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The Effect of Technology Readiness, Company Characteristics, and Innovation Adoption on Competitive Advantage in the Construction Industry in Indonesia

Novi Sudiansyah[1] ; Tri Joko Wahyu Adi[2]
Department of Civil Engineering, Institut Teknologi Sepuluh Nopember
Surabaya, Indonesia

Abstract:- Currently, Indonesia's construction industry still shows weak co. mpetitiveness with foreign construction companies. This is believed to be due to the low creativity and innovation in construction practices. This study aims to model the relationship between company characteristics, innovation adoption, and technology readiness to achieve competitive advantage. The research variables were obtained through an in-depth literature review and questionnaires, distributed to 106 large construction companies located in Indonesia. The research respondents were technical staff or high-level management involved in implementing construction innovations. Empirical data was then analyzed using Confirmatory Factor Analysis with Structural Equation Model (SEM) tools. The results showed a significant relationship between technology readiness, company characteristics, and competitive advantage mediated by innovation adoption.

Keywords:- *Competitive Advantage, Technology Readiness, Innovation Adoption, Company Characteristics, Structural Equation Model (SEM).*

I. INTRODUCTION

In today's fast-paced competitive environment, companies face the need to be increasingly agile and adaptive. While they are often able to establish a certain level of performance based on existing technologies, they are often unprepared for new emerging technologies. Urbancova [1] claims that the goal of every company in today's fiercely competitive environment is to outperform its rivals and win new customers. People with creativity, knowledge, and skills are likely to develop original ideas that will give the company a competitive advantage. Competitive advantage for customers means that the company can provide products or services to their expectations. As for investors, competitive advantage means that the company can provide significant profits or minimize the risk of default in terms of funding. That is why at present, competitive advantage is needed by companies for greater development.

One of the contributions of competitive advantage in the construction industry is the application of innovation. The construction industry with all its characteristics is known to be very conservative in terms of adopting innovations, both from digital technology innovations and management structure innovations, when compared to other industries. It can be difficult to prioritize innovation in the construction sector, especially when a project has dynamic changes and limited resources. The financial constraints of the construction sector must also be considered; budgets for investment in innovation adoption are sometimes lacking due to the risks involved in investing in low-return innovations.

According to the Global Competitiveness Index 4.0 data released by Klaus Schwab World Economic Forum 2019 [2] in October last year, Indonesia ranked 50th out of 141 countries. One proof of Indonesia's weak construction innovation is that more foreign contractors work in Indonesia than national contractors who expand abroad. In addition, the export value of Indonesian construction services in 2020 was IDR 2.2 trillion and the import value of Indonesian construction services reached 130.6 trillion in the same year [3], [4].

Suanda [5] stated that Indonesia was very weak in terms of research/development which is the main support for the innovation process. The low level of innovation in Indonesia is partly due to the characterization of construction industry companies that are traditionally reluctant to implement the latest innovations in both construction technology and data collaboration technology. The construction industry, which is more project-oriented with a relatively short time, makes innovation processing no longer a priority because innovation requires special time to determine goals, exploration - idea formulas/trials, and simulations.

In terms of construction technology, according to the Construction Industry Development Team from LPJKN in Permatasari et al. [6], it is said that the readiness of construction technology is still slow even and has not experienced much significant improvement. Even for some large companies, the use of construction technology related to informatics is also not fully maximized, especially for small and medium-sized companies where innovation is almost non-existent.

In connection with the above phenomenon, there is a relationship between technology readiness which is influenced by company characteristics to adopt innovations, which in turn will affect the company's ability to increase competitive advantage in the construction industry in Indonesia. This study aims to propose a structural equation model (SEM) to analyze the effect of technology readiness level, company characteristics, and innovation adoption on competitive advantage in the construction industry in Indonesia.

II. LITERATURE REVIEW

A. Competitive Advantage

Porter [7], defines competitive advantage as something that makes a product/service superior to other consumer choices. Competition is at the core of a company's success or failure. Competition determines the feasibility of a company's activities that contribute to performance such as innovation, cohesive culture, or good implementation. Danang and Tracey [8], [9] define it as the company's ability to create and maintain the company's position against its competitors. Porter, (1998) in Awwad et al., (2013) [10] state that the company's competitive advantage is the expertise gained through the characteristics and resources of the company so that it can outperform other companies in similar industry sectors.

