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Analysis of Factors affecting the Digital Maturity of Manufacturing Industries: Evidence from the Metal Sector in Ethiopia

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Abstract

Given that there are many maturity models proposed, there is a limited focus on explaining the link between digital maturity model dimensions and their impact on digital maturity level. Thus, the purpose of this paper is to examine the relationship between digital maturity model dimensions and their impact on digital maturity levels. 270 sample data were collected from metal industries in Addis Ababa. Results were analyzed using structural equation modeling. The paper analyzed the role of basic enablers in the digital maturity of metal industries through the mediation of organizational adaptability. It is found that “people and expertise” has a critical role in digital maturity. As it has a strong coorelation (0.077**) for digital operation and (0.165***) for digital product. The industries need to utiliz digital technologies to become digitally matured having a strong coorelation (0.433***). Moreover , they have to focus on their employee competency to positively influence their digital maturity level. The study in its uniqueness, hypothesize and test the relationshi]p between digital maturity model dimensions and their impact on the digital maturity level.

Keywords: Digital Maturity, Industry 4.0, Maturity model, Metal industry, Manufacturing

1. Introduction

The ongoing revolution in the industry, commonly referred to as Industry 4.0, is reshaping the landscape of manufacturing and its economic ecosystem. Thus, a comprehensive available approaches toward digital transformation in manufacturing industries has become increasingly demanded (Steinlechner et al., 2021). “Digital maturity is the measure of the digital transformation level of companies” (Hie, 2019). Digital maturity assessment helps the industry to understand the extent of its transformation to digitalization and to put a step forward plan toward digitalization (Lassnig et al., 2018).

The metal sector in Africa is expected to play a crucial role in the continent's economic development and industrialization as there is an unutilized abundant metal resource. Ethiopia, as one of the developing countries in Africa, has also identified the metal manufacturing sector as one of the core areas to support the national economy. In the country, there are metal industries engaged in different sub-sectors, including mining, steel production, metal fabrication, and manufacturing. The sector highly demands emerging digital technologies like big data, industrial Internet of things, networks, and integrated systems enhancing connectivity and integration (both vertical and horizontal) as well as creating new channels of interaction (Buer et al., 2021). These technologies significantly impact the overall operation including; quality control, process optimization, predictive maintenance, product innovation, etc. However, as compared to industries found in the developed world, the metal industries in Ethiopia are positioned in the infant stage towards adopting digital technologies.

Thus, there is still a need for research regarding digital maturity and maturity models to thrive in accelerated digital technology adoption for the Ethiopian metal industries.

In this regard, researchers such as Schumacher et al., (2016); VanBoskirk, (2016); Rossmann, (2018); Hie, (2019); Hizam-hanafiah et al, (2020); Gökşen and Gökşen, (2021); Steinlechner et al., (2021); Santos and Martinho, (2020); Kammerlohr et al., (2022) Rajnai and Kocsis, (2018); Rossmann, (2018); Hizam-hanafiah et al., (2020) contributed with studying and developing the digital maturity models. However, some researchers, for instance, Gökşen and Gökşen, (2021) have mentioned the scares of studies on the relationship between factors affecting the digital maturity of manufacturing industries. Only one paper by Kiraz et al. (2020) has been found that dealt with analyzing the factors affecting the industry 4.0 tendency with a structural equation model. But, the factors identified in the mentioned paper do not have a strict connection with digital maturity model dimensions. To the best of the author's knowledge, so far, there is no research paper conducted on the casual analysis of the digital maturity model dimensions and their impact on the digital maturity level. That conceptual link tends to be silent in the existing research. The relationship between factors (direct and mediating) affecting digital maturity and their impact on the level of digital maturity has to be thoroughly examined. Thus, the aim of this research is; (1) to identify the most common factors that influence the digital maturity of the manufacturing industries, (2) to establish a hypothesized model and, (3) to test the model using the structural equation modeling technique.

The remaining sections are organized as follows. In section 2, the theoretical background and research hypotheses are discussed. Section 3 presents the material and method, giving highlights about the sample size and instruments used. In Section 4, the findings of the data analysis are presented, which were obtained by testing the conceptual model using structural equation modeling (SEM). Section 5 concludes the study by discussing the significance of these findings in relation to digital maturity model research and their implications for industries, while also suggesting potential directions for future research.

2. Theoretical Background and Research Hypothesis

2.1 Digital Maturity

Like other sectors, the fourth industrial revolution (industry 4.0) brings a potential benefit for manufacturing as well (Hermann et al*,* 2020). However, for successful entry into Industry 4.0, manufacturing industries need to define a specific digital transformation strategy and evaluate the digital maturity level (Machado et al., 2021; Morteza Ghobakhloo, 2018; Rachinger et al., 2019). In this regard, Pirola et al., (2020) briefly discussed the three-stage digital transformation process. First, creating a plan second, strength and weakness analysis to deploy the digital transformation strategy, and third, changing strategies into action. Thus, it is observed that the second stage requires an examination of the company's current digital maturity to outline future steps fittingly. To achieve this, maturity models are the most crucial tools.

