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Investigating the factors of blockchain technology influencing food retail supply chain management: a study using TOE framework

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Abstract

In history, the food sector has remained the most vulnerable and is accountable for many crises and food scandals, so to avoid this in the near future, it is essential to have better control over the flow of products and the usage of blockchain technology can achieve this control in the supply chain, which can add trust, transparency, and traceability in the entire system. This paper investigates the factors affecting blockchain adoption in the food retail supply chain and creates awareness among retail managers for its adoption in their operations. A structured literature review is performed to identify the factors and a TOE framework is adopted for the research. Factors of technology, organization and environment are taken as independent variables; the intention to adopt the technology is taken as a mediating variable and blockchain adoption is considered a dependent variable. The findings contributed that TOE factors contribute to blockchain adoption by keeping the intention to adopt the technology as a mediating variable.

Key words: trust, transparency, traceability, blockchain, TOE framework.

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1. Introduction

Food products travel a lot from agriculture farms to customers in different cities. In India, other states grow different food products, so it remains challenging for organizations to keep track of food safety (Zhang et al., 2020). Food industries are responsible for approximately 30% of energy consumption globally, leading to 22% greenhouse gas emissions. There has been increasing consumer awareness regarding food safety in recent times. Perishable food items are at a higher risk of getting wasted or contaminated. In 2013 in Serbia, a food scandal involved toxic elements found in milk items (Makhdoom et al., 2019). In 2018, another food scandal was revealed regarding baby milk powder in one of the largest milk manufacturing companies. The leading cause of all the scandals happening worldwide is the lack of transparency in the FSC. The customers purchase retail foods from different malls, departmental stores, local shops, etc. (Wong et al., 2020). The Indian retail market is approx. 500 billion USD and growing at a rate of 7% annually.

BT technology (BT) is a distributed information base shared among a distributed organization. It comprises blocks linked together in the organization networks. When a component is added to the BT, it cannot be modified, transforming a BT into a permanent record of past action (Mukherjee, Nagariya, Baral, et al., 2022). Each block of the information base is connected to the other. Each block of the chain comprises many exchanges and is checked by every individual inside (Antonucci et al., 2019). In this digital age, all plans of action have been going through changes because of the latest discoveries in information and communication technology (ICTs). Disruptive BT technology changes the organizations' business models and how they are done. BT developed as an innovation for performing exchanges in the cryptographic money sector (Mukherjee, Baral, & Chittipaka, 2022). BT found many applications in the finance and banking industry but has recently been used in other areas like the supply chain (SC), the education sector, and many more. BT is still developing, with many innovations coming forward in the near future. BT can be a challenge and an opportunity for industries. BT can improve the food supply chain (FSC) industry by creating trust, transparency, security, accountability, and efficiency (Mukherjee et al., 2021). BT can be a solution to SC traceability problems and can generate closer trust in the relationships. This trust will not be limited to suppliers but the entire SC (Gökalp et al., 2022).

This paper investigates the factors affecting the food retail supply chain (FRSC) while adopting BT. We have used the TOE framework, where the constructs of technology, organization, and environment are taken as independent variables. Intention to adopt the technology is taken as a mediating variable and blockchain adoption (BA) as a dependent variable. The research is carried out with retail stores in different stores in India.

The rest of the paper is organized as follows. Section 2 comprises a literature review followed by research methodology in Section 3. Section 4 provides results, Section 5 comprises discussions, Section 6 comprises managerial implications, and Section 7 contains a conclusion.

2. Literature review

2.1. Blockchain Technology in Food Supply Chain Management

Food industries can expect better outcomes after adopting BT in their process. There are numerous ongoing innovations in the field of FSC using BT. BT can alter SC supportability. Use cases show organizations trying to execute BT into their SC activities for traceability of items, as on account of Maersk, Provenance, and Walmart (Kamilaris et al., 2019). Limiting fake items has likewise been an objective of specific BT applications (Lin & Liao, 2017). Notwithstanding the potential of BT benefits for improving traceability in an organization, the quantity of utilization cases applying BT for supportability is restricted. In contrast, organizations keep battling with the more all-encompassing parts of sustainability (Atlam et al., 2018).