B. Technology Readiness

Technology readiness is the level of a company's ability to implement new technology that can increase efficiency and productivity [11]. Technology readiness is an important factor in determining the success of companies in adopting new technology because companies that are more ready to adopt new technology tend to have a higher competitive advantage than companies that are less ready [12]–[14]. Technology readiness is a combination of technology-related beliefs that collectively determine the tendency of customers, users, or organizations to accept and use new technology [15]. Parasuraman [16] created the Technology Readiness Index (TRI) to measure how far a person generally believes in technology. The measurement has four indicators of perception, namely optimism, innovation, discomfort, and insecurity in the use of new technology. These four indicators make a person ready or not for the adoption of new technology and technology readiness is recognized as a key factor in the performance of contracting companies [17]. Research by Paraskevas and Avgerou (2011) in Panday [18] investigated the impact of technology readiness on the performance of IT systems used by construction companies. This study found that technology readiness has a significant impact on IT system performance, with higher technology readiness resulting in better performance [19]. In addition, the study found that the level of technology readiness is a better predictor of performance than the level of IT system complexity [20]. This suggests that construction companies should focus on improving technology readiness to improve the performance of their IT systems.

C. Innovation Adoption

Johnson [21] states that innovation is: changes in products or services that are sold to the market, changes in products or services that are different from the previous function, and changes in market share for products or services that were previously only for certain circles or certain markets, changes in the way products or services are developed and delivered away from the original operational and logistical design.

The adoption of innovation has been the subject of extensive theoretical and empirical study and is now widely recognized as an important determinant of sustained superior performance. Adoption typically begins with a need and proceeds to search for a solution, then to an initial decision to attempt adoption of the solution, and finally to a final decision to attempt to proceed with implementation of the solution [22]–[25].

Innovation adoption in the construction industry is an important process to improve efficiency and productivity [26]. Innovations can be new technologies, processes, and methods that can help improve the quality and efficiency of construction projects [27]. Some examples of innovations that can be applied in the construction industry are the use of project management systems to regularly monitor project work, workers, schedules, and tasks [28], the use of innovative technology to improve understanding of the complex adoption of innovative technology, the use of innovation and technology for infrastructure development [29], and the use of innovation processes to achieve the design and build project team performance [30].

D. Company Characteristic

Company characteristic is a concept that describes the characteristics of a company, which can be seen from several factors, such as business fields, markets, and resources [31]. Company characteristics can also be used to determine the extent of disclosure of the company's annual report [32]. Some factors that affect the extent of disclosure of the company's annual report are company characteristics, ownership structure, company size, and market conditions [33]–[35]. Meanwhile, company characteristics are understood as features that describe the influence of owners, managers, employees, and business partners on the decision process to determine the main objectives of the company and the resulting behavioral consequences [36].

III. RESEARCH METHODOLOGIES

The study used quantitative methods with data collection techniques in the form of questionnaires. The population sample was taken using a non-probabilistic sample on the population of construction companies located in Java with the criteria of respondents who have been involved in decision-making or direct activities to implement innovations in the company in the form of both management innovations and innovations in construction technology It is intended to provide answers by the research objectives. The questionnaire uses a Likert scale ranging from 1 strongly disagree to 5 strongly agree.

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Data collection was analyzed using multilevel factor confirmatory analysis and hypothesis testing using structural equation modeling with the help of *smartPLS* software. The model has three endogenous variables: technology readiness (TR), innovation adoption (IA), and competitive advantage (CA), and one exogenous variable: company characteristics (CC). The Innovation Adoption variable (IA also acts as a mediating variable (intervening variable In the initial model that can be seen in Figure 1. The model has variables of company characteristics (CC) with 3 indicators [37]–[44], technology readiness with 4 indicators [16], [45]–[47], innovation adoption with 6 indicators [48]–[55] and competitive advantage with 4 indicators [56]–[62].