Kırmızı and Kocaoglu, (2022) define maturity as "the state of being at the desired level". They describe digital maturity as "the desired level of the application of digital technologies and techniques on organizational and economic conditions". To reach the desired level of maturity, a progressive evolution in achieving a target, from an initial to the desired end stage, is required (Pirola et al*,* 2020*)*. Therefore, maturity models greatly help in the evaluation of a company's position and answer questions, about what needs to be measured and how to assign a level of maturity (Gökşen and Gökşen, 2021; Demeter et al., 2021). In this regard, the maturity model has an incremental level that includes different hierarchical maturity levels aiming to measure the ongoing progress through the maturation process. Maturity levels are defined as "the increase in the capabilities of digital technologies and can be evaluated either qualitatively or quantitatively" (Kırmızı & Kocaoglu, 2022). In the next subsection, some of the existing digital maturity models that have emerged in recent years are reviewed.

2.2 Digital Maturity Models

Maturity models provide a comprehensive framework used to evaluate a company's status from different maturity model dimensions and help to plan a development roadmap. Some scholars contributed to proposing a new digital maturity model and advancing the existing ones. For a review of recent developments in digital maturity models the readers are referred to Gökşen & Gökşen, (2021); Hizam-hanafiah et al., (2020); Kiraz et al., (2020); Rajnai & Kocsis, (2018); Rossmann, (2018); Schumacher et al., (2016); Şener et al., (2018); Steinlechner et al., (2021), Kammerlohr et al*.,* (2022)*;* Machado et al., (2021); Pirola et al., (2020); Santos & Martinho, (2020); Kırmızı and Kocaoglu, (2022). There is a considerable amount of ongoing research on the development and application of digital maturity models. In this particular literature review, the authors aggregated the review papers on maturity models conducted so far. This review has contributed by providing a recent and comprehensive view of the industry 4.0/digital maturity models collected from different review papers devoted to discussing the commonly incorporated model dimensions. See Table 1

Table 1: Summary of the digital maturity models review papers

S.n	Source	# of MM reviewed	Gaps identified	Review outcome	Model dimensions	Maturity levels
1	(Sener 2018)	7	Scarce of MMs for the manufacturing industry	Propose new model	Asset management, data governance, application management, process transformation, organizational alignment	6 levels of digital capability
2	(Rajnai and Kocsis, 2018)	2		-		
3	(Pirola et al., 2020)	13	Lack of focus on SMEs and models' rigidity	Propose new model	Strategy, people, process, technology integration	5 levels maturity
4	(Hizam-hanafiah et al., 2020)	30		-		
5	(Santos and Martinho, 2020)	3	Integrate the 3 models to maintain the natural process of continuous improvement over time	Propose new model	Organizational strategy, structure, and culture, workforce, smart factories, smart processes, smart products, and services	5 levels of maturity
6	(Steinlechner et al., 2021)	11	Less investigation of employee competency in the existing models	Propose new model	Digital content, human-machine, human-human, personal	4 levels of digital competency of the employee
7	(Gökşen and Gökşen, 2021)	10		-		
8	(Kırmızı and Kocaoglu, 2022)	21	Lack of maturity model development framework	Propose new model	Synergy and governance, organization and corporate culture, Smartness, employee, process, customer	5 levels; Awareness, pilot, engagement, integration, optimization

The major concern of the eight review papers presented in Table One is to identify the existing digital maturity models and extract the common maturity model dimensions.). Five out of eight papers proposed a new maturity model (briefly discussed in the next subsection). Among the papers, Hizam-hanafiah et al., (2020) have presented the highest number of models and dimensions (30 models and 158 dimensions). The review of reviewed models suggests that each model is different with diverse model dimensions. In terms of the number of dimensions, some models are broad having many dimensions and others are narrow with a few dimensions.

2.3 The Five Models Overview

Sener et al., (2018) have proposed a new maturity model known as the Industry 4.0 maturity model after reviewing seven existing maturity models systematically. The gap that initiates the authors to propose a new model is the scarcity of maturity models for the manufacturing industry. The model consists of 5 dimensions (see Table one) and 6 maturity levels of each dimension.

Pirola et al., (2020) have proposed another maturity model known as the Digital Readiness Level 4.0 Model. They developed the model to overcome the two major limitations commonly found in the existing models. Which are lack of focus on SMEs and models' rigidity. Strategy, people, process, and technology integration are the model dimensions considered. In addition, five digital maturity assessment levels are considered for the model. They are, not involved in Industry 4.0 pilot initiatives, including Industry 4.0 into its strategic orientation, formulated an Industry 4.0 strategy and investing to promote, already implementing an Industry 4.0 strategy, and already implemented its Industry 4.0 strategy and continuously monitoring.

