BLOCKCHAIN FOR SUPPLY CHAIN HUMAN RESOURCE TRANSPARENCY

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ABSTRACT

This paper examines the associations among significant constructs by the application of Structural Equation Modeling (SEM) to establish the associations of variables and test the fit of the model in general. The main purposes are the identification of associations that are statistically significant, establishing the intensity of the associations, and verifying whether the suggested model is valid. A total of 100 samples were subjected to EFA and SEM analyses through AMOS with the use of Maximum Likelihood Estimation. Regression weights were high for some variables and not significant for others, thus reflecting the differential influence of the constructs. Variance estimates revealed the spread of data and pointed out where the model needed improvement. The history of minimization indicated gradual improvement over iterations, suggesting a good methodological approach. Model fit indices- CMIN/DF ratios and Chi-square values- indicate that the Default model is more representative of variable relationships, though not perfect. Overall, it is a far better model than the Independence model. The complexity in the interactions between constructs, found in this study, determines the need for modification and improvement of the fit model. This study opens vistas for further research in areas of phenomena under study and provides a basis for a more refined theoretical framework. It thus contributes to a better understanding of relationships among variables through rigorous analysis and targeted objectives, indicating the importance of continually optimizing the model in achieving practical and theoretical advancements.

Keywords: Blockchain Technology, Human Resource Transparency, Supply Chain and HR Challenges.

INTRODUCTION

With a dynamic global supply chain, managing human resources is indeed challenging. Transparencies, securities, and efficiency in management are what are being expected (Mazharunnisa et al., 2024). This can be addressed through blockchain, an emerging revolutionary technology in the field known for decentralized and immutable ledger. With supply chain management, blockchain comes out to offer the possibility to have a transparent, effective, and secure system toward maximizing human resource management (HRM), enabling much greater credibility and practice of more functionable HR practices than usual (Ramachandran et al., 2023).

Supply chain human resource management often entails managing complex networks of employees, contractors, and vendors in different geographical locations (Mann et al., 2018). The most common challenges are verifying credentials, ensuring compliance with labor laws, fraudulent documentation, and payroll systems (Centobelli et al., 2022). These

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challenges are multiplied by the lack of transparency and inefficiencies in traditional HR systems. Blockchain's inherent characteristics include distributed ledger technology, smart contracts, and real-time updates, which present an opportunity to revolutionize this problem (Bai & Sarkis, 2020).

Blockchain technology significantly improves HR transparency through securely storing employee data, verifying their credentials, and ensuring compliance with labor regulations (Benton et al., 2018). It does this through the decentralized record-keeping system of blockchain technology, where data cannot be changed and can only be accessed by the respective stakeholders. For example, the verification of an employee's credentials can be made efficient to reduce the chances of hiring based on fraudulent documents (Sunny et al., 2020). Smart contracts can also be used for automating labor laws and payroll management, making them more efficient and accurate.

Transparency is the bedrock of successful HR practices, especially in supply chains, where trust among stakeholders is the most important. Blockchain creates transparency by allowing for real-time data sharing across stakeholders, so that all stakeholders can access the same verified information. This capability helps build trust and collaboration in the supply chain because organizations can rely on blockchain's integrity to manage workforce-related data. Further, the capability of blockchain to ensure data safety and privacy reduces risks on data breaches and unauthorized accesses (Agarwal et al., 2024).

Despite the potential of blockchain, the adoption in HR is quite challenging. Some of the key challenges are the high implementation costs, lack of technical know-how, resistance to change, and legal and regulatory uncertainty (Adel & Younis, 2023). Therefore, organizations have to consider these challenges in the face of benefits and weigh the possibility of implementing blockchain into their HR systems. Besides, integration of blockchain technology into the existing systems demands proper planning and execution so that it can be done without hassle.

The attitudes of HR professionals as well as organizational leaders are fundamental to the successful adoption of blockchain. A positive perception, coupled with organizational readiness, tends to drive the integration process of blockchain into HR practice. Surveys and studies on blockchain's applicability to HR transparency reveal that, although increasingly aware, the technology itself is still in its embryonic stages of adoption, according to (Mishra & Venkatesan, 2021.

