Blockchain adoption barriers in Moroccan sustainable supply chain: a proposed approach

Abdesadik Bendarag[1], Omar Boutkhoum[2], Driss Abada[2], Mohamed Hanine[3]
[1]Department of Mathematics and computer science, Faculty of Polydisciplinary, Cadi Ayyad University, Safi, Morocco
[2]Department of Computer Science, LAROSERI Laboratory, Faculty of Sciences, Chouaib Doukkali University, El jadida, Morocco
[3]Department of Telecommunications, Networks and Informatics, ENSA, Chouaib Doukkali University, El jadida, Morocco

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ABSTRACT

Currently, the emerging countries like Morocco seeks to benefit from the potential of blockchain technology to meet its various growing demands, especially in sustainable supply chain management (SSCM). This explains the need for more effort to understand blockchain implementation and identify the barriers influencing the blockchain adoption decision in SSCM, especially, from Moroccan industry and service sectors perspective. In this context, this research paper proposes a group decision-making approach to identify the barriers from a comprehensive literature search, then evaluate them based on intuitionistic fuzzy analytic hierarchy process (IFAHP). Due to the varied importance of the selected barriers, IFAHP is utilized to allocate priority weights for each barrier according to its importance level. The evaluation results reveal that "Government policy and support" and "Challenges in integrating sustainable practices and blockchain technology through sustainable supply chain management (SCM)" are the best ranked barriers that impact the implementation of blockchain technology in Moroccan context. The main objective is to inquire the barriers preventing the blockchain implementation, and assist industry decision-makers in developing supple short- and long-term decision-making strategies for better sustainable supply chain management.

Corresponding Author:

Omar Boutkhoum
Department of Computer Science, LAROSERI Laboratory, Faculty of Sciences
Chouaib Doukkali University
El jadida, Morocco
Email: boutkhoum.o@ucd.ac.ma

1. INTRODUCTION

In last years, blockchain technology has become an integral part of public discourse, where it's waiting to be integrated in various sectors such as cryptocurrencies, digital marketing, business practices, inter-organizational collaborations, and so on. As well as fifth generation (5G) cellular networks, the Internet of things (IoT), machine learning, blockchain technology is getting attention day by day, as its high scalability, its compatibility, and its technological readiness. It is a "shared, cryptographically unaltered distributed ledger" to record and maintain the digital transaction history [1], [2]. It stores and transmits transparent and secure information, and operates without a central controller. Due to the notable success of cryptocurrencies, especially, bitcoin, a wide range of practitioners and researchers have paid considerable importance of blockchain technology. In fact, blockchain can be an efficient technology thanks to its properties of immutability, decentralization, stability, and faster transaction [3], [4]. Divers' sectors have been influenced by blockchain technology such as real-time IoT operating systems, managing secure medical data, cryptocurrency transactions, food transparency and traceability, logistics monitoring, and supply chain sustainability, which is one of the foremost blockchain applications [5] because of global supply chain networks increasing its complexity.

Supply chain sustainability faces several significant strategic and competitive challenges related to the verification and confirmation that the supply chain processes and its products meet certain sustainability criteria and certifications [6]. Besides, industrial supply chain is in full transformation, so, control requirement in terms of transparency, quality, and traceability is increasingly important. Moreover, the lack of transparency harms the various actors in the supply chain. On the one hand for the consumer, if there is no means to verify the origins of the articles, on the other hand for the company which sometimes lacks vision on its supply chain. With its capability to improve supply chain security, transparency, durability, and process integrity [7], blockchain is proposed as a powerful technology that can deal with all these issues. Nevertheless, despite the large advantages offered by this emerging technology, its implementation is still in the Naïve stage [8], [9] in many industrial and service sectors. Morocco, like emerging countries, seeks to take advantage of the potential of the blockchain to meet its various growing demands, particularly in sustainable supply chain management (SSCM). This clarifies the necessity for more effort to understand the blockchain implementation mechanisms and identify the barriers that influence the decision to implement blockchain technology in SSCM from the point of view of Moroccan industry and service sectors.