Tracking the shipment is a significant part of SC. BT will assist one with checking continuously if the shipment has been taken care of appropriately and has shown up on time at some random area. BT will help track the lost or tampered items in the flow of FRSC (Al-Jaroodi & Mohamed, 2019). Likewise, BT-based trades will help the FR purchase or sell from one another just as merchants through the BT-shared record (Hastig & Sodhi, 2020). BT can collect information identified from the customer purchasing behaviour, request situation pattern, etc. This information can be used to keep the actual product inventory, like the just-in-time inventory facility (Mukherjee, Baral, & Venkataiah, 2022). BT will decrease the danger of fake financial exchanges (Hew et al., 2020).

2.2. Conceptual Framework development

2.2.1. Technological factors (TF)

Perceived benefits (PB): Researchers and analysts believe that BT-engaged SC gains benefits, including progressing information sharing, cost decrease, adequacy, straightforwardness, tracking, tracing, and improving operational excellence (Roy, Babakerkhell, et al., 2022). BT-engaged SC aims to grow the association's effectiveness and reality in the market (Hassani et al., 2018; van Hoek, 2019). As required, the introduction saw an advantage as an essential factor for an association to grasp BT in its SC. The higher the SC execution advantage is seen by an organization, the more probable to accept BT.

H1: PB influences the manager's intention to adopt BT.

Cost (C): Costs for adopting the latest technology refer to all the expenses incurred in the adoption process (Clohessy et al., 2019). In adopting BT, the cost will be incurred, like modifying the technology systems, training employees, and buying the latest devices and software for the technology (Saberi et al., 2019). But earlier research shown that the companies are already using RFID or IoT-based technologies in their FSC, so it will add an advantage as the organization needs to upgrade their technologies, which will have less costs with more benefits (Roy, Chekuri, et al., 2022).

H2: C influences the manager's intention to adopt BT.

Relative advantage (RA): RA refers to the degree to which the latest innovations are perceived in the organizations' context and how they are adopting them (Mukherjee & Chittipaka, 2021). RA is measured in terms of time, effort, profits, cost reduction, and production increase. In this research, this construct refers to improving FSC professionals' performance using BT technologies. This can offer transparency to the existing system and improve the suppliers' performance (Mendling et al., 2018).

H3: RA influences the manager's intention to adopt BT.

Security (S): S remains the most concerning factor for organizations, as many feel that the data they share might get destroyed or tampered (Queiroz et al., 2020). This creates a lack of trust and confidence among the technology providers and the organization (Alsetoohy et al., 2019). But BT is the opposite of other technologies as it provides complete security for the organizations' data.

H4: S influences the manager's intention to adopt BT.

2.3.2. Organizational factors (OF)

Top management support (TMS): TMS means the level of support and resources the top management puts into technology adoption (Lengoatha & Seymour, 2020). Management encouragement and support are required in the adoption process (Mezquita et al., 2019). Top management helps create coordination and solve the conflicts between the technology providers and the organization (Mukherjee, Baral, Pal, et al., 2022). Supports that are required for the technology adoption, which can be provided by top management, are funds for the projects, training of the staff, motivation for the change resistance and creating a belief that with the adoption of the new technologies, there will be no job loss (Hassan, 2017). BT system adoption will improve organizational changes if the project gets complete top management support.

H5: TMS influences the manager's intention to adopt BT.

Organizational readiness (ORN): ORN means whether the organizations are ready to adopt new technologies. The things looked after in ORN are whether the organization can incur innovations cost (Tashkandi & Al-Jabri, 2015). Successful technology adoption can happen only if adequate resources, knowledge, and top management support exist.

H6: ORN influences the manager's intention to adopt BT.

Blockchain knowledge (BK): refers to the organizations' employees' experience with technology adoption (Kamble et al., 2019). Technical knowledge is vital for adopting new technologies in organizations (Chiu et al., 2017). Organizations need to provide adequate training for the employees in the area of BT so that they become habituated to working with it and face no problems.

H7: BK influences the manager's intention to adopt BT.

2.3.3. Environmental factors (EF)

Competitive pressure (CP): Companies need to change their technologies to remain growing in the market. CP refers to the organization's pressure from its competitors (Pateli et al., 2020). If the organizations do not adopt the latest innovations, they might go out of the market and incur a loss. Using innovative technology strengthens the organization's position in the market and with the customers (Yusof et al., 2018). They will be able to provide better service to the customers.

