities than its competitors	0.82							
Q7_5	competitors find it hard to gain a competitive advantage against us	0.86							
Q7_6	sales growth is higher than competitors	0.86							
Q7_7	<i>continually attract new customers</i>								

Source: This study.

Table 2 presents each construct and its item measures as a detailed mix of item measure or construct fit and reliability assessments along with the necessary construct load and error values – ones necessary for CB-SEM single indicator composite construct path analysis assessment. Thus, eleven strong optimal constructs and their remaining item measures and made ready for multiple AMOS CB-SEM analysis approaches.

ANALYSIS and RESULTS

The theoretically developed framework model (Figure 1) and its SAI constructs described herein are both well understood by the authors and the constructs are supported by the above described EFA and CFA development stages. In CB-SEM modelling first a CB-SEM single indicator composite model is developed. This approach is useful in model path structure identification, and in clarification – as it removes many potential (or possible) interaction effects that may occur between various construct item measures and/or their error terms. These interaction effects can mask logical path identification or path significance. In addition, such interaction effects can affect model fit, and/or reduce prediction and/or introduce model estimates bias (Cheah et al, 2020). Thus, the single indicator composites CB-SEM path model (Figure 2) is a good investigatory starting approach, but it sacrifices opportunity to model measurement error explicitly and can compromise construct validity and accuracy of parameter estimates.



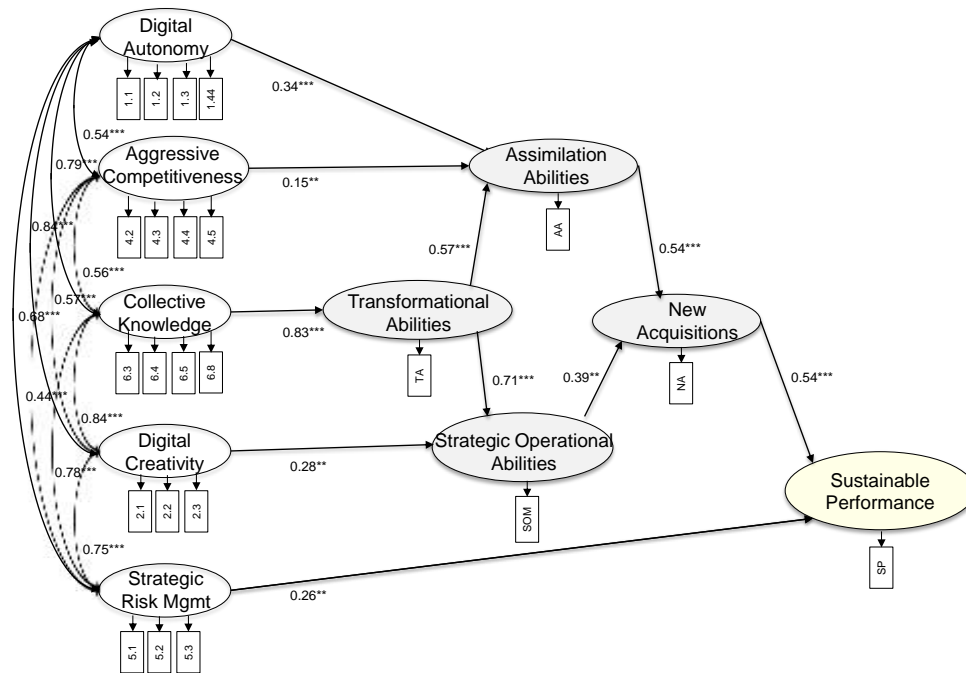
Source: This study.