Hence, the objective of this contribution is to developpe a group decision making approach based on the intuitionistic fuzzy analytic hierarchy process (IFAHP) to identify, evaluate and class the different identified barriers based on their priorities depending on the appreciation of expert. These barriers are identified from an exhaustive literature search while incorporating expert assessments from industrial and academia.

In this direction, several contributions have been proposed to study blockchain technology and its ability to grant the durability of the supply chain system. For example, multicriteria decision support methods approach is applied in several studies such as [10]-[13]. Moreover, recent works [14]-[17] have focalized their studies on various applications of blockchain in logistics and supply chain systems. Since Moroccan sustainable supply chains (SCMs) and SSCMs are very complex and suffer from several weaknesses, and many negotiators are called for, there is a need to adopt an appropriate consolidation platform such as blockchain technology to overcome these limitations. Beforehand, the proposed works in the available literature have not investigated the barriers that prevent the application of blockchain technology in the context of Moroccan SSCMs. In this paper, contributions are proposed in this direction.

2. THE PROPOSED APPROACH

In this contribution, modeling the barriers influencing the implementation of blockchain technology in Moroccan SSCM context is analyzed. Our aim is to propose a collective decision-making approach based on the intuitionistic fuzzy analytic hierarchy process (FAHP) technic to assist decision makers in identifying, evaluating and ranking the barriers that affect the implementation of blockchain technology in SSCM from the Moroccan industry and service sectors perspective. The stepwise group decision-making approach for the evaluation of barriers impact on blockchain adoption in Moroccan SSCM is presented in Figure 1.

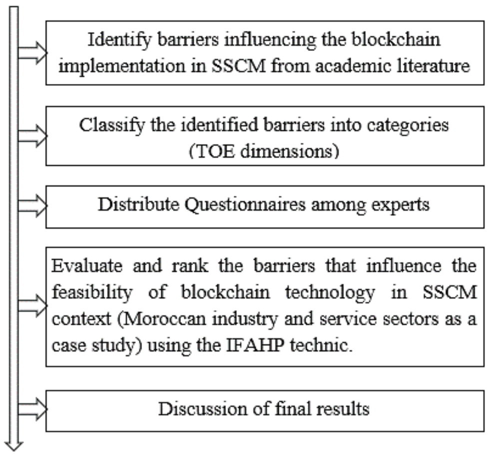

Figure 1. Proposed collective decision-making approach

3. METHOD AND APPLICATION

Intuitionistic fuzzy analytic hierarchy process (IFAHP) [18] is among the most used multi-criteria analysis methods to settle complicated problems where decision making is characterized by uncertainty and hesitation. Indeed, IFAHP which combines hesitancy, membership and a non-membership functions, has the advantage of modeling human's perception and cognition more comprehensively, compared to the FAHP method. The details of IFAHP steps applied in this contribution to evaluate all identified barriers influencing the blockchain adoption are presented in the following (see also [18], [19]).

Step 1: In this step, a hierarchal decision-making structure is constructed to identify and investigate the problem as presented in Figure 2.

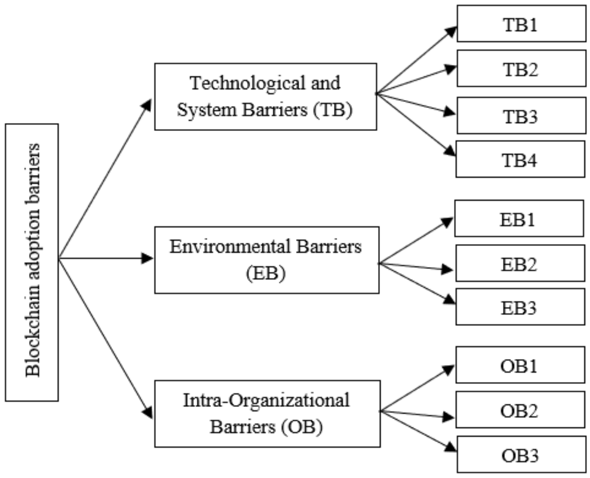

Figure 2. The proposed structure of the problem

In this paper, we have developed an online questionnaire to facilitate and simplify data collection. It is built on the basis of a set of barriers identified via an exhaustive documentary research, and validated by the views of industry and academic experts. The details of these identified barriers are presented in:

a. Technological and system (TB):
   - Absence of system scalability and speed (TB1) [9], [10], [20].
   - Availability of special blockchain tools (TB2) [21], [22].
   - The complication of designing blockchain based (TB3) [20], [23]).
   - Privacy and security issue (TB4) [21], [22], [24].
b. Environmental (EB):
   - Government policy and its encouragement (EB1) [10], [24], [25].
   - High durability costs [Energy uptake and exhaustion of materials] (EB2) [26], [27].
   - Defiance in combining sustainable practices and blockchain technology via SCM (EB3) [25], [28].
c. Intra-Organizational (OB):
   - SCM-Stakeholder Opposition to embracing blockchain culture (OB1) [1; Experts opinion].
   - Leadership encouragement and ability of human resources (OB2) [9], [24].
   - Shortage of tiding organizational policies for the application of blockchain technology (OB3) [29], [30].

Step 2: The experts importance level is computed. Assume that $D_k = [u_k, v_k, \pi_k]$ become an intuitionistic fuzzy (IF) number (IFN) to rate the k[th] decision-maker (DM) (see Table 1). The k[th] DMs weight can be computed using (1) as presented in Table 2.

$$\lambda_k = \frac{\mu_k + \pi_k(\frac{\mu_k}{\mu_k + v_k})}{\sum_{k=1}^{t}(\mu_k + \pi_k(\frac{\mu_k}{\mu_k + v_k})} \quad (1)$$

Where λ_k represents the influence weight of each DM, and $\sum_{k=1}^{t} \lambda_k = 1, \lambda_k \in [0,1]$.

Table 1. The weighting of decision makers using linguistic terms

Linguistic terms	IFNs (u, v, π)
Very unimportant	(0.1, 0.8, 0.1)
Unimportant	(0.25, 0.6, 0.15)
Medium	(0.5, 0.4, 0.1)
Important	(0.75, 0.2, 0.05)
Very important	(0.9, 0.05, 0.05)

Table 2. Evaluation of decision makers' weights

Decision Makers (D_k)	*u*	*v*	π	λ_k
D1	0.75	0.2	0.05	0.146899
D2	0.9	0.05	0.05	0.176279
D3	0.5	0.4	0.1	0.103373
D4	0.75	0.2	0.05	0.146899
D5	0.75	0.2	0.05	0.146899
D6	0.5	0.4	0.1	0.103373
D7	0.9	0.05	0.05	0.176279

Step 3: The barriers evaluation is performed via linguistic pairwise comparison matrices which are filled by k^{th} DMs taking into consideration the linguistic scale of Table 3 as defined by (2). In this context, the decision makers' judgments regarding the importance of each barrier are illustrated in Table 4 (here we focus our attention on the main barriers presented in Figure 2).

$$R^{(k)} = ({r_{ij}}^{(k)})_{n\times n} = \begin{pmatrix} {r_{11}}^{(k)} & {r_{12}}^{(k)} & \cdots & {r_{1n}}^{(k)} \\ {r_{21}}^{(k)} & {r_{22}}^{(k)} & \cdots & {r_{2n}}^{(k)} \\ \vdots & \vdots & \ddots & \vdots \\ {r_{n1}}^{(k)} & {r_{n2}}^{(k)} & \cdots & {r_{nn}}^{(k)} \end{pmatrix} \tag{2}$$

where ${r_{ij}}^{(k)} = ({\mu_{ij}}^{(k)}, {\nu_{ij}}^{(k)}, {\pi_{ij}}^{(k)})$

Table 3. Linguistic terms for DM' judgments [19]