Santos and Martinho, (2020) have proposed another maturity model based on the gap in the existing models. The model consists of two additional components which are transformation capabilities and the measurement instrument in addition to model dimensions and maturity levels. In contrast to other models that solely concentrate on assessing maturity, the model proposed by these authors not only identifies the present level of maturity but also uncovers the underlying reasons for failing to achieve the desired maturity. Furthermore, it effectively monitors the progress of actions aimed at improving both technical and managerial capabilities. In that way, a continuous improvement of the industry 4.0/digital maturity can be sustained.

Steinlechner et al., (2021) have presented a maturity model known as a digital competence maturity model (DigiCoM). The model they proposed consists of four dimensions (as indicated in Table One) and focused on digital maturity assessment at the individual employee level. The gap they identified from the reviewed models is ignorance or less investigation of employee competency in digitalized working conditions.

Lastly, Kırmızı and Kocaoglu, (2022) suggest a novel maturity model development framework based on design science and develop a digital maturity model by following the proposed framework. In this particular paper, the concept of descriptive and prescriptive types of maturity models is also highlighted. It is thus emphasized that the descriptive types of maturity models (measures the current state of maturity or serve as a diagnostic tool) need to advance to the prescriptive type of maturity model (able to provide improvement measures). There is a bit related concept to the model by Santos and Martinho, (2020) which integrates the elements of identifying the causes of non-attainment of the desired maturity and continuous monitoring. However, this issue needs further research.

Besides the above discussion, the major intent of this literature review is to identify the potential/commonly implemented digital maturity model dimensions. In this regard, from the review of reviewed papers, it is clearly understood that Technology, Digital operation, Digital product, Management commitment, People and expertise, and Culture are the most commonly incorporated digital maturity model dimensions. Detailed explanations of the digital maturity model dimensions are not presented here because of space constraints. However interested readers can refer to the eight summarized review papers.

Schumacher et al., (2016) categorize the dimensions of the digital maturity model as basic enablers and organizational adaptability. In this research, constructs considered basic enablers are Technology, digital product, and digital operation. Based on Gökşen & Gökşen, (2021); Hizam-hanafiah et al., (2020); Santos & Martinho, (2020) finding, technology is the dimension that needs to be emphasized more comprehensively in digital maturity models. The systematic review by Hizam-hanafiah et al., (2020) illustrate that out of the total 158 unique dimensions of Industry 4.0, 70 (44%) are specifically related to the evaluation of technology. This is attributed to the fact that Industry 4.0 and digitalization are built upon nine fundamental technological pillars, namely Big Data, Industrial Internet, Horizontal and Vertical Integration, Simulation, Augmented Reality, Additive Manufacturing, Cyber Security, and Advanced Manufacturing. (Klingenberg et al., 2021). Thus, technology in Industry 4.0 could go to one or many of the above-mentioned nine pillars. According to many of the scholar's arguments, digital product and digital operation are also basic enablers as they directly affect the digital maturity of industries. This establishes the conclusion that organizations need to largely improve their technology, digital product, and digital operation to strengthen their digital maturity.

Management commitment, people and expertise, and culture on the other hand are considered as organizational adaptability. Though they are commonly mentioned digital maturity model dimensions from the reviewed maturity models, it is believed that they have an indirect impact on the digital maturity of an organization. In other words, improvement of the organizational culture for digitalization may not directly enhance digital maturity. Rather, it may impact one of the basic enabler dimensions so that the digital maturity level of the company could be affected. People and expertise are another major digital maturity model dimension (Rossmann, 2018; Flores et al, 2020). Similarly, it has an indirect impact on digital maturity and the same goes for management commitment. Accordingly, the authors of this research deliberately structured these three dimensions as mediating factors. It is to mean that they have a mediating role between basic enablers and digital maturity.

2.4 Research Gap

From section 2.3, one can understand how the study on maturity models is getting evolved. The authors of this paper appreciated the devotion of scholars who are introducing new maturity models by identifying and adding new model dimensions, and incorporating untouched issues into the models (refer to Table one). From the literature review, it can be concluded that the digital maturity model research is following the trend; investigating the existing models, adding/reducing contributing factors, and measuring or asses the digital maturity level of industries. Indeed it is a great contribution to the acceleration of the entry of industries into the fourth industrial revolution. However, identifying the relationship of each dimension greatly helps the industries to easily deploy the digital strategy and implementation. Only one paper by Kiraz et al., (2020) has been found that dealt with analyzing the factors affecting the industry 4.0 tendency with a structural equation model. However, the factors identified in the mentioned paper do not have a strict connection with digital maturity model dimensions. In consideration of this, more research effort is expected in the analysis of the relationship between the digital maturity model dimensions/constructs and their impact on the digital maturity level which it is not yet been studied thoroughly.

2.5 Conceptual Framework

The causal relationships between digital maturity levels represented by six different levels and the six maturity model dimensions (presented above) are constructed. The six digital maturity levels are given by Rajnai & Kocsis, (2018) which are directly used in this research. Both the direct and indirect effect of the dimensions/latent constructs is considered. A direct effect signifies the impact of an independent variable (exogenous) directly on a dependent variable (endogenous), while an indirect effect signifies the influence of an independent variable on a dependent variable through the mediation of an intermediate variable. (Berhan, 2020). Figure 1 shows the conceptual framework developed.