Figure 2 Single indicator composites CB-SEM path model

Figure 2 applies Table 2’s dataset measures. It shows the single indicator composite CB-SEM model has all paths significant at better than $p < 0.05$. The covariances of the five exogenous constructs are both significant and sizeable. This is expected from the literature and logically as each construct is both literature and varimax EFA differentiated, yet each to some extent can be interpreted as related to and influencing other model constructs. However, as the exogenous standardized covariances range between 0.922 to 0.448, and nine of the ten covariances are well below 0.9, then collinearity is considered, but generally deemed acceptable across the exogenous constructs. This is supported by the regression sensitive variance inflation factor ($VIF = 1/[1-r^2]$) which shows one VIF path calculation (12.82) above 10, and the other nine VIF calculations ranging down to 1.91. Table 3’s AMOS sample moments condition number for the complex CB-SEM composites model (37.272) is also low. Hence, as all factors were literature, and theoretically supported into constructs, plus each was previously checked via EFA, and then optimized via CFA stage reduction (residuals < 0.05), multicollinearity between exogenous constructs, whilst present, is deemed acceptable, but recognized as possibly influencing and possibly altering item measurements and inflating error results.

All bar three CB-SEM composite model paths (aggressive competitiveness to assimilation abilities ($p = 0.008$), strategic operational abilities to new acquisitions ($p = 0.004$). and strategic risk management to sustainable performance $p = 0.0013$), deliver very highly significant paths (beta weights with $p < 0.000$). This very high significance level also applies to all covariances. The fit measure shown in Table 3a and 3b all indicate an overall excellent single indicator composites CB-SEM path model does exist. and this is in line with the literature and theoretically developed Figure 1 framework model.

Hence CB-SEM modeling progresses to a hybrid modelling stage where exogenous constructs are fully represented by their measurement items. Hybrid CB-SEM modelling offers advantages over traditional covariance-based SEM by better exposing pathways that may otherwise be partly masked by full CB-SEM parameter assessments. This approach offers a sound next step-up in modelling from single indicator composite modelling. The result of this modelling is presented as Figure 3.



Source: This study.

Figure 3 Hybrid CB-SEM path measurement model.

This hybrid model with full exogenous constructs and item measures has all paths significant at better than $p < 0.006$. It delivers decreased covariance (0.837 to 0.444) values and decreased multicollinearity. Comparing Figures 2 and 3 along with Table 3a and 3b differences shows the internal structural model and its endogenous pathways remain intact, indicating this dataset delivers a consistent overall model structure, and one driven by its five exogenous constructs and their input item measures. Hence operational software developer houses in Pakistan appear to have a viable approach from which each software house can beneficially positively structurally adjust its SAI capabilities and focus then towards delivering an ongoing and enhancing sustainable performance. As an excellent fit model is achieved, a full parameter structural model is attempted.

Table 3a Key model fit CMIN measures

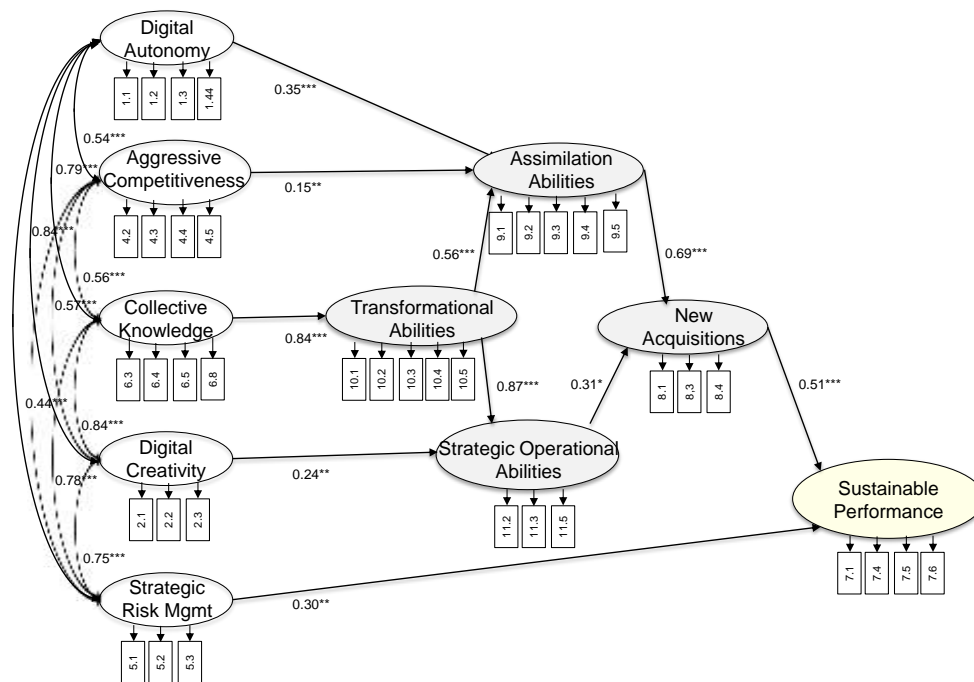
Model Approach	Sample Moments	Parameters	Degrees of Freedom (DF)	Chi Square (χ^2)	χ^2/DF	p value	p(Bollen-Stine)
5 x Composites	55	31	24	31.657	1.319	0.14	0.866
Hybrid	276	61	215	338.715	1.575	0.00	0.124
Full Parameter	703	80	609	1,045.637	1.717	0.00	0.104
Error Covaried	703	96	607	1,024.468	1.688	0.00	0.124