H8: CP influences the manager's intention to adopt BT.

Regulatory environment (RE): Some latest technologies come with regulations in different countries or markets (Zhu et al., 2006). This refers to the country's government's policies, rules, and rules for the latest technology. Organizations adopting this technology need to follow this (Xu et al., 2017).

H9: RE influences the manager's intention to adopt BT.

Government support (GS): Organizations need GS for any latest technology (Oliveira et al., 2014). This support can be in many forms like tax rebates, giving proper guidelines for the technology adoption, monitoring and advising in the adoption process (Puklavec et al., 2018). Without any GS no companies can adopt innovative technology in their operations.

H10: GS influences the manager's intention to adopt BT.

Intention to adopt the technology (I): Intention can be the willingness to embrace the organizations (Gangwar et al., 2015). Intention to adopt depends from person to

person and their knowledge towards technology. In this paper intention of the retail managers is being measured as a meditating variable. The intention to adopt the latest technology has been measured in earlier research (Gangwar, 2020).

H11: There is a positive relationship between the manager's intentions and the adoption of BT.

3. Research Methodology

Secondary data was collected through secondary sources like literature reviews and various other reports (Roy, Baral, et al., 2022). Primary data was collected through a structured questionnaire prepared with the consultant of the qualified persons. The questionnaire was checked and scrutinized by qualified professors and industry professionals in their respective academic fields before the survey began. The questionnaire utilized a seven-point Likert scale for measuring the constructs. Each sub-factor consisted of at least three indicators. A pilot survey was conducted by taking a sample size of 50. After that, the respondents, professors, and industry persons included the requirements and suggestions given by the respondents, professors, and industry persons included in the final questionnaire. The target crowd was retail stores in India, and a stratified random sampling approach was adopted. The retail stores mainly contacted retail managers, floor managers, and procurement managers for the surveys. The questionnaires were sent to 420 respondents from different retail stores through the mail, but only 303 respondents returned usable questionnaires, which were valid for analysis. Exploratory factor analysis (EFA) was done, and structural equation modeling (SEM) was performed to get the results. SPSS 20.0 was used to test reliability and EFA. AMOS version 22.0 was used for SEM.

Table 1: Demographics of the respondents

SL. NO	CHARACTERISTICS	PERCENTAGE
A	**Gender**	
1	Male	59
2	Female	41
B	**RESPONDENTS CURRENT POSITION**	
1	Department Manager	43
2	Retail Manager	32
3	Procurement Management	25
C	**BLOCKCHAIN ADOPTION**	
1	Already adopted	19
2	Not adopted	69
3	Adopted but not using it properly	12

4. Results

4.1. Reliability and Validity

The reliability test was performed for each construct based on Cronbach's alpha value, introducing Cronbach's alpha for the constructs (Fornell & Larcker, 1981). Table 2 shows the value of α, composite reliability, and average variance extracted.

4.2. Exploratory Factor Analysis (EFA)

The exploratory factor analysis (EFA) was performed at the initial stage to group the variables having similar properties, and each variable can be grouped under different factors during this process. Table 2 displays the KMO values for all the perspectives: TF (0.816), OF (0.807), and EF (0.729). This Rotated Component Matrix is important for interpreting the results of the analysis. Rotation helps group the items; each group contains more than one item, simplifying the structure. Hence, this is the aim of the goal of rotation. In this research, we have achieved this aim.

Table 2: Cronbach's alpha, Composite Reliability, Average variance extracted and KMO values

Construct	Latent Variables	No. of items	Measurement entry	Cronbach's alpha (α)	CR	AVE	KMO	Factor Loadings
Technological	Relative Advantage	4	RA1, RA2, RA3, RA4	0.8490	0.8662	0.6191	0.8160	0.761, 0.818, 0.842, 0.720
	Security	4	S1, S2, S3, S4	0.8300	0.8628	0.6117		0.813, 0.746, 0.756, 0.811
	Perceived Benefits	3	PB1, PB2, PB3	0.8400	0.8802	0.7106		0.848, 0.889, 0.789
	Cost	3	C1, C2, C3	0.7250	0.8297	0.6212		0.846, 0.832, 0.675
Organizational	Top management support	4	TMS1, TMS2, TMS3, TMS4	0.8460	0.8699	0.6269	0.8070	0.773, 0.823, 0.853, 0.711
	Organizational readiness	4	ORN1, ORN2, ORN3, ORN4	0.8290	0.8657	0.6174		0.815, 0.750, 0.759, 0.816
	Blockchain knowledge	3	BK1, BK2, BK3	0.7210	0.8334	0.6271		0.838, 0.839, 0.689

Table 2: Cronbach's alpha, Composite Reliability, Average variance extracted and KMO values (cont.)