Linguistic terms/variables	Abbreviations	IFNs (u, v, π)	Reciprocal
Extreme poor/Extreme low	EP/EL	(0.05, 0.95, 0.00)	(0.95, 0.05, 0.00)
Very poor/Very low	VP/VL	(0.15, 0.8, 0.05)	(0.8, 0.15, 0.05)
Poor/Low	P/L	(0.25, 0.65, 0.1)	(0.65, 0.25, 0.1)
Medium poor/Medium low	MP/ML	(0.35, 0.55, 0.1)	(0.55, 0.35, 0.1)
Fair/Medium	F/M	(0.5, 0.4, 0.1)	(0.4, 0.5, 0.1)
Medium good/Medium high	MG/MH	(0.65, 0.25, 0.1)	(0.25, 0.65, 0.1)
Good/High	G/H	(0.75, 0.15, 0.1)	(0.15, 0.75, 0.1)
Very good/Very high	VG/VH	(0.85, 0.1, 0.05)	(0.1, 0.85, 0.05)
Extreme good/Extreme high	EG/EH	(0.95, 0.05, 0)	(0.05, 0.95, 0)

Table 4. Judgments of DMs for the main barriers

	D1			D2			D3			D4			D5			D6			D7		
Main Barriers	TB	EB	OB	TB	EB	OB	TB	EB	OB	TB	EB	OB	TB	EB	OB	TB	EB	OB	TB	EB	OB
TB	M	VH	EH	M	H	VH	M	MH	EH	M	H	VH	M	H	H	M	MH	H	M	EH	H
EB		M	H		M	VH		M	MH		M	M		M	H		M	MH		M	H
OB			M			M			M			M			M			M			M

Step 4: Considering all DMs opinions, the aggregated IF judgment matrix $R^{(k)} = ({r_{ij}}^{(k)})_{n\times n}$ is built using IF weighted averaging suggested by [31]. The specification of the aggregated IF decision matrix is given using (3) and (4) as presented in Table 5 (this aggregated matrix is carried out by transforming the DMs judgment to IFN then using (3) and (4)).

$$R = \begin{pmatrix} r_{11} & r_{12} & \cdots & r_{1n} \\ r_{21} & r_{22} & \cdots & r_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ r_{n1} & r_{n2} & \cdots & r_{nn} \end{pmatrix} \tag{3}$$

where:

$$r_{ij} = IFWA_\lambda(r_{ij}^{(1)}, r_{ij}^{(2)}, \dots r_{ij}^{(t)}) = \lambda_1 r_{ij}^{(1)} \oplus \lambda_2 r_{ij}^{(2)} \oplus \cdots \lambda_t r_{ij}^{(t)} = (\mu_{ij}, \nu_{ij}, \pi_{ij}), \quad (4)$$

and,

$$\mu_{ij} = 1 - \prod_{k=1}^{t}\left(1 - \mu_{ij}^{(k)}\right)^{\lambda_k},\ \nu_{ij} = \prod_{k=1}^{t}\left(1 - \nu_{ij}^{(k)}\right)^{\lambda_k},$$
$$\pi_{ij} = \prod_{k=1}^{t}\left(1 - \mu_{ij}^{(k)}\right)^{\lambda_k} - \prod_{k=1}^{t}\left(1 - \nu_{ij}^{(k)}\right)^{\lambda_k}, i, j \in N.$$

Table 5. The aggregated intuitionist fuzzy judgment matrix

Main Barriers	r_{ij} matrix								
	TB			EB			OB		
	µ	v	π	µ	v	π	µ	v	π
TB	0.5000	0.6000	-0.1000	0.8300	0.8609	-0.6909	0.8500	0.8874	-0.7374
EB	0.1391	0.1700	0.6909	0.5000	0.6000	-0.1000	0.7450	0.8089	-0.5539
OB	0.1126	0.1500	0.7374	0.1911	0.2550	0.5539	0.5000	0.6000	-0.1000

Step 5: Computing the criteria IF entropy weights and final entropy weight using (5) and (6) as presented in Table 6. An exemplification of main barriers weights is illustrated in Figure 3.

$$H_j = -\frac{1}{n\ln 2}\sum_{i=1}^{n}\left[\mu_{ij}\ln\mu_{ij} + \nu_{ij}\ln\nu_{ij} - (1-\pi_{ij})\ln(1-\pi_{ij}) - \pi_{ij}\ln 2\right] \quad (5)$$

Then W can be obtained as shown in:

$$W_j = \frac{1-H_j}{n-\sum_{i=1}^{n} H_j} \quad (6)$$

Table 6. Main barriers intuitionistic fuzzy entropy weight and final entropy weight

Intuitionistic fuzzy entropy weight		Final entropy weight	
H1	0.9958	W1	0.3588
H2	0.9955	W2	0.3850
H3	0.9970	W3	0.2562

Step 6: By carrying out the same calculations of the IFAHP process presented in steps 3 to 5, we obtain the definitive results illustrated in Table 7 for all the sub-barriers. Each sub-barrier weight (local weight) is calculated by multiplying it by the main barrier weight (global weight) in the hierarchical structure [32].