Background of The Study

A global supply chain refers to a complex system with many organizations and people engaged across multiple locations and functions. It requires an effective management of human resources, since HR will impact the productivity, compliance, and trust between the different stakeholders. Yet most HR management systems face various difficulties when trying to validate credentials, protect data, administer compliance to labor laws, and pay employees effectively. These challenges are made worse by the lack of transparency, inefficiency, and the possibility of fraudulent activities in existing systems (Balon et al., 2022).

Originally, blockchain technology was developed as the backbone for cryptocurrencies like Bitcoin, but it has evolved into a versatile tool that has found application in all sorts of industries. Its core features, which include decentralization, immutability, and transparency, make it especially suitable for overcoming the deficiencies of traditional HR systems in supply chains (Chhibber et al., 2024). Using blockchain will allow organizations to securely store and share employee data, instantly verify credentials, and be sure that all labor laws are met locally and internationally. These capabilities positioned

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blockchain as the promising solution for transforming human resource management within supply chains (Tuladhar et al., 2024).

Supply chain HR processes can make things run smoother and improve openness with the use of blockchain. For example, one of the most important components of blockchain is smart contracts. They can automate regular HR work such as paying employees, managing benefits, and performance evaluation. These systems cut down on mistakes and time and money required for the same amount of manual work. Besides, blockchain's immutable ledger ensures all HR-related transactions and data entries are permanent and irreversible, hence providing a credible record for stakeholders (Manda, 2021).

Openness is highly crucial for the sustenance of trust in supply chains, especially with workforces across different people in different places. Blockchain helps openness as it allows authorized users to share data in real time and ensure that all persons are receiving the same correct information. Openness reduces the probability of conflicts, fosters teamwork, and increases the effectiveness of supply chain operations (Morgan et al., 2023).

Some of the adoption challenges of blockchain in supply chain HR include the cost to implement, a lack of technical skill, and a resistance in the organization towards change as well as ambiguous laws. Many organizations are cautious to spend on blockchain because it is considered complicated and requires plenty of resources before implementation. Additionally, integration of blockchain with the current systems has to be done in such a manner to ensure everything goes well with minimal problems (Zhang, 2023).

Despite all these challenges, many researchers and practitioners are interested in how blockchain can improve transparency in HR. It has been proved to solve some of the important problems in HR processes, especially in industries where supply chains are very important (Medhi, 2021). Additionally, the more people learn about what blockchain can do, the more organizations look into using it to create a strong, clear, and effective HR system.

Objectives

1. To analyze the role of blockchain technology in enhancing transparency within supply chain human resource management.
2. To identify the challenges and benefits associated with adopting blockchain for HR processes in supply chain operations.

LITERATURE REVIEW

Gligor et al., 2022 concluded that because of such demands from different stakeholders SCT was the need of times. For addressing the problems about the practices and process by which raw materials come that the source of the items is uncertain in global chains BCT can improve the SCT. Supply chain research began to help improve the understanding of SCT, but many questions were still left unanswered. These included how SCT should be thought about, how companies could support it effectively, and what benefits it offered, especially when BCT was used. These gaps portrayed the need for basic theoretical work on the resources and skills required for developing, using, and gaining value from SCT. This study developed a case study about a project using BCT between a small coffee producer and a new BCT service provider. It exposed how resource structuring was looked at as offering ideas related to the ways in which the processes of structuring, bundling, and leveraging operated in delivering SCT to stakeholders and also concerning value that was built.

(Venkatesh et al., 2020) mentioned that social sustainability is one of the major concerns in global supply chains to ensure that workers are protected against exploitation and provided with a healthy working environment. Despite standards set for social sustainability in supply chains, businesses, including well-reputed companies like Unilever, have been

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known to violate these standards and exploit labor. Consumers want sellers to share information regarding social sustainability, and sellers face problems tracing their worldwide supply chains. Blockchain technology provides a hopeful answer for immediate tracking in the social sustainability of the supply chain. This study built a system that combined blockchain, the internet-of-things, and big data analytics to improve the tracing and monitoring capacity of sellers over supply chain social sustainability. Considering the costs of implementing the system as well as other possible hurdles, the research was concluded.