Construct	Latent Variables	No. of items	Measurement entry	Cronbach's alpha (α)	CR	AVE	KMO	Factor Loadings
Environmental	Competitive pressure	4	CP1, CP2, CP3, CP4	0.8340	0.8844	0.6612	0.7290	0.839, 0.884, 0.888, 0.609
	Regulatory environment	3	RE1, RE2, RE3	0.7310	0.8513	0.6573		0.843, 0.858, 0.725
	Government support	4	GS1, GS2, GS3, GS4	0.8310	0.8837	0.6552		0.799, 0.805, 0.813, 0.821

4.3. Structural Equation Modeling

To test the hypothesis, SEM was used. AMOS 22.0 was utilized for this research because of its powerful graphic representations and user-friendly interfaces (Byrne, 2010). This section represents the outputs of hypothesis testing. The results of the significant paths of the model are shown here. Figure 1, 2, 3 represent the final model and the latent variables, along with their indicators, mediating, and dependent variable.

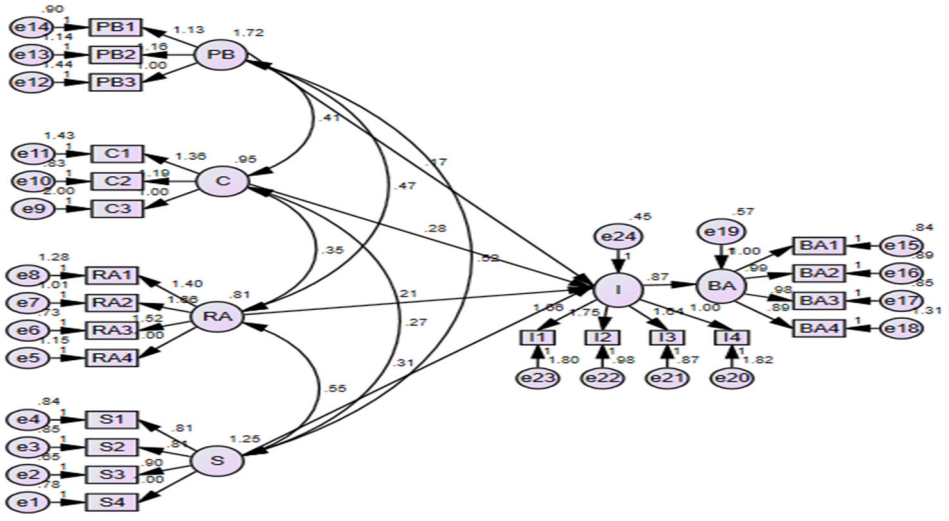

Figure 1: Final SEM for Technological Factor

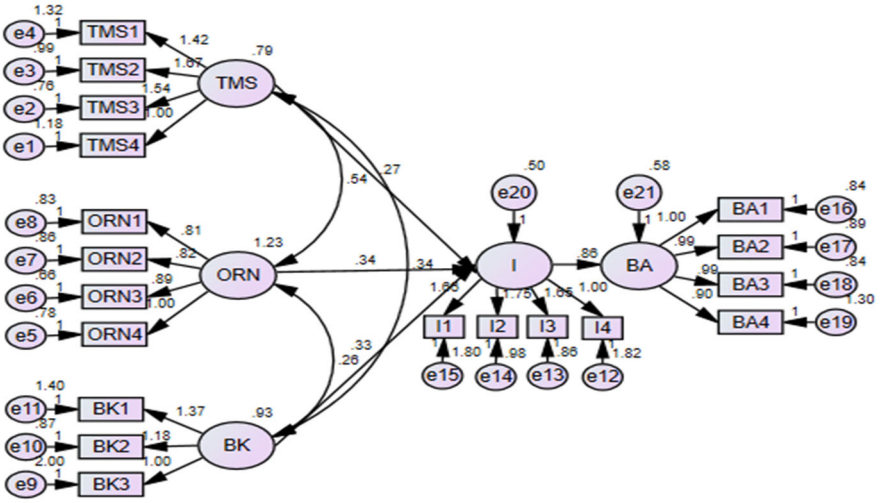

Figure 2: Final SEM for Organizational Factor

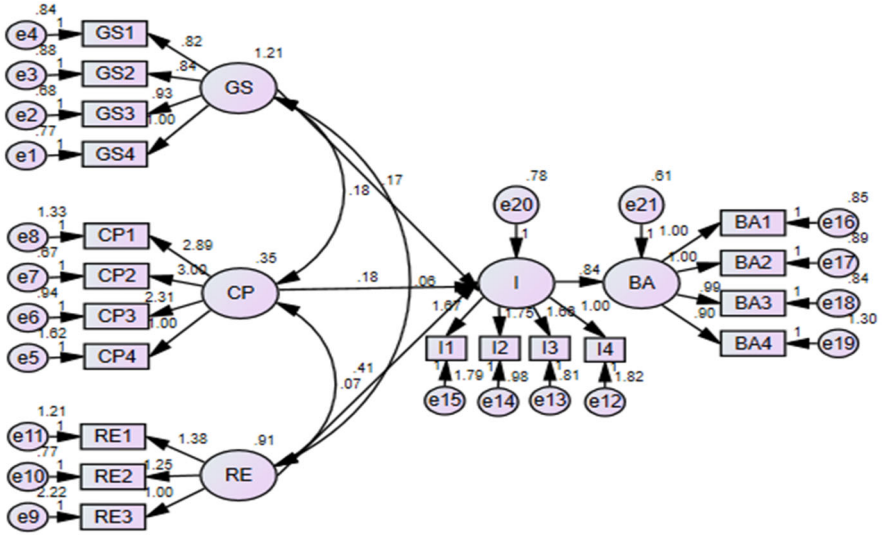

Figure 3: Final SEM for Environmental Factor

4.4. Structural Model Goodness of Fit

The above three models (Figure I, Figure II, and Figure III) show the latent variables and their indicators and a mediating variable with four indicators that contributed significantly to the dependent variable, which also had four indicators. The final output is shown in Table 3.

Table 3: SEM Output

Specification		Chi-square	DF	P-Level	CMIN/DF	RMSEA	CFI	NFI	IFI	GFI	AGFI