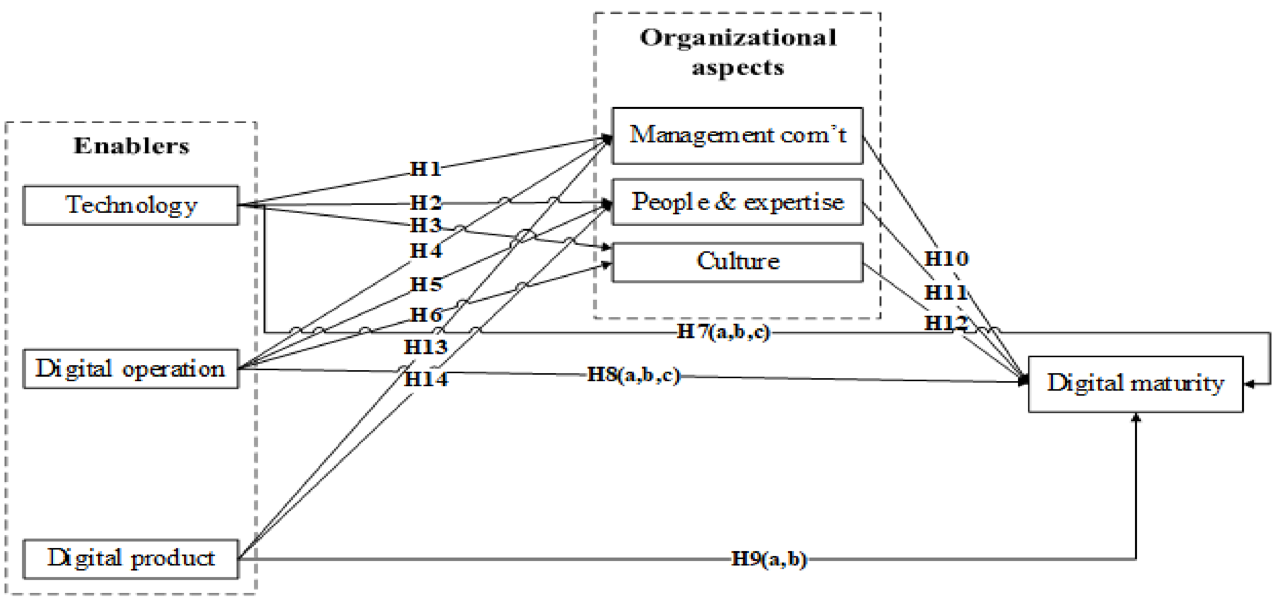

Figure 1 Caption: Digital maturity hypothesized causal model
Source: (Authors)

2.6 Research Hypothesis

The model assumes that digital maturity can directly be affected by the basic enablers and indirectly or through a mediating effect of organizational adaptability. Based on the above assumptions and the model the following hypothesis is formulated.

1. The basic enablers (Technology, Digital product, and Digital operation) have a positive impact on the digital maturity level of the industry.

2. Organizational adaptability regarding digital maturity (Management commitment, People and Expertise, and Culture) have a positive impact on the basic enablers for digital maturity (Technology, Digital product, and Digital operation).

3. The basic enablers for digital maturity (Technology, Digital product, and Digital operation) have a positive impact on digital maturity through organizational adaptability (Management commitment, Culture, People, and expertise).

3. Materials and Methods

3.1 Sample Size

In this paper, Metal industries in Ethiopia were considered for data collection. A total of 270 representative samples were collected. As the nature of the respondents is the critical aspect for the reliability of the responses, some descriptive statistics have been taken. The larger group of work experience of the respondent were above six years (48.6 percent) and between 2-6 years (44.7 percent), below two years (6.3 percent). Their level of education was 49 percent with a BSc. /BA, 44.2 percent MSc. /MA and college diploma (4.3 percent). Many of the respondents working positions were, team leaders (44.2 percent), general managers (2.9 percent), directors (26.9 percent), it managers (7.2 percent), and other positions (18.8 percent). Thus, it is believed that they can understand the term digitalization and properly represent their company.

3.2 Sample Size Determination

In the city of Addis Ababa (the capital of Ethiopia), there are a total of around 297 metal industries. which are engaged in different sub-sectors including; vehicle assembly, spare parts manufacturing, metal fabrication, machinery, household utensils, electronics, wire and nails, corrugated sheet, hollow section, and aluminum profile. Considering a 95% confidence interval, an optimal sample of 168 industries has been considered for data collection.