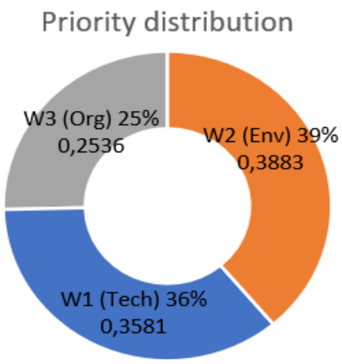

Figure 3. Weight distribution for main barriers

Table 7. Final barrier weights

Main barriers	Relative weights	Sub-barriers	Local weights	Global weights	Final Rank
Technological and system	0.3581	TB1	0.2232	0.0799	9
		TB2	0.2489	0.0891	8
		TB3	0.2696	0.0965	5
		TB4	0.2583	0.0925	7
Environmental	0.3883	EB1	0.4335	0.1683	1
		EB2	0.2621	0.1018	4
		EB3	0.3044	0.1182	2
Intra-Organizational	0.2536	OB1	0.3743	0.0949	6
		OB2	0.2135	0.0541	10
		OB3	0.4122	0.1045	3

4. DISCUSSION AND MANAGERIAL INSIGHTS

In this paper, the IFAHP analysis process aims to determine the importance of barriers affecting the adoption of blockchain by calculating their weights, in order to assist decision-makers in adopting flexible procedures of short-term decision-making. This computation takes into account the uncertainty and levels of hesitation that characterize this type of decision-making problem. In this context, the main barriers and sub-barriers importance weights are computed as mentionned in Table 7. Actually, each sub-barrier weight is computed by multiplying it by its respective main barrier weight.

According to the final results of IFAHP process presented in Table 7 and Figure 3, the EB main barriers acquire the top priority as it ranks first with its highest weight of "0.3883" compared to the rest of the barriers. This indicates why more attentiveness is paid to the impacts of environmental and governmental barriers. Within this context, the global priority weights of the environmental sub-barriers "EB1: 0.1683", "EB2: 0.1018" and "EB3: 0.1182" account for this concern. Among the concerns that this barrier focuses on, we cite the complexity, availability and security of blockchain adoption in the Moroccan SSCM. The priorities division for the technological and systemic sub-barriers “TB1: 0.0799”, “TB2: 0.0891”, “TB3: 0.0965” and “TB4: 0.0925” expose this concern. Due to the enduring nature of our application field, the intra-organizational barrier comes in last with a score of 0.2536, even if the global weight of the intra-organizational sub-barrier "OB3" (score of "0.1045") is greater than the overall weight of technological sub-barriers as shown in Table 7.

Accordingly, the objective of the investigated barriers in this study is to provide policy makers and supply chain managers with appropriate information to organize plans in order to begin the process of surmounting all obstacles allied to the implementation of blockchain technology. In fact, as the findings of this study revealed that the “Government policy and support”, “Challenges in integrating sustainable practices and blockchain technology through SCM” and “Lack of new organizational policies for using blockchain technology” are the most significant sub-barriers which impact the blockchain adoption in SSCM, it is advisable to work on a new strategy specifying the suitable government regulations regarding the blockchain implementation. Also, blockchain technical developers should suggest a solution to address certain issues related to security and privacy concern so as to involve the consumer satisfaction and minimize blockchain complexity.

5. CONCLUSION AND PERSPECTIVES

The main aim of this contribution is to present a decision-making approach based on Intuitionistic Fuzzy AHP to collectively identify and evaluate the barriers influencing the blockchain adoption in Moroccan SSCM. To construct this approach, we took help from a comprehensive literature search and use of expert views on most significant barriers to blockchain adoption.