TP	Model	491.461	198	0	2.482	0.070	0.913	0.864	0.914	0.874	0.84
	Recommended Standard	-	-	<0.05	<3.0	<0.08	0-1.0	0-1.0	0-1.0	0-1.0	>0.80
OP	Model	399.983	145	0	2.759	0.076	0.911	0.869	0.912	0.88	0.842
	Recommended Standard	-	-	<0.05	<3.0	<0.08	0-1.0	0-1.0	0-1.0	0-1.0	>0.80
EP	Model	368.056	145	0	2.538	0.071	0.918	0.873	0.919	0.89	0.855
	Recommended Standard	-	-	<0.05	<3.0	<0.08	0-1.0	0-1.0	0-1.0	0-1.0	>0.80

5. Discussion

The primary aim of this research was to determine the factors affecting the FRSC in India's FR industry. Another objective was to create awareness among the managers towards BT and its advantages. In the semi-urban areas, knowledge about BT was less than in urban areas. For this, a structured literature review was done to identify the factors affecting BT. TOE framework was considered for the research; prior research was conducted using the TOE framework in many sectors like cloud computing in healthcare, intelligent agent technology in the hotel industry, internet of things adoption in the agriculture sector. BT adoption in the retail industry entirely depends on the retail managers' intention to implement this technology in their retail stores (Seebacher & Schüritz, 2017). The managers whose operations depend upon their decisions. The managers hold the sole responsibility for achieving technical excellence in retail operations. As found out in the research, many problems may arise with BT's adoption, like a lack of knowledgeable people in the area. Another reason may be different state laws compared to national laws.