Source: This study.

Table 3b Goodness-of-fit comparisons table

Model Approach	RMSEA	RMR	TLI	CFI	GFI	AGFI	Condition Number	Multi-collinearity Problem
5 x Composites	0.042	0.017	0.990	0.994	0.996	0.922	37.272	x
Hybrid	0.056	0.043	0.953	0.960	0.868	0.830	112.61	x
Full Parameter	0.063	0.047	0.909	0.917	0.770	0.734	209.06	x
Error Covaried	0.062	0.046	0.913	0.920	0.773	0.738	209.06	x

Source: This study.



Source: This study.

Figure 4 Full parameter CB-SEM structural and measurement model.

Figure 4 and Table 3a and 3b show the traditional full parameter CB-SEM model has all paths significant at better than $p < 0.003$, and again retains the same model structure, and again delivers a very good complex model fit. Hence, operational software developer houses in Pakistan now have a viable approach from which each software house can beneficially positively structurally adjust its SAI capabilities and focus then towards delivering an ongoing and enhancing sustainable performance.

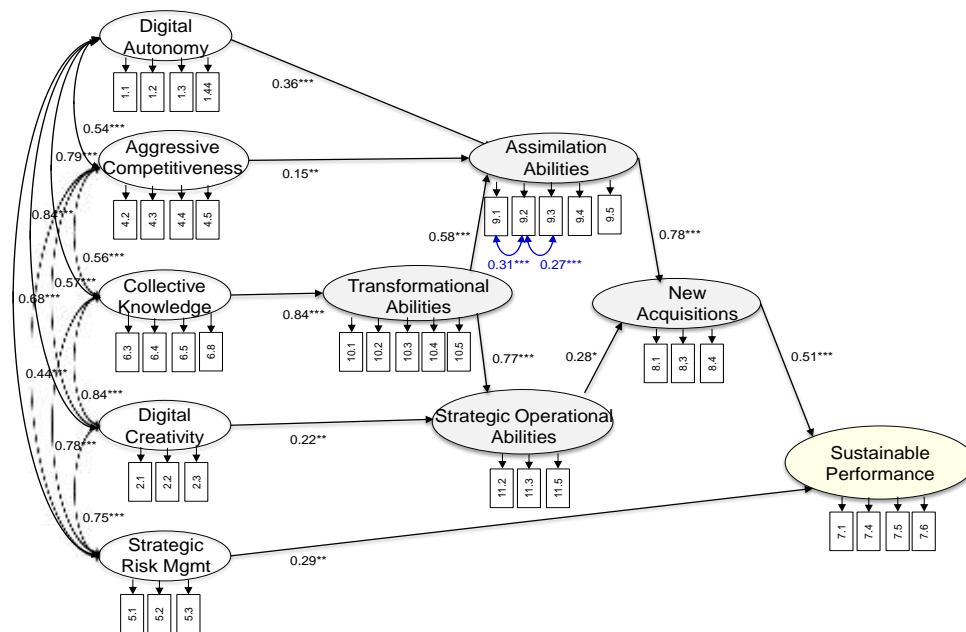
This CB-SEM model (Figure 4) introduces multiple additional parameters into the modelling. The exogenous covariances are acceptable and range from 0.836 to 0.442 (refer Figure 4). This best fit model has many goodness-of-fit measures just below the excellent range, but it is the best that is achievable for this 182-case data set, without adding modification indices suggested shared variance or error covariance terms. Such additions remain difficult to apply as covariance between such terms means the two variables are correlated and likely have some degree of common cause that leads to their correlation, and some of the first and second variable’s variance belongs to this common cause. This is definitely a possible inclusion, but it remains hard to establish, as a reason is needed for the inclusion of such a selective covariance error term.