Concerning the IFAHP process, the obtained results frequently represent short-term decision-making strategies by distributing priorities to all identified barriers impacting the implementation of blockchain. Therefore, the main advantages of using the IFAHP method are to structure and assess factors/barriers in a systematic and rational way and to give decision makers the opportunity to express evidence of support, objection and hesitation in a such situation of assessing barriers to blockchain adoption.

Thus, other research work dealing with the topic of barriers impacting the adoption of blockchain technology, as already explained in the introduction section, can be compared to our final results. As a perspective, we are working on a fuzzy group decision making framework combining IFAHP and Fuzzy DEMATEL to assist decision-makers in adopting flexible procedures of short and long-term decision-making approches to conduct a sustainable SCM. This will help decision makers to address the different interactions and relationships amongst the investigated barriers.

REFERENCES

[1] V. S. Yadav, A. R. Singh, R. D. Raut, and U. H. Govindarajan, “Blockchain technology adoption barriers in the Indian agricultural supply chain: an integrated approach,” *Resources, Conservation and Recycling*, vol. 161, p. 104877, Oct. 2020, doi: 10.1016/j.resconrec.2020.104877.

[2] O. W. Purbo, Sriyanto, Suhendro, R. A. Aziz, and R. Herwanto, “Benchmark and comparison between hyperledger and MySQL,” *Telkomnika (Telecommunication Computing Electronics and Control)*, vol. 18, no. 2, pp. 705–715, Apr. 2020, doi: 10.12928/TELKOMNIKA.v18i2.13743.

[3] M. M. Khubrani and S. Alam, “A detailed review of blockchain-based applications for protection against pandemic like COVID-19,” *Telkomnika (Telecommunication Computing Electronics and Control)*, vol. 19, no. 4, pp. 1185–1196, Aug. 2021, doi: 10.12928/TELKOMNIKA.v19i4.18465.

[4] B. Assiri and W. Z. Khan, “Fair and trustworthy: Lock-free enhanced tendermint blockchain algorithm,” *Telkomnika (Telecommunication Computing Electronics and Control)*, vol. 18, no. 4, pp. 2224–2234, Aug. 2020, doi: 10.12928/TELKOMNIKA.V18I4.15701.

[5] S. Saberi, M. Kouhizadeh, J. Sarkis, and L. Shen, “Blockchain technology and its relationships to sustainable supply chain management,” *International Journal of Production Research*, vol. 57, no. 7, pp. 2117–2135, Apr. 2019, doi: 10.1080/00207543.2018.1533261.

[6] J. H. Grimm, J. S. Hofstetter, and J. Sarkis, “Exploring sub-suppliers’ compliance with corporate sustainability standards,” *Journal of Cleaner Production*, vol. 112, pp. 1971–1984, Jan. 2016, doi: 10.1016/j.jclepro.2014.11.036.

[7] B. T. Edmondson, “Blockchain explained: A simple overview of how it works,” *thebalancesmb*, 2019. https://www.thebalancesmb.com/blockchain-explained-4773366 (accessed Feb. 13, 2021).

[8] L. Ge *et al*., “Blockchain for agriculture and food : findings from the pilot study,” *TNO Innovation for life*, pp. 1-40, 2017. doi: 10.18174/426747.

[9] G. Zhao *et al*., “Blockchain technology in agri-food value chain management: A synthesis of applications, challenges and future research directions,” *Computers in Industry*, vol. 109, pp. 83–99, Aug. 2019, doi: 10.1016/j.compind.2019.04.002.

[10] B. Biswas and R. Gupta, “Analysis of barriers to implement blockchain in industry and service sectors,” *Computers and Industrial Engineering*, vol. 136, pp. 225–241, Oct. 2019, doi: 10.1016/j.cie.2019.07.005.

[11] I. J. Orji, S. Kusi-Sarpong, S. Huang, and D. Vazquez-Brust, “Evaluating the factors that influence blockchain adoption in the freight logistics industry,” *Transportation Research Part E: Logistics and Transportation Review*, vol. 141, p. 102025, Sep. 2020, doi: 10.1016/j.tre.2020.102025.