The factor TF comprised latent variables like PB, RA, S, and C. Each of the constructs had three or more indicators. The recommended level was Cronbach's alpha, and composite reliability values were above 0.7. There were 14 indicators in measuring TF constructs' impact as an independent variable in the BA as a dependent variable, with I as a mediating variable. The KMO value of TF was 0.816, which is also above the recommended level of 0.6. The total variance explained was 69.298%, and in the rotated component matrix, the variables were grouped under four groups. Then, the SEM was performed in AMOS 22.0, CMIN/Df was 2.482, and all the fit indices were within the acceptance level. Hence, the model shows the goodness of fit. Prior research supports that factors like C, RA, and S were taken in BT for the banking industry (Önder & Treiblmaier, 2018). The factors PB, S, and C were found in the prior research using the

technology adoption model (Kumar, 2014). PB was found in another research for innovative education (Salam et al., 2016). So, all the TF constructs' hypotheses were accepted and fit the model well.

The factor OF comprised latent variables like TMS, ORN, and BK. Each of them had three or more indicators. The recommended level was Cronbach's alpha, and composite reliability values were above 0.7. A total of 11 indicators measured the impact OF constructs as an independent variable in the BA as a dependent variable, with I as a mediating variable. The KMO value of OP was 0.807, which is also above the recommended level of 0.6, which allows the data for factor analysis. The total variance explained was 66.969%, and in the rotated component matrix, the variables were grouped under three groups. Then, the SEM was performed in AMOS 22.0, CMIN/Df was 2.759, and all the fit indices were within the acceptance level. Hence, the model shows the goodness of fit. TMS and ORN constructs were found in the education sector's prior research (Clohessy & Acton, 2019). ORN factors were also found in the previous studies that supported these results. BK was found to be an essential factor as, without its knowledge, the adoption process cannot succeed, so the organizations should look into this so that the employees are given proper and adequate BT training (Teller et al., 2018).

The factor EF comprised latent variables like GS, CP, and RE. Each of them had three or more indicators. The recommended level was Cronbach's alpha, and composite reliability values were above 0.7. A total of 11 indicators measured the impact OF constructs as an independent variable in the BA as a dependent variable, with I as a mediating variable. The KMO value of TP was 0.729, which is also above the recommended level of 0.6. The total variance explained was 66.829%, and in the rotated component matrix, the variables were grouped under three groups. Then the SEM was performed in AMOS 22.0, CMIN/Df was 2.538, and all the fit indices were within the acceptance level. Hence, the model shows the goodness of fit. RE varies from country to country and state to state, so it is essential to go through the government's rules and regulations before adopting the technology. This research's results were also supported by the previous study using the same constructs like GS, RE, and CP (Queiroz et al., 2020).

6. Managerial implications

This research aimed to identify the factors affecting BT adoption in FRSC. The survey was conducted with the retail, department, and procurement managers. It was found that the awareness for adopting BT is much less as they do not want to change the technology they are using now. But after making them understand the benefits of BT in FR, they agreed to use it in their stores with the management's support. This

research used intention as a mediating variable for BT's adoption. The retail store is being entirely run under managers' supervision, so their willingness and attitude to adopt the latest technology are essential. For this, top management also needs to give a lot of support in training, funds allocation, and many more. Managers need to change their working styles with time as the latest technology makes the process faster and easier, but initial adoption will be difficult, which needs to be overcome. Only organizations can achieve customer satisfaction, reduce procurement timing, and have greater profits in the long run.

7. Conclusion

This research was conducted to determine the factors affecting BT adoption in the FRSC and to create awareness among the managers to adopt BT in their operations for better results. A structured literature review was conducted to identify the TOE factors used in the research. TOE factors were used in many previous studies on technology adoption, like RFID, IoT, cloud computing, intelligent agent technology, and many more. With these factors, a questionnaire was developed for the survey. The questionnaires were sent to retail stores across India through online mode. The results were analysed using EFA and SEM techniques. Eleven hypotheses supported this, and the three models fit well. Managers need to understand the latest technologies and implement them in their process with the management's support. This will create a significant impact on the way they deliver services to the customers.

7.1. Future research

This research was mainly concentrated on the FR sectors as the research can also be extended to other industries like fashion retail, e-commerce, and restaurants. This research was done for the only country to be extended to other countries. Comparative analysis can be performed between developing and developed countries across the world.

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