Full Parameter CB-SEM Model Improvements

The Figure 4 model’s modification indices indicate two covariances can add between three adjacent error terms on assimilation abilities. This is both logical, and likely as the construct ‘item measure ‘emphasizes cross-departmental support to help solve problems,’ and this likely has some overlap with ‘identifies new opportunities to provide quick service to customers,’ and ‘employees collaborate regularly to communicate ideas and concepts.’ Hence, these two error covariances add, delivering Figure 5, its model fit improves from Figure 4’s $p(\text{Bollen Stine}) = 0.102$ to Figure 5’s $p(\text{Bollen Stine}) = 0.124$. This Figure 5 complex CB-SEM model also retains all paths significant at better than $p < 0.006$.

Considering Figure 5 and noting CB-SEM is a logical multivariate extension of linear regression modelling capturing a related suite of variables and their means, variances and covariances that enable estimation of multiple dependent and independent variables within a multivariate model (Rappaport *et al.* 2020). In this CB-SEM model covariance is further tested and specified amongst multiple measurement items and across one or more latent variables, and residual item specific variance (Bentler, 1980), with three assimilation abilities construct items showing weak but significant covariance.

Other model improvements to the Figure 5 full parameter model include (1) altering construct item load measure by moving the ‘1’ onto another item load measure on the same construct, and/or (2) deleting one construct load from the construct, and/or (3) deleting a construct item, and/or (4) removing one minor but acceptable outlier. Further, if modification indices between measurement errors or zeta error terms are sizeable then (5) covarying pairs on adjacent constructs can sometimes offer a logic and acceptable change. Such changes can improve the model. For example, if a two unsystematic zeta error terms shown as ‘Z’ error terms have a substantive paired modification indices value (often between adjacent endogenous construct measurement items), then they may sometimes be covaried. If so, adding a covariance between these zeta error terms, then represents each endogenous construct’s unexplained variance that is not predicted (nor accounted for by antecedent constructs) in the model. Such an addition may sometimes raise the model’s $p(\text{Bollen-Stine})$ value and sometimes improves the model fit.



Source: This study.

Figure 5 Full parameter CB-SEM model with two endogenous internal construct error covariances included

The Figures 2, 3, 4, and 5 complex CB-SEM models each operate on the same 182 case dataset, and also meet minimum 100-200 sample size (Boomsma,1982), exceed Nunnally’s (1967) 5-10 cases per construct, and exceed 5-10 observations per estimated parameter, and approximates (or exceeds) all of Hair *et al.*’s (2019) criteria. This acceptable dataset size, when applied to the most complex full parameter with an error covariance included Figure 5 CB-SEM model then delivers an acceptable Chi Square (p(Bollen Stine) >0.125) significance level. Likewise, Bentler and Hu, (1998) goodness of-fit cut-offs for excellent complex models exceed (or match) cut off levels including: RMSEA ≤ 0.06, RMR ≤ 0.05, TLI > 0.90, and CFI > 0.90. However, the GFI and AGFI suggest some more model fit aspects may still require extra theoretical and/or item consideration. The GFI suggests the model only explains nearly 80% of the exogenous constructs’ variance, and with the low AGFI suggests a sub-optimal model fit. However, with complex CB-SEM model solid Chi Square, RMSEA, and RMR values, parsimony is strongly accepted – especially as this is an empirical, first of a kind, SAI software house developer perspective in Pakistan.