[12] S. S. Kamble, A. Gunasekaran, and R. Sharma, “Modeling the blockchain enabled traceability in agriculture supply chain,” *International Journal of Information Management*, vol. 52, p. 101967, Jun. 2020, doi: 10.1016/j.ijinfomgt.2019.05.023.

[13] I. M. Ar, I. Erol, I. Peker, A. I. Ozdemir, T. D. Medeni, and I. T. Medeni, “Evaluating the feasibility of blockchain in logistics operations: A decision framework,” *Expert Systems with Applications*, vol. 158, p. 113543, Nov. 2020, doi: 10.1016/j.eswa.2020.113543.

[14] P. Verhoeven, F. Sinn, and T. Herden, “Examples from Blockchain implementations in logistics and supply chain management: exploring the mindful use of a new technology,” *Logistics*, vol. 2, no. 3, p. 20, Sep. 2018, doi: 10.3390/logistics2030020.

[15] D. Y. Liao and X. Wang, “Applications of blockchain technology to logistics management in integrated casinos and entertainment,” *Informatics*, vol. 5, no. 4, p. 44, Nov. 2018, doi: 10.3390/informatics5040044.

[16] R. Cole, M. Stevenson, and J. Aitken, “Blockchain technology: implications for operations and supply chain management,” *Supply Chain Management*, vol. 24, no. 4, pp. 469–483, Jun. 2019, doi: 10.1108/SCM-09-2018-0309.

[17] M. M. Queiroz, R. Telles, and S. H. Bonilla, “Blockchain and supply chain management integration: a systematic review of the literature,” *Supply Chain Management*, vol. 25, no. 2, pp. 241–254, Aug. 2020, doi: 10.1108/SCM-03-2018-0143.

[18] Z. Xu and H. Liao, “Intuitionistic fuzzy analytic hierarchy process,” *IEEE Transactions on Fuzzy Systems*, vol. 22, no. 4, pp. 749–761, Aug. 2014, doi: 10.1109/TFUZZ.2013.2272585.

[19] X. Ouyang and F. Guo, “Intuitionistic fuzzy analytical hierarchical processes for selecting the paradigms of mangroves in municipal wastewater treatment,” *Chemosphere*, vol. 197, pp. 634–642, Apr. 2018, doi: 10.1016/j.chemosphere.2017.12.102.

[20] Deloitte, “Deloitte’s 2020 global blockchain survey from promise to reality, London, United Kingdom: Deloitte Insights,” *Deloitte*, 2020. [Online]. Available: https://www2.deloitte.com/content/dam/insights/us/articles/6608_2020-global-blockchain-survey/DI_CIR 2020 global blockchain survey.pdf.

[21] N. Kshetri, “1 Blockchain’s roles in meeting key supply chain management objectives,” *International Journal of Information Management*, vol. 39, pp. 80–89, Apr. 2018, doi: 10.1016/j.ijinfomgt.2017.12.005.

[22] M. A. Moktadir, S. M. Ali, S. K. Paul, and N. Shukla, “Barriers to big data analytics in manufacturing supply chains: A case study from Bangladesh,” *Computers and Industrial Engineering*, vol. 128, pp. 1063–1075, Feb. 2019, doi: 10.1016/j.cie.2018.04.013.

[23] Iansiti Marco and Lakhani R. Karim, “The truth about blockchain,” *Harvard Business Review*, no. February, pp. 1–11, 2017.

[24] Y. Wang, M. Singgih, J. Wang, and M. Rit, “Making sense of blockchain technology: How will it transform supply chains?,” *International Journal of Production Economics*, vol. 211, pp. 221–236, May 2019, doi: 10.1016/j.ijpe.2019.02.002.

[25] V. J. Morkunas, J. Paschen, and E. Boon, “How blockchain technologies impact your business model,” *Business Horizons*, vol. 62, no. 3, pp. 295–306, May 2019, doi: 10.1016/j.bushor.2019.01.009.

[26] H. Vranken, “Sustainability of bitcoin and blockchains,” *Current Opinion in Environmental Sustainability*, vol. 28, pp. 1–9, Oct. 2017, doi: 10.1016/j.cosust.2017.04.011.