➢ *The Hypotheses that are Built Based on the Initial Model are as follows:*

- *H1: Company characteristics (CC) have a significant effect on technology readiness (TR)*
- *H2: Company characteristics (CC) have a significant effect on innovation adoption (IA)*
- *H3: Technology readiness (TR) has a significant effect on innovation adoption (IA)*
- *H4: Innovation adoption (IA) has a significant effect on competitive advantage (CA)*

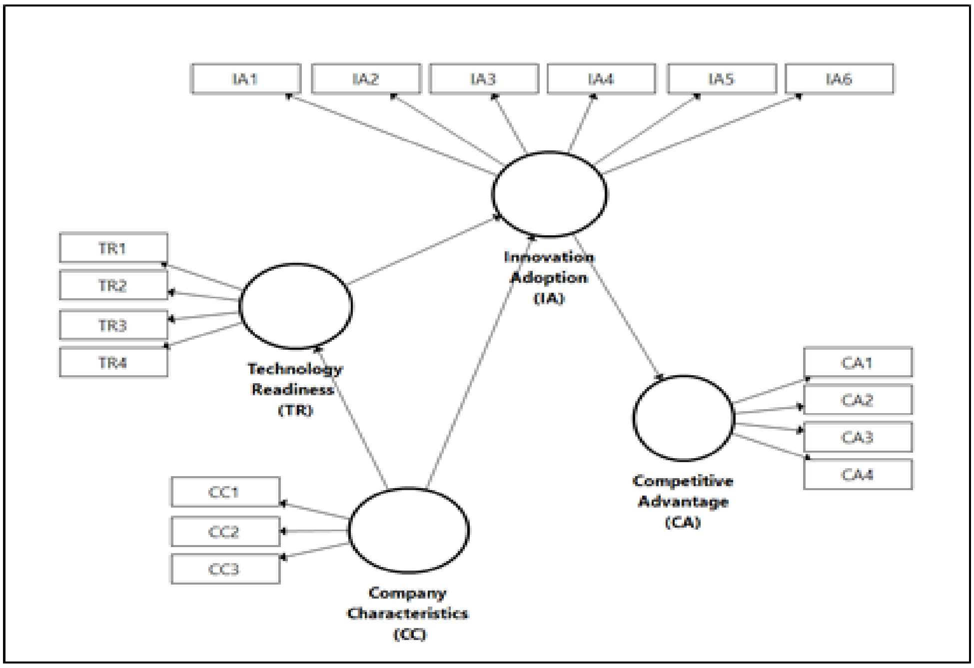

Fig 1 Initial Model

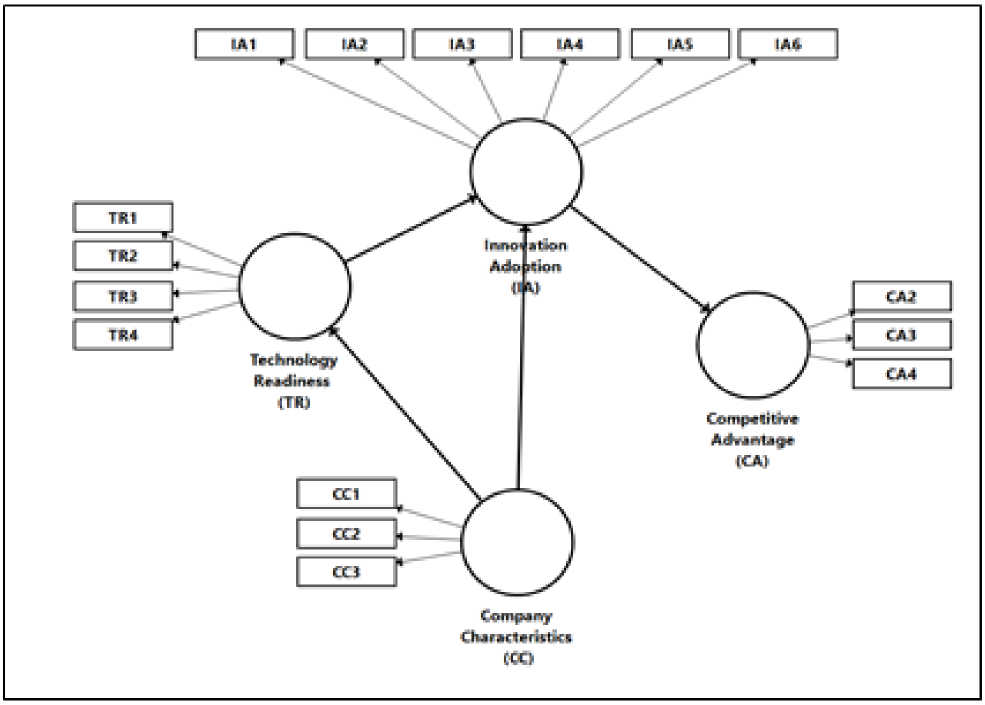

Fig 2 Final Model

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IV. RESULT FROM RESEARCH

After the analysis is done by testing the outer model and inner model. Because one of the variables is a dimension that must be measured, namely Technology Readiness (TR) indicated by the grey color in Figure 3. First Order CFA, the confirmatory factor analysis test is carried out through the First Order and Second Order processes. The results of the First Order construct test can be seen in the discussion below.