DISCUSSION

This complex CB-SEM modelling approach engages ten SAI related constructs. It pursues whether Pakistan’s SAI houses can astutely deliver sustainable performances and so achieve their government’s desire to be one of the top five SAI digital solutions providers internationally. It captures specific nuances around the ten constructs their item measures, and their relationships with other constructs. As the modelling becomes progressively more complex from Figure 2 to Figure 5 model variants there is an empirical (or balance) consideration, between model accuracy (and deliverables) against each overall model’s complexities and resultant goodness-of-fit measures.

As complexities continually introduce model-by-model, extra degrees of freedom and many more avenues for multiple construct item measure interactive effects arise. Across this comparative Figure 2 to 5 modelling process, the dataset, and the exogenous inputs, still maintain the same internal endogenous pathways and internal model structure.

The final optimal modelling solution is delivered as Figure 5. This indicates Pakistan software houses developer respondents now have a viable approach from which each software house can beneficially re-structure and adjust its actioning SAI capabilities and specifically network them towards delivering their chosen net sustainable performance position.

Implications of Research: Measurement

This study links together theory and literature across a transitional stagewise process operating across the Figure 1 framework as it progresses towards delivering a sustainable performance outcome. Table 4’s standardized total effects measures capture the individual and combined net indirect and direct effects of relationships between constructs involved. Thus, a one-unit change in the initiating construct exerts a fractional change on the subsequent constructs involved.

The four Table 4 complex CB-SEM modelling standardized total effects tables show similar relative contributions towards sustainable performance positioning progress left to right across model. Across all four models, most important exogenous constructs are strategic risk management and collective knowledge, with aggressive competitiveness, digital autonomy and digital creativity making smaller contributions. All intermediate endogenous constructs contribute significantly Transformational abilities is an important endogenous level 1 change driver, and its positive changes consistently deliver

around a 0.30 to 0.34 change in sustainable performance. Assimilation abilities is a stronger endogenous level 2 change driver than strategic operational abilities, and its positive changes can deliver around a 0.31 to 0.40 change in sustainable performance. Strategic risk management is a direct 0.26 to 0.3 driver of sustainable performance. New acquisitions is a strong 0.51 to 0.58 level 3 endogenous driver of sustainable performance.

Table 4a Standardized Total Effects: Figure 2 Composite Model

Full Parameter Model Standardized Total Effects	Aggressive Competitiveness	Digital Autonomy	Digital Creativity	Strategic Risk Management	Collective Knowledge	Transformational Abilities	Strategic Operational Abilities	Assimilation Abilities	New Acquisitions
Transformational Abilities					0.838				
Strategic Operational Abilities			0.236		0.635	0.758			
Assimilation Abilities	0.155	0.346			0.470	0.561			
New Acquisitions	0.106	0.238	0.072		0.517	0.618	0.307	0.686	
Sustainable Performance	0.054	0.120	0.037	0.299	0.262	0.313	0.155	0.348	0.507

Source: This study.

Table 4b Standardized Total Effects: Figure 3 Hybrid Model

Hybrid Model Standardized Total Effects	Aggressive Competitiveness	Digital Autonomy	Digital Creativity	Strategic Risk Management	Collective Knowledge	Transformational Abilities	Strategic Operational Abilities	Assimilation Abilities	New Acquisitions
Transformational Abilities					0.834				
Strategic Operational Abilities			0.28		0.59	0.707			
Assimilation Abilities	0.151	0.342			0.479	0.574			
New Acquisitions	0.082	0.186	0.108		0.488	0.586	0.386	0.544	
Sustainable Performance	0.047	0.107	0.062	0.256	0.281	0.337	0.223	0.313	0.576

Source: This study.