Li et al., 2021 "*explained that traditional human resource management systems are accompanied by many problems: the quality of hiring staff is uncertain, training versus real performance differs, performances are evaluated unfairly, and so are the payments. The problems have a great effect on the motivation and loyalty of employees, which adversely affects the survival and development of businesses*". Over and above the challenges, the paper proposes to apply blockchain-based technology to HR management. This will make the HR system of the company accurate, efficient, open, and clear. The study was based on a strong linkage between blockchain technology and HRM systems. It creates a blockchain-based HR management system that introduces new means of applying blockchain and useful guidance in building and enhancing HR systems for the future.

Francisco & Swanson, 2018 noted that blockchain technology refers to an open-source, distributed, decentralized database for recording and storing transaction information. Blockchain technology had its initial popularity through a Bitcoin cryptocurrency. Unlike using banks as centralized intermediaries, blockchain allows two-party direct transactions using duplicate and linked ledgers. Due to this decentralized nature, a transaction is more transparent since explicit trust in third parties is not required but rather upon the consensus of the network.

This has immense potential for increasing transparency in supply chains because blockchain technology can bring out the history of products, which often remain concealed. Harmful practices in production, like child labor, and exploitation of resources in unethical manners can be major scandals, leading to financial turmoil. Blockchain is still limited in its acceptance by the academic and managerial circles due to a lack of understanding. To address this, the study uses the Unified Theory of Acceptance and Use of Technology (UTAUT) and the technology innovation adoption concept as a conceptual framework for supply chain traceability. The research culminates in developing a conceptual model and concludes with supply chain implications of blockchain informed by theory and literature review.

The core message of Onik et al., 2018 is the need for Information Technology integration into frameworks of Human Resource Management with specific emphasis for organizations as a means of effectively accepting and implementing Industry 4.0. These systems must facilitate fair, efficient, transparent, and secure systems because this is key to new HR functions in contemporary days. Blockchain is seen, through its nature of keeping accounts digitally in decentralized manners, as a method that shall aid in accomplishing what matters. An extensive review of existing literature was performed to evaluate the present application of information technology in human resource management and to investigate the potential of blockchain technology in improving the effectiveness, cost-efficiency, transparency, and security of human resource systems. This research introduced a Blockchain-based Recruitment Management System (BcRMS) as well as a Blockchain-based Human Resource Management System (BcHRMS) algorithm. The analysis of the case study revealed that the suggested blockchain-based systems provide distinct benefits compared to conventional recruitment approaches. The study also provided future research directions, which will enable further application enhancement of blockchain systems within HRM.

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METHODOLOGY

The methodology describes the systematic approach adopted to explore the role blockchain serves in enhancing transparency of supply chain human resource management. The study used a descriptive research plan and quantitative data collection and analysis to understand the views of HR practitioners.

Research Design

This study applied a descriptive research design to address how blockchain technology enhances human resource management (HRM) transparency in supply chain operations. To reveal some latent dimensions that influence the adoption of blockchain, EFA was incorporated into this study. The descriptive research design will give insight to the current state of blockchain awareness, challenges, benefits, and attitudes, while the use of EFA can identify and group underlying factors contributing to HR transparency improvement.

Population and Sampling

The population targeted are HR professional individuals working with organizations that maintain some form of active supply chains. A particular kind of purposive sampling technique is utilized to target only persons having experience or understanding regarding the processes carried out through HR in their supply chain. The target sample population is 100 respondents and meets conditions set for applying robust factor analysis. This sample size ensures statistical validity but also allows meaningful interpretation of the results derived from the exploratory factor analysis.