3.3 The Instrument

A close-ended questionnaire was designed to collect primary data related to factors affecting digital maturity (see the Appendix for the original questionnaire). As the model is reflective, all the questions are positive (e.g. strongly agree is supposed for positive agreement). The questionnaire contains the most frequently used digital maturity measuring factors or model dimensions from the literature. The measuring items/questions are also directly taken from Rossmann, (2018). However, some of the questions were modified by improving only the clarity of the questions (the way that particular item was asked). The questionnaire was filled out by directors, team leaders, IT managers, and other experts in the company. At last, the result of the reliability analysis showed a Cronbach's alpha value greater than 0.76 and above, which is above the acceptable cut-off point. The data collection was conducted in the time frame of October 2021 to January 2022 via email and physical.

4. Results

4.2 Construct validity and reliability

To evaluate the reliability and validity of the constructs and scales utilized, confirmatory factor analysis was conducted. To accomplish this, a measurement model was developed, comprising seven latent factors and 34 measurement items. Three items were excluded from the analysis, one from digital maturity and two from management commitment, as they exhibited low factor loadings. The outcome of this is presented in Table 2

Constructs and measurement items	FL	Alpha	CR	AVE	Mean	SD	P-value	TLI	CFI	RMSEA
1. Management Commitment		0.844	0.870	0.584	2.7837	0.78434	2.027(0.155)	0.981	0.998	0.070
The company uses a road map for the planning of digital activities.	0.722									
The company adopts new business models driven by digitalization.	0.847									
The management introduces/promotes digitalization.	0.427									
Management empowers active employees with digital technologies.	0.933									
There is management competence and central coordination for digitalization.	0.795									
2. Digital Operation		0.856	0.848	0.594	3.7163	0.87024	2.047(0.152)	0.986	0.998	0.071
In the company, processes are decentralized.	0.523									
Our company implements modeling and simulation for the production process.	0.717									
In the company, the working process is interdisciplinary.	0.996									
In the company, there is an interdepartmental collaboration.	0.772									
3. Culture		0.787	0.813	0.474	3.9288	0.69528	3.568(0.168)	0.976	0.995	0.062
Internet/ICT has a significant value in a company.	0.535									
Our company has a strong approach to knowledge sharing.	0.853									
Our company has a good approach to open innovation and cross-company collaboration.	0.788									
Continuous change is part of our corporate culture.	0.540									
Decisions within our firm are transparent to our employees.	0.665									
4. Digital Product		0.821	0.843	0.584	2.9591	0.83775	4.916(0.086)	0.976	0.992	0.084
Products are Individualized/customized using customer data.	0.472									
Products are commercialized through digital technologies.	0.772									
Digital products of our company create a significant impact on customer experience.	0.839									
There is a direct added value created by the progressive digitization of products of our company (e.g., cost reductions, increased productivity, better customer experience, customer differentiation)	0.901									
5. People and Expertise		0.816	0.837	0.524	2.7731	0.79299	2.897(0.089)	0.966	0.997	0.096
In the company, ICT competencies and openness to new technologies of employees are in good condition.	0.411									
Within our firm, there are sufficient experts on digital core issues.	0.642									
Within our firm, further education opportunities for digital core topics are available.	0.818									
Within our firm, comprehensive measures to strengthen digital literacy development are implemented	0.968									
Within our firm, new job profiles have been created for employees with expertise in digital core topics	0.658									
6. Technology		0.76	0.843	0.491	3.2260	0.63572	9.026(0.060)	0.963	0.990	0.078
There is an existence of ICT infrastructure in the company.	0.742									
Digital platforms are used for day-to-day collaboration.	0.887									
Our firm uses large amounts of data to optimize strategies, processes and products.	0.825									
Within our firm, we use tools for digital modeling, automation and control of business processes.	0.574									
Our firm has implemented enterprise-wide digital workplace concepts	0.310									
There is utilization of machine-to-machine communication	0.708									
7. Digital maturity		0.824	0.855	0.559	2.3846	0.92279	4.433(0.351)	0.999	0.999	0.023
The company's systems are connected in to a manufacturing execution system (MES).	0.512									
Events are seen by sensors	0.464									
The company's all relevant data is available and analyzed.	0.779									
Future scenarios are simulated and events are predicted.	0.949									
Decisions are based on predictive analysis supported by IT systems.	0.900									

Model fit was evaluated using $\chi2/df=2.77$ ($p\leq0.001$), Tucker–Lewis index (TLI) =0.95, comparative fit index (CFI) =0.96, and root mean square error of approximation (RMSEA) =0.06, mean and standard deviation (Berhan, 2020; Cangur & Ercan, 2015). The model estimated shows a good fit with the data, as most of the fit indices indicated above fall within the acceptable cut-off limits (Boateng, 2019). The standardized factor loadings of all the measurement items for each construct are also detailed in Table 2. Most of the factor loading in the table is greater than 0.5 (except 5 items), satisfying the requirements for acceptability (Bagozzi & Yi, 2012; Hair Jr. et al., 2014).