Table 4c Standardized Total Effects: Figure 4 Full Parameter Model

Composite Model Standardized Total Effects	Aggressive Competitiveness	Digital Autonomy	Digital Creativity	Strategic Risk Management	Collective Knowledge	Transformational Abilities	Strategic Operational Abilities	Assimilation Abilities	New Acquisitions
Transformational Abilities					0.838				
Strategic Operational Abilities			0.306		0.573	0.683			
Assimilation Abilities	0.102	0.456			0.401	0.478			
New Acquisitions	0.057	0.253	0.115		0.438	0.523	0.377	0.555	
Sustainable Performance	0.033	0.146	0.066	0.252	0.252	0.300	0.217	0.319	0.575

Source: This study.

Table 4d Standardized Total Effects: Figure 5 Full Parameter 2 error pairs correlated

Full Parameter Error Correlated Model Standardized Total Effects	Aggressive Competitiveness	Digital Autonomy	Digital Creativity	Strategic Risk Management	Collective Knowledge	Transformational Abilities	Strategic Operational Abilities	Assimilation Abilities	New Acquisitions
Transformational Abilities					0.838				
Strategic Operational Abilities			0.223		0.645	0.770			
Assimilation Abilities	0.150	0.357			0.485	0.578			
New Acquisitions	0.118	0.279	0.046		0.511	0.609	0.204	0.782	
Sustainable Performance	0.060	0.143	0.023	0.293	0.261	0.311	0.105	0.400	0.511

Source: This study.

Across the models all constructs contribute either indirectly or directly towards sustainable performance. The most important exogenous change drivers are collective knowledge and strategic risk management. These two exogenous domains are key input and capture advancement areas upon which Pakistan's SAI house developers should concentrate. In attempting to grow its sustainable performance enhancements along the key pathway of collective knowledge transformational abilities are most important, then conjoint actioning of two different level 2 endogenous pathways (assimilation abilities and strategic operational abilities) should be promoted to build final new acquisitions solutions. Table 4d provides the most accurate total effects solution to the data set. The other three total effects tables are provided for trends and comparison purposes.

This longest complex CB-SEM model pathway of Figure 5 is also the strongest outcomes deliverance pathway. It runs from collective knowledge to transformational abilities to either assimilation abilities or strategic operational abilities, to new acquisitions, and to sustainable performance. This pathway is both logical and is a key development sequence for those Pakistan SAI software house developers who remain in constant pursuit of improving their sustainable performance position.

Figure 4d shows all constructs exert positive influences on sustainable performance. Hence, to grow sustainable performance outcomes within Pakistan's SAI houses, strategic risks management and collective knowledge are two strongest development approaches that should be conjointly followed. This means SAI houses first need to remain very current with their collective knowledge and risk assessment competencies, whilst retaining and enhancing their digital autonomy, digital creativity, and aggressive competitiveness competencies.

Implications of Research: Practical

This Pakistan SAI Houses study shows there are multiple pathways to enhance sustainable performance, and each can be improved or adjusted to deliver better SAI solutions into the future. For example, starting with collective intelligence. This competency is a vital ingredient into delivering capabilities – starting with transformational abilities which can then affect both assimilation abilities and strategic operations abilities. This developing system can then influence the development of new acquisitions, and the entire system can then influence sustainable performance. Thus, positively adjusting any or all of these construct deliverables can enhance the resultant sustainable performance outcome. Thus, SAI Houses need to be cognisant and to pursue ongoing market leaders across all of these SAI related areas.

Implications of Research: Theoretical

This theoretical model framework approach delivers a combined theoretical solution capturing its SAI enabling competencies theory (encompassing a framework of specific SAI related constructs and their measurement items). Building solution components using a developing and new capabilities theory approach and coalescing these towards a unique sustainable performance outcome. This SAI Houses study adds to the theoretical literature by extending SAI sustainable performance understanding as a likely overarching competitively advantageous SAI outcome.