Data Collection

The primary data was collected by using a structured questionnaire. The online distribution of this questionnaire was done to make it convenient and accessible to the participants. The questionnaire covered five sections: (1) Awareness of Blockchain technology, (2) Current Challenges in HR in the Supply chain, (3) Potential Benefit of Blockchain for HR's Transparency, (4) Challenges in Blockchain Adoption toward HR, and (5) Attitudes toward Adoption of Blockchain. Each of the sections consisted of statements that were rated on a 5-point Likert scale, ranging from "*1 = Strongly Disagree*" to "*5 = Strongly Agree*." This structured format allowed for the collection of detailed and quantifiable data for later analysis

Data Analysis

AMOS was used in EFA to determine the latent constructs that could explain the observed variables. Prior to the analysis, Bartlett's Test of Sphericity and Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy were done to determine the appropriateness of the data set for factor analysis. The extraction method was Principal Component Analysis (PCA), while Varimax rotation was implemented for easier and meaningful interpretation of the factor structure. Items with loading values less than 0.5 or significant cross-loadings were excluded for validity and reliability purposes. Thereafter, the factors were factor analyzed and interpreted to help in identifying the main blocks of dimensions influencing blockchain adoption by HR for transparency.

Exploratory Factor Analysis

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Maximum Likelihood Estimates

Table 1
REGRESSION WEIGHTS: (GROUP NUMBER 1 - DEFAULT MODEL)

			Estimate	S.E.	C.R.	P	Label
ATBA	<---	ABT	.814	.076	10.701	***	
ATBA	<---	CBAHR	-.008	.030	-.251	.802	
ATBA	<---	CHRCSC	-.695	.780	-.891	.373	
ATBA	<---	PBBHRT	.341	.061	5.568	***	
ATBA1	<---	ATBA	1.000				
ATBA2	<---	ATBA	1.245	.126	9.876	***	
ATBA3	<---	ATBA	1.046	.125	8.345	***	
ATBA4	<---	ATBA	.035	.169	.209	.834	
ATBA5	<---	ATBA	.183	.154	1.191	.234	
ABT5	<---	ABT	1.000				
ABT4	<---	ABT	.344	.121	2.850	.004	
ABT3	<---	ABT	.365	.125	2.915	.004	
ABT2	<---	ABT	.450	.107	4.198	***	
ABT1	<---	ABT	.621	.104	5.991	***	
CHRCSC5	<---	CHRCSC	1.000				
CHRCSC4	<---	CHRCSC	.446	1.046	.427	.669	
CHRCSC3	<---	CHRCSC	11.581	10.805	1.072	.284	
CHRCSC2	<---	CHRCSC	9.949	9.299	1.070	.285	
CHRCSC1	<---	CHRCSC	11.644	10.857	1.073	.283	
PBBHRT5	<---	PBBHRT	1.000				
PBBHRT4	<---	PBBHRT	1.141	.142	8.052	***	
PBBHRT3	<---	PBBHRT	1.433	.146	9.788	***	
PBBHRT2	<---	PBBHRT	.962	.139	6.911	***	
PBBHRT1	<---	PBBHRT	.039	.099	.398	.691	
CBAHR5	<---	CBAHR	1.000				
CBAHR4	<---	CBAHR	.920	.068	13.623	***	
CBAHR3	<---	CBAHR	.820	.053	15.503	***	
CBAHR2	<---	CBAHR	-.304	.092	-3.303	***	
CBAHR1	<---	CBAHR	.256	.091	2.808	.005	

Regression weights indicate different construct relationships. Awareness of Blockchain Technology (ABT) has a very high predictability for Attitudes Toward Blockchain Adoption (ATBA) with a regression weight of 0.814 and p-value < 0.001. That means the more aware HR professionals are about blockchain technology, the higher their chances of developing a positive attitude toward its adoption. The promotion of awareness, therefore, becomes another enabler for the uptake of blockchain in supply chain HR processes (Table 1).

The relationship of ATBA and CBAHR was found not to be significant with the regression weight at -0.008 and the p-value at 0.802. Thus, perceived challenges such as costs of implementing blockchain technology and resistance towards change will not have any direct effects on attitudes regarding blockchain adoption. Similarly, Current HR Challenges in the Supply Chain (CHRCSC) has a non-significant impact on attitudes with a regression weight of -0.695 (p = 0.373). This finding means that although HR challenges exist, they may not directly drive attitudes toward adopting blockchain technology.