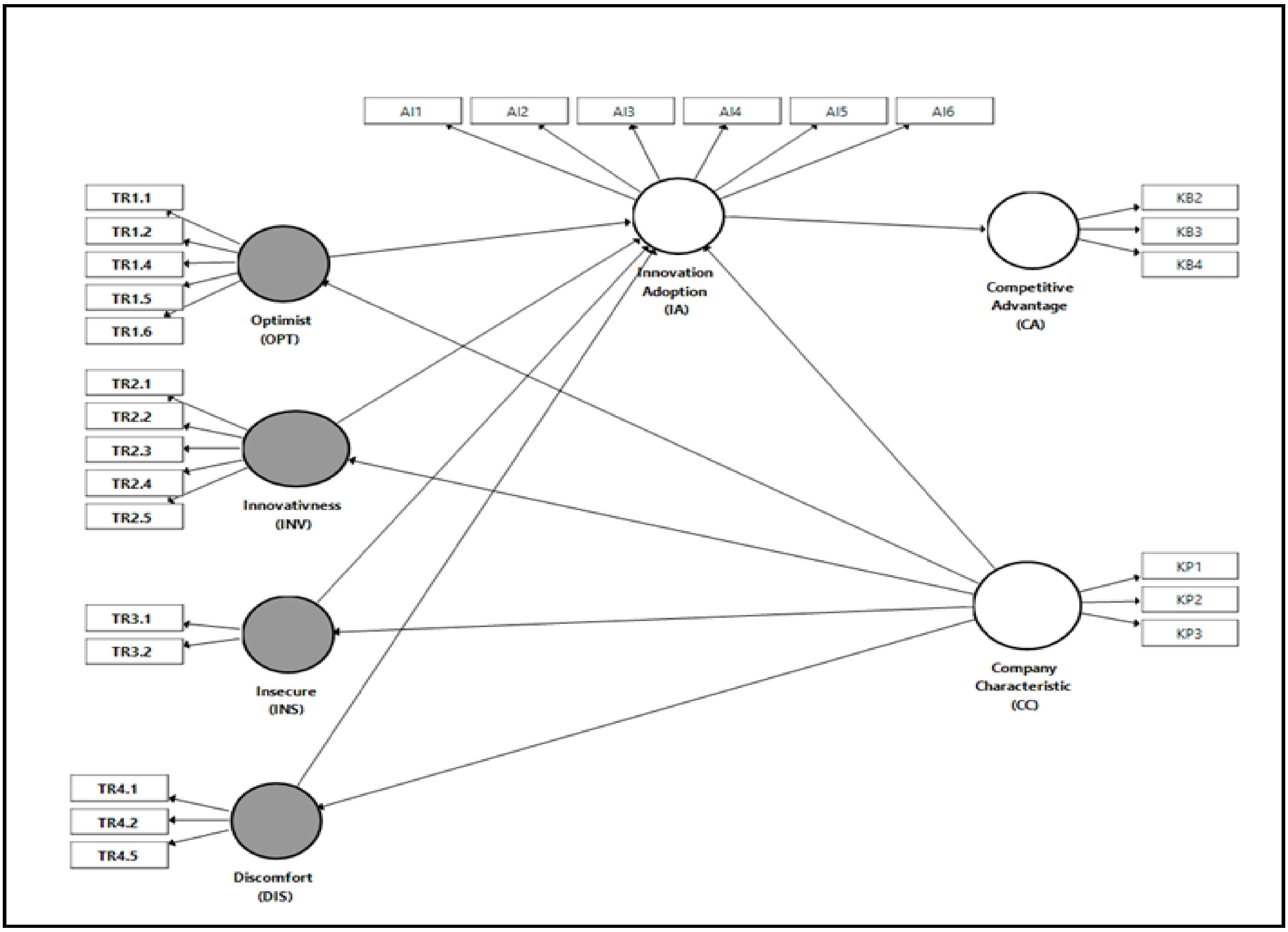

Fig 3 First Order CFA

E. The Convergent Validity Test

In the table, the test results for the outer loading of the model indicators are all declared valid because they are in the range of 0.708 to 0.917.

Table 1 Outer Loading

Variable	Dimension	Indicator	Value
Innovation Adoption IA		IA4	0.917
		IA6	0.913
		IA3	0.908
		IA2	0.889
		IA5	0.863
		IA1	0.855
Competitive Advantage CA		CA2	0.881
		CA3	0.915
		CA4	0.896

Variable	Dimension	Indicator	Value
Company Characteristics CC		CC1	0.870
		CC2	0.751
		CC3	0.870
Technology Readiness TR	Optimist OPT	TR1.1	0.844
		TR1.2	0.804
		TR1.4	0.766
		TR1.5	0.822
		TR1.6	0.708
	Innovative INV	TR2.1	0.791
		TR2.2	0.820
		TR2.3	0.869
		TR2.4	0.831
		TR2.5	0.824
	Discomfort DIS	TR3.1	0.889
		TR3.2	0.831
	Insecure INS	TR4.1	0.876
		TR4.2	0.855
		TR4.5	0.709

Based on Table 3, Innovation Adoption (IA), Competitive Advantage (CA), Company Characteristics (CC), Technology Readiness (TR) with sub-dimensions Optimism (OPT), Innovative (INV), Discomfort (DIS), and Insecure (INS).

We can see that the variables with the highest loadings for each dimension are as follows:

Innovation Adoption (IA): The indicators IA4, IA6, IA3, IA2, IA5, and IA1 all have high loadings, ranging from 0.855 to 0.917. These variables are strongly associated with the Innovation Adoption variable.