Future Research: Measurement Aspects – Capabilities

This study can be widened by other researchers to capture a wider cross-section of national SAI ‘experts.’ Expansion studies can capture other age and cultural groups, other demographics, and even other religious groups. Such alternatives may provide additional measurement solutions and wider understanding.

Future Research: Measurement Aspects – Modelling

Figure 5’s traditional CB-SEM full path measurement approach shows Figure 1’s framework and the study’s aim are significantly, and structurally CB-SEM model supported. Thus, a three-stage modelling approach is appropriate to highlight ongoing SAI Houses related studies.

Future Research: Theoretical Aspects

Competencies theory (Khang, 2024) and capabilities theory (Khang, 2024) and sustainable performance theory (Khan, 2025) frame a theoretical shell for competencies to capabilities to sustainable performance studies within the SAI research domain.

Future Research: Management Aspects

Managing Pakistan SAI Houses into the future requires ongoing high-tech instantaneous, monitoring of latest and developing SAI components and their fit within the SAI Houses’ operational systems. Any additional contributions must fit and compliment within the relevant SAI business domain.

CONCLUSION

Complex CB-SEM models can be selectively, and sequentially developed, depending on their purpose. For simple Figure 2 path model identification composite modelling defines possible paths, but the Figure 3 hybrid models provide greater insight into path and measurement modelling. Figure 4 and figure 5 full parameter modelling enables detailed understanding of the model structure and its measurement., but the introduction of so many parameters also add further potential interaction effects and exogenous multicollinearity. In addition, the full parameter models also present beta path weights that more accurately represent the model and its pathway effects, with Figure 5 being the best model available for the data set.

This study of Pakistan SAI house developers and their perspectives into the SAI future delivers many useful future development strategies and shows there is a sequential or staged development approach that can be directionally focused into beneficially delivering ongoing improvements that are likely capable of networking towards enhancing the current and ongoing sustainable performance positioning of Pakistan SAI houses.

REFERENCES

- Ajamieh, A., Benitez, J., Braojos, J., & Gelhard, C. (2016). IT infrastructure and competitive aggressiveness in explaining and predicting performance. *Journal of Business Research*, 69(10), 4667-4674.
- Ali, S. A., Hamilton, J. R., Tee, S., & Underdown, M. (2022). Sustainable competitive advantage in entrepreneurial software firms in Pakistan: Establishing a conceptual research framework In *Proceedings of the International Conference on Electronic Business* (pp. 1-15). ICEB’22, Bangkok Thailand.
- Amin, A., Basri, S., Rehman, M., Capretz, L. F., Akbar, R., Gilal, A. R., & Shabbir, M. F. (2020). The impact of personality traits and knowledge collection behavior on programmer creativity. *Information and Software Technology*, 128, 106405.
- Barney, J. (1991). Firm resources and sustained competitive advantage. *Journal of Management*, 17(1), 99-120.
- Bentler, P. M. (1980). Multivariate analysis with latent variables: Causal modeling. *Annual Review of Psychology*, 31, 419-456.
- Bentler, P. M., & Chou, C. P. (1987). Practical issues in structural modeling. *Sociological Methods & Research*, 16(1), 78-117.
- Boomsma, A. (1982). The robustness of LISREL against small sample sizes in factor analysis models. In K. G. Jöreskog & H. Wold (Eds.), *Systems under indirect observation: Causality, structure, prediction* (pp. 149-173). North-Holland. Retrieved from <https://www.econbiz.de/Record/the-robustness-of-lisrel-against-small-sample-sizes-in-factor-analysis-models-boomsma/10001936630> (accessed 15 July 2025)