The composite reliabilities (CR) of the seven constructs were computed to assess their reliability. The CR values ranged from 0.813 to 0.870, surpassing the recommended criterion of 0.6 and above. (Bagozzi & Yi, 2012). To test the inter-item reliability, Cronbach's α values were considered all of which exceeded the suggested criteria of 0.70, as presented in Table 2. To evaluate the construct validity, the convergent and discriminant validities were each examined.

For the discriminant validity, both Fornell and Larcker criterion and Hetrotrait, Monotrait (HTMT) ratio are used (Henseler et al., 2015). In terms of convergent validity, the average variance extracted (AVE) for each construct was assessed. Out of the seven constructs, five were found to have AVE values above 0.5 (Table 2), indicating satisfactory convergent validity. (Bagozzi & Yi, 2012). To evaluate discriminant validity using the Fornell and Larcker criterion, the AVE values for each construct were compared with the squared individual inter-construct correlations, as depicted in Table 3. (Ab Hamid et al., 2017).

Table 3: Correlational matrix of each construct

	Correlations					
	MC	**DO**	**CL**	**DP**	**PE**	**TG**
MC						
DO	.553**					
CL	.445**	.820**				
DP	.303**	.565**	.639**			
PE	.557**	.532**	.591**	.631**		
TG	.406**	.747**	.821**	.707**	.575**	
DM	.436**	.513**	.522**	.666**	.722**	.652**
(Note):. Correlation is significant at the 0.01 level (2-tailed).**						

It indicates that most of the AVE values were greater than the square of each inter-construct correlation except two, culture with the digital operation (0.92) and culture with technology (0.81) and thereby; satisfying the criteria for discriminant validity.

Table 4: Discriminant validity using Fornell and Larcker Criterion

	AVE	DM	MC	DP	TG	PE	CL	DO
DM	0.559	**0.747663**						
MC	0.584	0.421	**0.764199**					
DP	0.584	0.441	0.266	**0.764199**				
TG	0.491	0.37	0.245	0.677	**0.700714**			
PE	0.524	0.686	0.647	0.603	0.39	**0.723878**		
CL	0.474	0.313	0.434	0.648	0.81	0.537	**0.688477**	
DO	0.594	0.351	0.585	0.614	0.63	0.548	0.92	**0.770714**

Table 5: Discriminant validity using HTMT Ratio

	DP	TG	PE	DO	CL	MC	DM
DP							
TG	0.715023						
PE	0.627405	0.422862					
DO	0.61741	0.660187	0.566383				
CL	0.61741	0.883047	0.576487	0.954356			
MC	0.278521	0.268214	0.696857	0.608449	0.46962		
DM	0.423618	0.370518	0.677324	0.342472	0.310148	0.418287	

Using Heterotrait-monotrait (HTMT) ratio, HTMT values close to 1 indicate a lack of discriminant validity with a suggested threshold of 0.9 (Ab Hamid et al., 2017). The result of this study indicates all (except one, Digital operation and culture having 0.95) the values are below the threshold (0.9) as shown in Tables 4 and 5. Thus the discriminant validity is satisfied.

4.3 The direct role of the basic enablers and organizational adaptability on digital maturity

Structural equation modeling (SEM) was employed to examine the hypothesized causal relationships between the predictor and outcome variables within the research framework. Separate structural models were estimated using Amos 23 to assess both the direct and mediating relationships. The estimates for the direct relationships are provided in Table 6 and are visually depicted in both the conceptual model and structural model.

These capture the findings of the tests for H1 to H14. Among all, seven of the hypotheses were supported (H4, H14, H12, H6, H7, H9, H11). This outcome substantiates the work of scholars such as Rossmann, (2018); Şener et al., (2018); Hizam-hanafiah, Soomro and Abdullah, (2020); Kiraz et al., (2020); Gökşen and Gökşen, (2021); Machado et al., (2021). Digital operation was found to have a significant positive effect on management commitment (β=0.456, p=0.001). Digital product on people and expertise and digital maturity (β=0.414, p=0.001) and (β=0.233, p=0.001) respectively. Technology and digital operation were found to have a significant positive influence on culture (β=0.471, p=0.001) and (β=0.469, p=0.001) respectively. Technology, digital product and people and expertise have a significant positive effect on digital maturity (β=0.433, p=0.001), (β=0.233, p=0.001) and (β=0.390, p=0.001) respectively. The negative effect of digital operation on digital maturity (β=-0.004, p=0.954) becomes a surprise; given that digital operation has been found and is expected to contribute positively to enhancing digital maturity Schumacher et al., (2016); Rossmann, (2018); Hizam-hanafiah et al., (2020); Soomro and Abdullah (2020); Gökşen and Gökşen, (2021). Similar to digital operation, culture is found to have a negative relationship with digital maturity (β=-0.122, p=0.166) which is far from the previous findings by Schumacher et al., (2016) and the researcher's hypothesis. The rest of the five relationships were found to be insignificant as seen in Table 6. In general, the model shows a good fit, with $\chi 2/df=1.627$, IFI=0.999, TLI=0.989, CFI=0.999, and RMSEA=0.055 according to Cangur and Ercan, (2015).