Competitive Advantage (CA): The indicators of CA3, CA4, and CA2 have high loadings, ranging from 0.881 to 0.915. These indicators are strongly associated with the Competitive Advantage variable.

Company Characteristics (CC): The indicators of CC1 and CC3 have high loadings, ranging from 0.870 to 0.870. These indicators are strongly associated with the Company Characteristics variable.

Technology Readiness (TR): The sub-dimensions of TR have the following high loadings:

Optimism (OPT): The indicators TR1.1, TR1.2, TR1.4, TR1.5, and TR1.6 have high loadings, ranging from 0.708 to 0.844. These indicators are strongly associated with the Optimism sub-dimension of Technology Readiness and may be measuring similar constructs related to optimism about technology adoption.

Innovative (INV): The indicators of TR2.1, TR2.2, TR2.3, TR2.4, and TR2.5 have high loadings, ranging from 0.791 to 0.869. These indicators are strongly associated with the Innovative sub-dimension of Technology Readiness and may be measuring similar constructs related to innovative behavior.

Discomfort (DIS): The indicators of TR3.1 and TR3.2 have high loadings, ranging from 0.831 to 0.889. These indicators are strongly associated with the Discomfort sub-dimension of Technology Readiness and may be measuring similar constructs related to discomfort with technology adoption.