However, on the other hand, Potential Benefits of Blockchain for HR Transparency has highly positive effects on the attitudes to adoption with a regression weight of 0.341 and a p-value < 0.001. It means that the views of those HR professionals will be favorable who are convinced that blockchain brings the advantages of data accuracy, reducing fraud, etc. Hence, effective communication of such benefits of blockchain with stakeholders will help in its adoption.

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Several items exhibit strong and reliable relationships with their constructs in the measurement model. For ATBA, the items ATBA1, ATBA2, and ATBA3 have significant loadings, thus confirming that they are useful in measuring attitudes. However, items ATBA4 and ATBA5 show non-significant loadings, thus suggesting that they may not effectively capture the construct and could require revision.

All the items for ABT load significantly, which therefore substantiates the construct of awareness. For PBBHRT, all indicators PBBHRT2, PBBHRT3 and PBBHRT4 all load significantly to the construct and hence further substantiate. In the case of the construct CHRCSC, all items load non-significatively, which suggests a probable problem in item clarity or representation of the construct.

Table 2
STANDARDIZED REGRESSION WEIGHTS: (GROUP NUMBER 1 - DEFAULT MODEL)

			Estimate
ATBA	<---	ABT	.937
ATBA	<---	CBAHR	-.012
ATBA	<---	CHRCSC	-.077
ATBA	<---	PBBHRT	.340
ATBA1	<---	ATBA	.773
ATBA2	<---	ATBA	.879
ATBA3	<---	ATBA	.770
ATBA4	<---	ATBA	.021
ATBA5	<---	ATBA	.122
ABT5	<---	ABT	.973
ABT4	<---	ABT	.282
ABT3	<---	ABT	.288
ABT2	<---	ABT	.399
ABT1	<---	ABT	.533
CHRCSC5	<---	CHRCSC	.113
CHRCSC4	<---	CHRCSC	.049
CHRCSC3	<---	CHRCSC	.854
CHRCSC2	<---	CHRCSC	.772
CHRCSC1	<---	CHRCSC	.924
PBBHRT5	<---	PBBHRT	.753
PBBHRT4	<---	PBBHRT	.772
PBBHRT3	<---	PBBHRT	.970
PBBHRT2	<---	PBBHRT	.674
PBBHRT1	<---	PBBHRT	.041
CBAHR5	<---	CBAHR	.963
CBAHR4	<---	CBAHR	.857
CBAHR3	<---	CBAHR	.901
CBAHR2	<---	CBAHR	-.324
CBAHR1	<---	CBAHR	.279

The standardized regression weights of the model indicate the strengths of the relationships between constructs and their indicators (Table 2).

ABT is a very strong predictor of ATBA, with a standardized regression weight of 0.937. It indicates that awareness plays a critical role in the formation of positive attitudes toward blockchain adoption. The better the understanding of blockchain, the more positive the HR professional will be toward the adoption of blockchain for transparency and efficiency in HR.

The relationship of CBAHR with ATBA is at -0.012, and thus perceived challenges about technical complexity or legal problems are not found to significantly influence attitudes. Likewise, Current HR Challenges in the Supply Chain have a very poor correlation

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of -0.077 with ATBA. Therefore, the existing problems related to HR do not serve as a good predictor for attitude towards blockchain adoption.

On the other hand, the Potential Benefits of Blockchain for HR Transparency (PBBHRT) has a moderate positive influence on ATBA at 0.340, indicating that the adoption of blockchain must be encouraged through benefits such as accuracy and reduction of fraud. At the measure level, many indicators are robust to their constructs. For instance, in ATBA, ATBA1, ATBA2, and ATBA3 all have high loadings of 0.773, 0.879, and 0.770 respectively, so that all capture the construct adequately. On the other hand, ATBA4 has a very low loading of 0.021 and ATBA5 is at 0.122, suggesting these do not represent attitudes as well and should either be improved or dropped.