Table 6: Direct path analysis

Path description	Hypothesis	Standardized estimate	Results
PeopleExpertise <---DigitalOpration	H5	0.199(0.011)	Not supported
ManagmentComt <--- Technology	H1	0.213(0.020)	Not supported
ManagmentComt <--- DigitalOpration	H4	0.456(***)	**Supported**
ManagmentComt <--- DigitalProduct	H13	0.049(0.507)	Not supported
PeopleExpertise <--- DigitalProduct	H14	0.414(***)	**Supported**
PeopleExpertise <--- Technology	H2	0.135(0.138)	Not supported
Culture <--- Technology	H12	0.471(***)	**Supported**
Culture <--- DigitalOpration	H6	0.469(***)	**Supported**
DigitalMaturity <--- Technology	H7	0.433(***)	**Supported**
DigitalMaturity <--- DigitalOpration	H8	-0.004(0.954)	Not supported
DigitalMaturity <--- ManagmentComt	H10	0.041(0.447)	Not supported
DigitalMaturity <--- Culture	H12	-0.122(0.116)	Not supported
DigitalMaturity <--- DigitalProduct	H9	0.233(***)	**Supported**
DigitalMaturity <--- PeopleExpertise	H11	0.390(***)	**Supported**

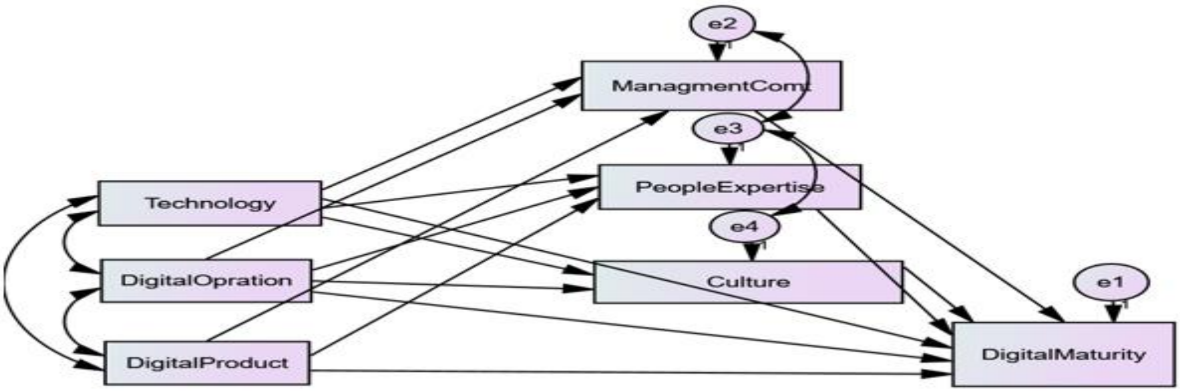

Figure 2 Caption: Structural model
Source: (Authors)

4.4 The mediating role of organizational adaptability on digital maturity

Following the above analysis, a mediation analysis was performed using a bootstrap sample of 2,000. The results in the table indicate that technology has a direct impact on digital maturity. However, through the mediation, (the three mediators failed to have a significant indirect effect); thereby demonstrating that management commitment, people and expertise and culture cannot mediate the relationship between technology and digital maturity; thereby failing to provide support for H7(a,b,c). the result of this research contrasts with what VanBoskirk, (2016) and Rajnai and Kocsis, (2018) proposed. Digital operation has a negative relationship with digital maturity (of their direct relationship) but, through the mediation of people and expertise, it has a significant relationship. Thus people and expertise (excluding the rest two mediators, culture and management commitment) fully mediate the relationship between digital operation and digital maturity Thus, providing support for H8b. Additionally, the direct path from digital product to digital maturity, and the indirect path through people and expertise are both significant. This signifies that people and expertise partially mediate the relationship between digital product and digital maturity, as predicted in H9b. These findings are consistent with the previous research (Kiraz et al., 2020). However, taking management commitment as a mediating factor, the relationship is insignificant implying that has no indirect effect on the relationship between digital product and digital maturity. Table 7 highlights the outcome of this analysis, indicating the presence of all partial and full mediation relationships and no mediation.