Insecure (INS): The indicators of TR4.1, TR4.2, and TR4.5 have high loadings, ranging from 0.709 to 0.876. This suggests that these variables are strongly associated with the Insecure sub-dimension of Technology Readiness, and may be measuring similar constructs related to insecurity about technology adoption

F. Discriminant Validation Test

The test results, in Table 2 criteria using the Fornel-Lacker criterion, have shown good results, so it can be said that the indicators that are in the same construct are valid.

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Table 2 Discriminant Test Results with Fornell-Larcker criteria

	IA	INV	CA	CC	INS	DIS	OPT
IA	*0.891*						
INV	*0.778*	*0.827*					
CA	*0.666*	*0.442*	*0.897*				
CC	*0.778*	*0.593*	*0.634*	*0.832*			
INS	*0.326*	*0.306*	*0.303*	*0.468*	*0.861*		
DIS	*0.298*	*0.254*	*0.089*	*0.521*	*0.552*	*0.817*	
OPT	*0.622*	*0.583*	*0.504*	*0.487*	*0.232*	*0.140*	*0.790*

Based on Table 2, the variable represented by IA has a strong positive correlation with factor 1 (IA), with a loading of 0.891. The second row shows that the variable represented by INV has a strong positive correlation with factors 2, with loadings of 0.827, respectively. It is important to note that the value of the variable to the factor must be greater than the value of the variable to a different factor.

The pattern of correlations among variables and factors can be used to interpret the underlying dimensions that the variables are measuring. Factors with high positive correlations to certain variables indicate that these variables are strongly related and may be measuring the same underlying construct.

Table 3 Cross Loading

	IA	CA	CC	OPT	INV	INS	DIS
IA1	**0.855**	0.587	0.678	0.524	0.603	0.331	0.327
IA2	**0.889**	0.605	0.675	0.574	0.709	0.249	0.272
IA3	**0.908**	0.574	0.665	0.505	0.684	0.232	0.252
IA4	**0.917**	0.534	0.730	0.533	0.721	0.359	0.324
IA5	**0.863**	0.550	0.706	0.574	0.701	0.264	0.220
IA6	**0.913**	0.698	0.704	0.607	0.732	0.311	0.207
CA2	0.488	**0.881**	0.492	0.362	0.288	0.210	-0.015
CA3	0.575	**0.915**	0.504	0.449	0.401	0.194	-0.012
CA4	0.694	**0.896**	0.679	0.520	0.471	0.381	0.223
CC1	0.731	0.617	**0.870**	0.421	0.618	0.343	0.471
CC2	0.457	0.482	**0.751**	0.273	0.236	0.502	0.463
CC3	0.714	0.480	**0.870**	0.496	0.564	0.362	0.382
TR1.1	0.536	0.464	0.472	**0.844**	0.473	0.240	0.134
TR1.2	0.431	0.279	0.307	**0.804**	0.559	0.154	0.149
TR1.4	0.568	0.416	0.445	**0.766**	0.505	0.215	0.133
TR1.5	0.496	0.478	0.376	**0.822**	0.455	0.195	0.099
TR1.6	0.380	0.309	0.269	**0.708**	0.279	0.070	0.013
TR2.1	0.670	0.389	0.501	0.422	**0.791**	0.275	0.193
TR2.2	0.620	0.279	0.431	0.345	**0.820**	0.227	0.222
TR2.3	0.684	0.366	0.525	0.556	**0.869**	0.270	0.216
TR2.4	0.626	0.430	0.435	0.552	**0.831**	0.225	0.144
TR2.5	0.611	0.363	0.549	0.526	**0.824**	0.262	0.273
TR3.1	0.354	0.319	0.406	0.248	0.334	**0.889**	0.457
TR3.2	0.194	0.192	0.401	0.142	0.179	**0.831**	0.500
TR4.1	0.306	0.062	0.469	0.188	0.258	0.415	**0.876**
TR4.2	0.264	0.135	0.409	0.083	0.259	0.434	**0.855**
TR4.5	0.139	0.016	0.395	0.053	0.082	0.531	**0.709**

Table 3 shows that for each latent variable, the factor loading (which is dark in color) compared to the other cross-loading factor, has the highest value for each indicator. This shows that the discriminant validity criteria based on cross-loading look good. For example, variable IA (Innovation Adoption) which has indicators belonging to IA (IA1, IA2, IA3, IA4, IA, IA6) has higher values compared to another indicator in the same column. Respectively other variables for indicators that belong to variables in the same column should have a higher value than another indicator that does not belong to the variable itself.