ABT has a strong indicator in ABT5 (0.973), whereas the other items reveal relatively weaker contributions, ranging from 0.282 to 0.533. This indicates that ABT5 is a prime indicator for measuring awareness while the other indicators may require reconsideration.

CHRCSC has mixed results. Although CHRCSC1 (0.924) and CHRCSC3 (0.854) are strong indicators, CHRCSC4 (0.049) and CHRCSC5 (0.113) contribute minimally, which may indicate some problem with the clarity of the item or the alignment of the construct.

For PBBHRT, PBBHRT3 (0.970) is the strongest indicator, followed by PBBHRT4 (0.772) and PBBHRT5 (0.753). However, PBBHRT1 (0.041) shows a virtually insignificant contribution, and it needs to be further developed.

CBAHR indicators are mostly strong, with high loadings for CBAHR5 (0.963), CBAHR4 (0.857), and CBAHR3 (0.901). However, CBAHR2 (-0.324) has a negative loading, which means it is not a good fit with the construct and should be reviewed or revised (Table 3).

Table 3
VARIANCES: (GROUP NUMBER 1 - DEFAULT MODEL)

	Estimate	S.E.	C.R.	P	Label
ABT	1.110	.171	6.507	***	
CHRCSC	.010	.019	.536	.592	
PBBHRT	.831	.193	4.306	***	
CBAHR	2.050	.321	6.381	***	
e1	.563	.086	6.524	***	
e2	.383	.069	5.591	***	
e3	.630	.096	6.537	***	
e4	2.261	.321	7.035	***	
e5	1.859	.264	7.031	***	
e6	.062	.039	1.598	.110	
e7	1.523	.217	7.010	***	
e8	1.639	.234	7.009	***	
e9	1.185	.170	6.978	***	
e10	1.078	.156	6.910	***	
e11	.801	.114	7.027	***	
e12	.852	.121	7.034	***	
e13	.511	.115	4.425	***	
e14	.688	.118	5.813	***	
e15	.239	.097	2.476	.013	
e16	.635	.101	6.311	***	
e17	.734	.119	6.185	***	
e18	.108	.082	1.323	.186	
e19	.922	.139	6.634	***	
e20	.760	.108	7.035	***	
e21	.160	.075	2.135	.033	
e22	.626	.108	5.790	***	
e23	.319	.066	4.814	***	

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e24	1.616	.231	6.994	***	
e25	1.592	.227	7.006	***	

The variances of the model present interesting findings on the percentage of the variability explained by the constructs and the residua left unexplained that are picked up by the error terms. The construct Awareness of Blockchain Technology (ABT) has a considerable variance of 1.110, with a C.R. of 6.507 ($p < 0.001$). This suggests that ABT occupies a significant place in accounting for blockchain adoption differences within the HR supply chain context; therefore, it is an important explanatory variable of attitudes and actions towards blockchain technology.

Current HR Challenges in the Supply Chain construct has a very low variance at 0.010 though with a non-significant C.R. of 0.536 at $p = 0.592$. This means CHRCSC does not have much contribution to the model variance. Thus, the issues regarding human resources in the supply chain could have little impact on how the blockchain technology is being embraced when compared to the constructs being observed in the study.

The variance in the construct of PBBHRT is significantly high at 0.831 with a C.R. of 4.306 and $p < 0.001$, which points out that PBBHRT has a highly significant impact on the model and on the adoption process regarding the benefits blockchain could potentially bring into HR transparency.

Likewise, the CBAHR construct has a variance of 2.050 with an extremely significant C.R. at the level of 6.381 ($p < 0.001$). That means that challenges of blockchain adoption in HR are major in the model and influence the level to which blockchain technology is adopted in the HR practices of the supply chain sector.

The error terms represent the residual variability in the observed indicators that is not accounted for by the model. For example, e1 has a variance of 0.563, with a C.R. of 6.524 ($p < 0.001$), which means that there is a significant amount of unexplained variability in this indicator. This suggests that the model does not capture all the nuances or external factors that could be impacting this specific indicator. In a similar fashion, other error terms such as e2 and e3 display notable residual variances, further supporting the fact that some indicators possess aspects not completely explained by the model but significantly contributing to the analysis.