Table 7: Mediation Analysis

Relationship	Hypothesis	Direct effect	Indirect effect	Mediation type
Technology – ManagementComt-DigitalMaturity	H7a	0.433***	0.012	No mediation
Technology – PeopleExpertise – DigitalMaturity	H7b		0.071	No mediation
Technology – Culture – DigitalMaturity	H7c		-0.077	No mediation
DigitalOperation – ManagementComt – DigitalMaturity	H8a	-0.004(0.954)	0.018	No mediation
DigitalOperation – PeopleExpertise – DigitalMaturity	H8b		0.077**	**Full mediation**
DigitalOperation – Cultuer – DigitalMaturity	H8c		-0.056	No mediation
DigitalProduct – ManagmentComt – DigitalMaturity	H9a	0.233***	0.002	No mediation
DigitalProduct – PeopleExpertise – DigitalMaturity	H9b		0.165***	**Partial mediation**

5. Discussion and Conclusion

5.1 Discussion

The objective of this study was to investigate the impact of basic enablers.; digital technologies, digital operation and digital product on digital maturity level; and how these relationships are mediated by organizational adaptability; management commitment, people and expertise and organizational culture within metal industries in Ethiopia. The results of the data analysis largely validate the hypothesized relationships outlined in the conceptual model presented in Figure 1, as evidenced by the findings reported in Tables 6 and 7. Specifically, by applying the digital maturity model proposed by previous researchers Schumacher et al, (2016); Rajnai and Kocsis, (2018); Rossmann, (2018); Şener, Gökalp and Eren, (2018); Hizam-hanafiah et al, (2020); Kiraz et al., (2020); Gökşen and Gökşen, (2021); Steinlechner et al, (2021); Lassetnig et al., (2018); Pirola, et al., (2020); Santos and Martinho, (2020). Unlike, most of the maturity models reviewed gave more emphasis on "technology" as a basic factor for digital maturity, this study suggests that irrespective of the basic enablers (technology, digital product and digital operation), people and expertise (employee competency) must always be considered for metal industries to enhance the level of digital maturity. Llopis-albert et al., (2020); Bretz et al., (2022); Mazurchenko and Zelenka, (2022) also emphasize that enhancing the digital competency of people and expertise plays a major role in the digital maturity of the metal industries. The authors of this research also argued that these industries will not be immune to digital disruptions unless working on creating a digitally ready employee and changing the mindset towards the new way of doing jobs. Remarking that people and expertise is the major digital maturity model dimension parallel to technology. On the other hand, the significant influence of digital operation on digital maturity was expected, given that previous research asserts the positive effects of digital operation measured via the given digital operations like; decentralization of processes, modeling and simulation, interdisciplinary, interdepartmental collaboration on digital maturity Schumacher et al., (2016); Şener et al., (2018); Hizam-hanafiah et al., (2020). Surprisingly, from the finding of this research, digital operation doesn't have a significant effect on the digital maturity of the industries unless mediated by people and expertise. Some scholars argued with the finding of this research (Abdallah et al., 2022). Abdallah et al., (2022) declare that the adoption of digital product and digital operation cannot guarantee the digital maturity of the industry. Therefore, the lack of digital operation affects digital maturity level needs the assertion of researchers who purport that; industries that are engaged in digital operation are digitally matured. Additionally, the relationship between culture and technology, was proven to be insignificant without the mediation of People and expertise (employee competency), once again, the result manifests the great importance of people and expertise digital competency to digital maturity which is in line with the argument by Schumacher et al.,(2021) within the metal industries context. In addition, People and expertise serve to mitigate the negative effects relationship between digital operation and digital maturity. As Strutynska et al., (2019); Irimiás and Mitev, (2020) explained, digital maturity uses the term digitalization as the transition from traditional business activities to working in a digital form and highlights the vital role of human intelligence and expertise in parallel with the operation.

5.2 Conclusions

The findings of this study have given conclusions concerning digital transformation or digitalization in the metal industries. First, metal industries globally are engaged in high competition through the introduction of new digital technologies, to sustain and enhance their competitiveness. Thus, without any doubt, it is important to understand the factors and their relationship in the journey of digitalization to follow the right and useful approach. The impact of maturity model dimensions on the digital maturity level of metal industries was scientifically checked. The organizational adaptability (management commitment, people and expertise and culture) do not have a mediation effect between technology and digital maturity. Technology has a significant direct effect on digital maturity. Digital operation do not have a direct positive impact on digital maturity of metal industries unless it is mediated by People and expertise. From the previous studies, technology was given the leading role in digital maturity. Digital product and digital maturity have a direct positive relationship. People and expertise have a partial mediation effect between digital product and digital operation. In general, people and expertise have a notable impact on the digital maturity of the metal industries. Thus, industries need to cope with the new manufacturing revolution and leverage digital transformation by working exhaustively on their employee's digital competency in parallel with other digital maturity dimensions.

5.3 Future Research Directions

To begin, external environments like digital infrastructure are not considered as a construct. Future research can go with considering both internal and external factors. This study was constrained to the metal industry, which limits the generalizability of the findings. Therefore, future research could focus on examining the applicability of the underlying concept and comparing the results across different industrial sectors such as the leather industry, textile industry, and chemical industry. This would provide a broader understanding of the concept and its implications across various sectors.. Finally, the study focused on a developing economy – Ethiopia. It is a country with a context where comparably internet infrastructure and penetration is just in its infant stage. Thus, many new digital technologies are yet to catch up with industries. Hence, conducting a future study in a country with a higher level of internet penetration or greater utilization of digital technologies could serve as a valuable test for exploring the factors influencing digital maturity and examining the relationships proposed within the conceptual framework.

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