[27] R. L. Rana, P. Giungato, A. Tarabella, and C. Tricase, “Blockchain applications and sustainability issues,” *Amfiteatru Economic*, vol. 21, no. Special Issue 13, p. 669, Nov. 2019, doi: 10.24818/EA/2019/S13/861.

[28] S. K. Mangla *et al*., “Barriers to effective circular supply chain management in a developing country context,” *Production Planning and Control*, vol. 29, no. 6, pp. 551–569, Apr. 2018, doi: 10.1080/09537287.2018.1449265.

[29] M. C. Lacity, “Addressing key challenges to making enterprise blockchain applications a reality,” *MIS Quarterly Executive*, vol. 17, no. 3, pp. 201–222, 2018.

[30] Y. Wang, J. H. Han, and P. Beynon-Davies, “Understanding blockchain technology for future supply chains: a systematic literature review and research agenda,” *Supply Chain Management*, vol. 24, no. 1, pp. 62–84, Jan. 2019, doi: 10.1108/SCM-03-2018-0148.

[31] Z. Xu, “Intuitionistic preference relations and their application in group decision making,” *Information Sciences*, vol. 177, no. 11, pp. 2363–2379, Jun. 2007, doi: 10.1016/j.ins.2006.12.019.

[32] M. Hanine, O. Boutkhoum, T. Agouti, and A. Tikniouine, "A new integrated methodology using modified Delphi-fuzzy AHP-PROMETHEE for Geospatial Business Intelligence selection," *Information Systems and e-Business Management*, vol. 15, no. 4, pp. 897–925, Nov. 2017, doi: 10.1007/s10257-016-0334-7.

BIOGRAPHIES OF AUTHORS

Abdesadik Bendarag holds a Ph.D. in corpuscular physics from the University Blaise Pascal Clermont Ferrand France. He has worked for two years as an ATER (Temporary teaching and research associate) in computer science at the University of Auvergne in the GTR and Computer Science departments. He is currently an assistant professor in the Mathematics and Computer Science Department at the Polydisciplinary Faculty of Safi, Caddi Ayyad University. He is a member of the L.M.C. Laboratory, Polydisciplinary Faculty of Safi UCAM, Safi, Morocco. He can be contacted at a.bendarag@uca.ac.ma.

Omar Boutkhoum is an Associate Professor at computer Science department in the Faculty of Sciences of Chouaib Doukkali University, EL Jadida, Morocco. He received his PhD degree in Computer Science from the Faculty of Sciences and Techniques of Caddi Ayyad University, Marrakesh in 2017. His research interests are in the application of decision support systems and Blockchain technology to sustainable supply chain management. He can be contacted at email: boutkhoum.o@ucd.ac.ma.

Driss Abada is an assistant professor at faculty of science, Chouaib Doukkali University, Morocco, since May 2019. He received Master's degree in Computer Science and Distributed Systems form faculty of science, Ibn Zohr University, Morocco, and Ph. D degree in Computer Science with specialization Networks. He is member of both lab, Information system and Computer Vision Lab, Department of Computer Science, Faculty of science, Ibn Zohr University, Morocco, and LAROSERI Lab, Department of Computer Science, Faculty of science, Chouaib Doukkali University, Morocco. His research interests are in wireless ad-hoc, Internet of things and 5G. Particularly, he works on wireless routing, routing protocols in Internet of things, inter-vehicular communications and security, Quality of service, and MAC layer performance evaluation. Recently, his researches are focused on clustering communication in heterogeneous wireless networks such as VANET and LTE (4G). He can be contacted at email: drissmisr@gmail.com.

Mohamed Hanine is an Associate Professor at the National School of Applied Sciences, University of Chouaib Doukkali, EL Jadida Morocco. He Holds a PhD degree in Computer Science with specialization in spatial decision making. His research areas are Big Data, Multicriteria Decision Making, and Business Intelligence. In 2017, he obtained the Ph.D. degree in computer science from the University of Cadi Ayyad, Marrakesh (Morocco). Then in 2018 he joined the Department of Telecommunications, Networks and Computer Science at the National School of Applied Sciences, teaching engineering students in the area of Big Data and Business Intelligence. He can be contacted at email: Hanine.m@ucd.ac.ma.