Error terms however, for example e6 (0.062), e18 (0.108), have very low variance levels with non-significant C.R.s > 0.05 meaning that these variables have a minimal explained variation. The model explains very well to these certain indicators and these are highly resistant to influence from aspects beyond the scope of this model.

Some of the error terms have moderate residual variances. For instance, e15 (0.239) has a C.R. of 2.476 ($p = 0.013$). Although significant, this residual variability is fairly small, so this model can be further optimized to minimize this portion of the residuals in the indicators. Overall, the significant differences in both the constructs and error terms suggest that while the model is reasonably well-specified, there is still some unexplained variability that could be explored further to enhance model precision and fit.

Table 4
MINIMIZATION HISTORY (DEFAULT MODEL)

Iteration		Negative eigenvalues	Condition #	Smallest eigenvalue	Diameter	F	NTries	Ratio
0	e	10		-0.795	9999	2476.023	0	9999
1	e	9		-0.348	1.828	2067.628	19	0.666
2	e*	1		-0.324	1.784	1653.432	5	0.924
3	e	1		-0.342	0.632	1585.636	4	0.689
4	e*	1		-0.022	1.532	1482.196	7	0.689

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5	e	0	109.296		0.538	1461.66	5	0.754
6	e	0	212.552		0.664	1447.617	1	1.214
7	e	0	439.654		0.746	1441.509	1	1.154
8	e	0	1630.397		0.636	1437.513	1	1.277
9	e	0	5385.349		1.018	1436.386	1	0.611
10	e	0	21704.837		0.602	1434.149	1	1.152
11	e	0	41090.796		1.219	1434.048	1	0.145
12	e	0	189789.59		0.568	1432.929	1	1.107
13	e	0	257771.49		0.645	1432.744	2	0
14	e	0	552622.1		0.84	1432.562	1	1.281
15	e	0	1214817.2		0.754	1432.449	1	1.311
16	e	0	2013589.8		0.797	1432.384	1	1.241
17	e	0	4647098.7		0.601	1432.344	1	1.305
18	e	0	5689871.8		0.727	1432.325	1	1.108
19	e	0	16042249		0.374	1432.313	1	1.22
20	e	0	14851502		0.547	1432.31	1	0.919
21	e	0	33887810		0.147	1432.308	1	1.079
22	e	0	35896375		0.149	1432.308	1	1.02
23	e	0	39335559		0.011	1432.308	1	1.007
24	e	0	39614164		0.001	1432.308	1	1

The minimization history will contain the step-by-step detail of how the process has been optimized to achieve an optimal fit of the model. This process is necessary for determining how the negative eigenvalues, condition numbers, and other parameters evolve with time to eventually help find a solution that minimizes the difference between observed and predicted values (Table 4).

The model in iteration 0 has a high negative eigenvalue (-0.795) and a highly large condition number (9999). This shows that the model is far from the optimal solution, while the diameter and F-statistics are highly large; they reflect the degree of non-optimality. It should therefore be in the first stage of the minimization process, and significant changes would be required.

By iteration 1, the eigenvalue improved to -0.348, implying some positive progress in reduction of negative values and therefore enhancing the stability of the model. The condition number dropped to 1.828 and the model improves with an F-statistic of 2067.628. The number of tries was 19, which indicates the number of attempts taken to refine the solution.

Iterations onwards, improvements are made steady in reducing the negative eigenvalues and condition number. For instance, at iteration 4, the negative eigenvalue is further reduced to -0.022, thus implying an improvement. The tries made fluctuate, but on average, the optimization is going towards a better solution; for example, iterations 5 shows minimal changes. From iteration 5 to 9, oscillation in the condition number occurs but as a whole condition number remains stable which reflects that model fit must be improving but not up to an optimal level. But in iteration 10, the model starts to depict major convergence because there exists a positive value of the eigenvalue such as 21704.837, which is a sign of good fit.