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G. *Construct Reliability*

Table 4 Cronbach's Alpha and Composite Reliability values

Variable	Cronbach's Alpha	Composite Reliability
Adoption of Innovation	0.948	0.959
Innovativeness	0.884	0.915
Competitive Advantage	0.881	0.925
Company Characteristic	0.779	0.871
Insecure	0.653	0.851
Discomfort	0.748	0.856
Optimist	0.850	0.892

The calculation test results in this study show the Cronbach alpha value and Composite Reliability above 0.7 except for the insecure variable, so it can be that the questionnaire used is reliable or reliable.

The results of testing convergent validity, discriminant validity, and reliability tests can be concluded that the measurement model test on the first order construct is fit or feasible to proceed to further testing.

H. *Validation of Second Order Constructs*

The test method for Second Order Construct is the same as the test method for the first-order construct, but here, researchers only take test scores for the technology readiness construct (KT) which is a summary of the OPT, INV, KTA, and KTN constructs in the first order construct. Because during the first order, the other latent variables have been carried out then the second order need only to be carried out on the technology readiness construct (KT) to ensure that the composite reliability value is > 0.7.

Table 5 Discriminant of Second Order

	Composite Reliability	AVE
Technology Readiness	0.800	0.504

I. *Model Fit*

The model is considered fit if the Standardized Root Mean Square Residual (SRMR) value is below 0.8, however (see Table 6), the range below 0.1 is still acceptable [63].

Table 6 SRMR Validation

	Saturated Model	Estimated Model
SRMR	0.080	0.110

J. *Inner Model / Structural Model*

The Inner Model is a structural model used to predict causal relationships between latent variables or variables that are not directly measured, hypotheses testing, and evaluate the significance of path coefficients. In this study, testing was conducted by examining the Coefficient of Determination, Q-Square Predictive Relevance, and hypothesis testing.

K. *R^2 Coefficient of Determination*

The coefficient of determination can tell us how well the linear regression model fits the data we have. The higher coefficient of determination, the better our linear regression model is at explaining the relationship between these variables. Chin (1998), in Yamin & Kurniawan [64] explains the criteria for the R2 value in 3 classifications, namely 0.67 (substantial), 0.33 (moderate), and 0.19 (weak). The value of R2 in the simulation model can be seen in the table below.

Table 7 Result Coefficient of Determination

	R^2	R^2 Adjusted	Result
Innovation Adoption	0.690	0.684	Substantial
Competitive Advantage	0.443	0.438	Substantial
Technology Readiness	0.528	0.524	Substantial

L. *Q^2 Predictive Relevance*

Q^2 measures the predictive relevance of the model and indicates how well the observed values are generated by the model as well as the estimates. The higher the Q^2 value, the better the predictive ability of the model.

Table 8 Predictive Relevance

	SSO	SSE	Q^2 (=1-SSE/SSO)
Innovation Adoption	630	292.87	0.535
Competitive Advantage	315	208.62	0.338
Technology Readiness	420	310.81	0.260

M. *Hypothesis Test*

The analysis is done using *SmartPLS* software, which produces a number called a "path coefficient". The path coefficient is then compared to statistical limits, which are a t-test value greater than or equal to 1.980 and a p-value less than 0.05. If the path coefficient meets these requirements, the hypothesis is accepted. If not, the hypothesis is rejected.