- Cheah, J. H., Memon, M. A., Richard, J. E., Ting, H., & Cham, T. H. (2020). CB-SEM latent interaction: Unconstrained and orthogonalized approaches. *Australasian Marketing Journal*, 28(4), 218-234.
- Chung, S., Lee, K. Y., & Choi, J. (2015). Exploring digital creativity in the workspace: The role of enterprise mobile applications on perceived job performance and creativity. *Computers in Human Behavior*, 42, 93-109.
- Dai, L., Maksimov, V., Gilbert, B. A., & Fernhaber, S. A. (2014). Entrepreneurial orientation and international scope: The differential roles of innovativeness, proactiveness, and risk-taking. *Journal of Business Venturing*, 29(4), 511-524.
- Gallivan, M. J. (2003). The influence of software developers' creative style on their attitudes to and assimilation of a software process innovation. *Information & Management*, 40(5), 443-465.
- Hair, J. F., Black, W. C., Babin, B. J., & Anderson, R. E. (2019). *Multivariate data analysis* (8th ed.). Andover, Hampshire, UK: Cengage Learning EMEA.
- Hakala, H. (2013). Entrepreneurial and learning orientation: Effects on growth and profitability in the software sector. *Baltic Journal of Management*, 8(1), 102-118.
- Hu, L. T., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling: A Multidisciplinary Journal*, 6(1), 1-55.
- Huu, P. T. (2023). Impact of employee digital competence on the relationship between digital autonomy and innovative work behavior: A systematic review. *Artificial Intelligence Review*, 56(12), 14193-14222.
- International Trade Administration. (2025). Pakistan Country Commercial Guide: Computer Software Section. *Trade.gov*. Retrieved from: <https://www.trade.gov/country-commercial-guides/pakistan-computer-software> (accessed 5th May 2025).
- Khan, A. N. (2025). Artificial intelligence and sustainable performance: Role of organizational agility and environmental dynamism. *Technology Analysis & Strategic Management*, 37(5), 568-583.
- Khang, A. (2024). Design and modeling of artificial intelligence-oriented competency framework for information technology sector. In *AI-Oriented Competency Framework for Talent Management in the Digital Economy* (pp. 268-291). CRC Press.
- Khin, S., & Ho, T. C. (2019). Digital technology, digital capability and organizational performance: A mediating role of digital innovation. *International Journal of Innovation Science*, 11(2), 177-195.
- Lee, K., & Roh, T. (2020). Proactive divestiture and business innovation: R&D input and output performance. *Sustainability*, 12(9), 3874, 1-19.
- Na, K. S., Simpson, J. T., Li, X., Singh, T., & Kim, K. Y. (2007). Software development risk and project performance measurement: Evidence in Korea. *Journal of Systems and Software*, 80(4), 596-605.
- Nonaka, I., & Konno, N. (1998). The concept of "Ba": Building a foundation for knowledge creation. *California Management Review*, 40(3), 40-54.
- Nunnally J. C. (1967). *Psychometric Theory*. New York, NY: McGraw-Hill.
- Rappaport, L. M., Amstader, A. B., & Neale, M. C. (2020). Model fit estimation for multilevel structural equation models. *Structural Equation Modeling: A Multidisciplinary Journal*, 27(2), 318-329.
- Ravichandran, T. (2005). Organizational assimilation of complex technologies: An empirical study of component-based software development. *IEEE Transactions on Engineering Management*, 52(2), 249-268
- Sherif, K., & Xing, B. (2006). Adaptive processes for knowledge creation in complex systems: The case of a global IT consulting firm. *Information & Management*, 43(4), 530-540.
- Todorova, G., & Durisin, B. (2007). Absorptive capacity: Valuing a reconceptualization. *Academy of Management Review*, 32(3), 774-786.
- Xu, W., Ou, P., & Fan, W. (2017). Antecedents of ERP assimilation and its impact on ERP value: A TOE-based model and empirical test. *Information Systems Frontiers*, 19, 13-30.
- Yulianto, E., Pratomo, T., Zein, Z., & Supardin, L. (2023). Impact of work demand and job autonomy on employee sustainable performance with digital leadership as moderating variable: A proposed framework. In *Proceedings of the 8th North American Conference on Industrial Engineering and Operations Management*, Houston, Texas, USA (pp. 1013-1023).
- Zahra, S. A., & George, G. (2002). Absorptive capacity: A review, reconceptualization, and extension. *Academy of Management Review*, 27(2), 185-203.