At iteration 24, the negative eigenvalue has stabilized to an extremely small value of 0.001, while the condition number approaches 1.000, which means that the model is almost completely converged and close to the optimum solution. The final value for the F-statistic was 1432.308, which indicates relative stability and goodness of fit for the model.

Table 5
CMIN MODEL SUMMARY

Model	NPAR	CMIN	DF	P	CMIN/DF
Default model	53	1432.308	272	.000	5.266

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Saturated model	325	.000	0		
Independence model	25	2474.178	300	.000	8.247

The CMIN (Chi-Square Minimum) Model Summary gives the goodness-of-fit statistics for the models, namely Default, Saturated, and Independence (Table 5). For the Default model with 53 parameters, Chi-square equals 1432.308 with 272 degrees of freedom and a p-value equal to 0.000. That is, the differences between observed and predicted frequencies are statistically significant, but the fit is less than perfect. For the Default model, the CMIN/DF is at 5.266, well over the ideal threshold of 3, meaning it's probably not a good-fitting model. The Saturated model, which gives a perfect fit to the data, has 325 parameters and no degrees of freedom. Its Chi-square value will be 0, a perfect fit, but also overfitting and serving only as a benchmark of comparison. The Independence model assumes no relationship among variables and is thus a baseline model with 25 parameters. It has a Chi-square value of 2474.178 with 300 degrees of freedom and a p-value of 0.000, showing that the model does not fit the data well due to its high Chi-square value and the ratio of CMIN/DF, which is 8.247, far exceeding the desired threshold. This indicates that variables in the data set are dependent, and the model failed to capture the structure behind the data. In any case, the Default is the most reasonable model out of the three, even if it is not fully fit, as shown through comparisons with both the Saturated and Independence models (Figure 1).

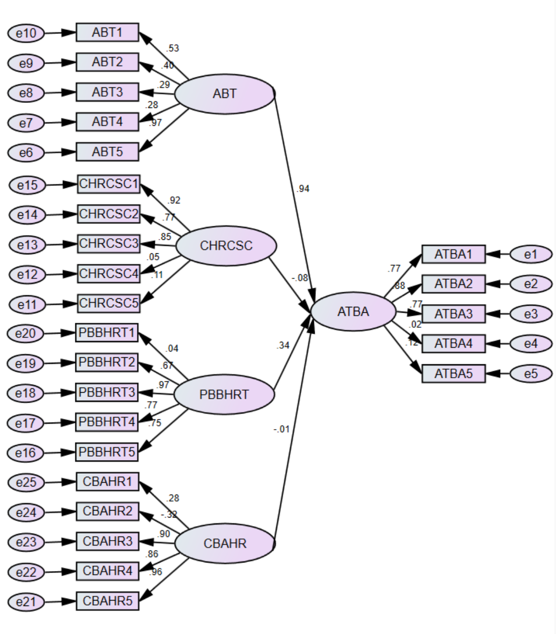

FIGURE 1
EFA

CONCLUSION

This research provides a more general evaluation of the relationships of the variables and the goodness of fit of the model using Structural Equation Modeling. Maximum Likelihood Estimates have been employed to highlight significant regression weights. Such weights denote the magnitude and direction of relationships between pertinent constructs. The standardized regression weights indicate that some paths were highly correlated while others were less so and/or not significant. Variance estimates highlighted where latent and observed variables vary much and points where refinements could be needed since the model was doing quite well. Minimization history indicated stepwise convergence towards the

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optimum solution, in that there was progressive diminution in the smallest eigenvalue as well as in successive increments in the goodness-of-fit. Summary of the CMIN model stated a very significant Chi-square for the Default model with CMIN/DF ratio crossing the desirable limit. Although this suggests that the model fit is still improvable, it still outperformed the Independence model that badly failed in representing interrelationship between the variables. The Saturated model was expected, for it perfectly fits but can't be used on the real problems. This study presents the complexity of the relationship among constructs and partly the adequacy of the proposed model. The results outline the need for revision along the paths of low regression weights and for alternative models in better representing data. This study contributes to an understanding of the studied constructs and serves as a base for further refinement and practical application in future studies.

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