Table 9 Hypothesis Test

	β	t	p
H1 : Company characteristics (CC) → technology readiness (TR)			
	0.727	13.546	0.000
H2: Company characteristics (CC) → innovation adoption (IA)			
	0.480	5.486	0.000
H3: Technology readiness (TR) → innovation adoption (IA)			
	0.414	5.589	0.000
H4: Innovation Adoption (IA) → Competitive Advantage (CA)			
	0.666	10.541	0.000

- *H1: Company characteristics (CC) have a significant effect on technology readiness (TR). Based on the test results, the value of $\beta = 0.727$, $t = 13.546$, and $p < 0.001$, thus H_0 is accepted*
- *H2: Company characteristics (CC) have a significant effect on innovation adoption (IA). Based on the test results, the value of $\beta = 0.480$, $t = 5.486$, and $p < 0.001$, thus H_0 is accepted.*
- *H3: Technology readiness (TR) has a significant effect on innovation adoption (IA). Based on the test results, the value of $\beta = 0.414$, $t = 5.589$, and $p < 0.001$, thus H_0 is accepted*
- *H4: Innovation adoption (IA) has a significant effect on competitive advantage (CA). Based on the test results, the value of $\beta = 0.666$, $t = 10.541$, and $p < 0.001$, thus H_0 is accepted.*

N. Mediation Analysis

According to Hair [65], mediation occurs when the mediator variable part of the relationship between the independent and dependent variables. In mediation, the mediator variable not only affects the dependent variable directly but also affects the dependent variable indirectly through the independent variable. The results of the mediation analysis in this study can be seen in Table 10.

Table 10 Mediation Analysis

	Original Sample (O)	T	P
CC → AI → CA	0.320	5.164	0.000
TR → AI → CA	0.276	4.512	0.000
CC → TR → AI → CA	0.200	3.934	0.000

V. DISCUSSION

- *H1:*

The results of the effect of company characteristics (CC) on technology readiness (TR) show a significant relationship. The results of this study are consistent with previous findings showing that company characteristics have a positive influence on technology readiness [66]–[70] [43], [44]. Factors such as a company's size, structure, resources, expertise, partnerships, communications, and strategic focus can affect a company's ability to effectively adopt and use new technologies. Companies that are committed to innovation, have a culture of experimentation and learning, and are agile and adaptable tend to be more technologically ready [43]. Understanding the relationship between business characteristics and technology readiness can help companies position themselves for success in today's rapidly changing technology landscape [44].

- *H2:*

Company characteristics (CC) have a significant effect on innovation adoption (IA). The results of this study are consistent with previous findings showing that company characteristics have a positive influence on innovation adoption [38], [39], [42], [71]–[77]. An organization needs to identify and measure the characteristics that influence the adoption of innovations so that success factors in implementing innovations will be found [78].

- *H3:*

Technology readiness (TR) has a significant effect on innovation adoption (IA).. This is in line with several other studies which show that technology readiness has a positive effect on the adoption of innovation [16], [27], [79]–[82]. Technology readiness (TR) refers to people's propensity to embrace and use new technologies to accomplish goals in home life and at work [18]. Technology readiness plays a crucial role in innovation adoption, and understanding this concept can help organizations facilitate the successful implementation of new technologies.

- *H4:*

Innovation adoption (IA) has a significant effect on competitive advantage (CA). The results of this study are consistent with previous findings showing that innovation adoption has a positive influence on competitive advantage [25], [56], [58], [83]. The adoption of managerial innovation is also considered a type of non-technological innovation that can affect an organization's performance and competitiveness [84], [85]. Managerial innovation involves the adoption of management, organizational, and operational methods that are new to an organization [86]. Overall, adopting innovations can help organizations for a competitive advantage by improving their performance and efficiency.

VI. CONCLUSION

Research has demonstrated that firm characteristics and technology readiness have a significant relationship to competitive advantage mediated by innovation adoption. A significant relationship also exists between firm characteristics on innovation adoption and technology readiness. And finally, the direct relationship of innovation adoption also has a high significance on competitive advantage.

RECOMMENDATION

Future research could include variables such as marketing strategy, risk management, and supplier relationships. In addition, the researchers could consider using different research methods such as qualitative research or a combined approach to provide more holistic and in-depth insights.

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