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Digitalization of Operations Management with Emotional and Intelligence Tools. Blockchain and IoT integration, the last disruption?

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ABSTRACT

Digital advances and the emergence of disruptive technologies have dramatically changed the business models across sectors and operations economics. The scope of this paper is to contribute to analyze the current disruptive revolution in operations management in a digitalized global market focusing on the impact of blockchain technology and IoT integration. New intelligence tools and emotional analysis are contributing to add trust and promote digital expansion across different sectors. Given the high economic impact of the operations management on virtually all productive enterprises, the benefits of digitalizing operations have continuously increased productivity and enhanced international competitiveness. This paper studies the opportunities of what could be one of the last disruptions in operations management, the introduction of blockchain combined with IoT technology and emotional intelligence tools to automate, in a cryptographically verifiable process, activities in digital supply chain networks.

Keywords: Blockchain, IoT, Supply Chain Network, Operations Management, Digital Policy

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JEL Codes: L23, L81, M11

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1. Introduction

New digital advances and the rapid decline in communication costs have effectively changed the landscape in operations management in a few decades. Efficient management of the supply chains has become more complex than ever. Old tools that were valid for the business yesterday are no longer suitable for business today. The digital transformation is causing disorders for all kinds of real-world agents and processes. Empowered customers used to online services and real time information in their mobile devices have more demanding expectations than customers in the past.

One of the more potential innovations for most production sectors is the recent introduction of distributed ledger technology (DLT), related with digital currencies and the anonymous online ledger technology better known as blockchain (Boucher, 2017). Another technology with a great potential to deliver digital business advantage is the Internet of things (IoT) (Burton & Barnes, 2017), defined by the International Telecommunication Union (ITU) and the European Research Cluster on the Internet of Things (IERC) as “a dynamic global network infrastructure with self-configuring capabilities based on standard and interoperable communication protocols, where physical and virtual things have identities, physical attributes and virtual personalities and use intelligent interfaces and are seamlessly integrated into the information network”. These new technologies and the transformations from the business perspective have received increasing attention across business sectors, policy makers and regulatory authorities, mainly competition authorities (PWC, 2017; Renda et al., 2016; CEPS, 2014).

Early adoption of new technologies has a major impact on improving business performance and competitiveness in a global economy, *vid.* Europe’s Digital Economy and Society Index Report 2018 (EC, 2018). In the last years, access to high capacity networks and digital advances across the world, new devices, high-end tools, and SW solutions, have evolved from the benefit of larger corporations to the benefit of all sort of agents, small and medium enterprises (SMEs), primarily.

This paper aims to identify strengths, weaknesses, opportunities and threats of blockchain technology and the disruptive influence that blockchain and IoT with emotional intelligence tools could introduce in supply chain networks (SCNs). There are many concerns about scalability, costs, or fair trade, e.g., about the adoption of digital tools, but not only. Regulatory challenges regarding the dimensions: performance, competition, openness and innovation of operations management in the different sectors need to be better analyzed. This paper explores by a detailed analysis of the literature, influential factors for the development and application of these technologies in SCNs, and contrast the relevance of those factors with the responses received from interviews and surveys with relevant experts on retail, supply chain, logistics, finance and technology. The rest of the paper proceeds as follows. Section 2 introduces enabling technologies in digital supply chain networks; Section 3 details the proposal for emotional analysis as linked data with digital platforms; the next Section 4 explains the research methodology followed; Section 5 offers results; finally, conclusions and future research are given in Section 6.

2. Digital Platforms and Operations Management

The early adoption of digital technologies provides many competitive advantages. That is the situation in operations management. In the case of IoT adoption revenue growth is by far the largest driver of its adoption for now (PWC, 2017). IoT essentially connects physical objects to each other through the Internet, and as a result of those interactions between the different elements new, or additional activities or actions; or data gathering to monitor the system, are facilitated and permit the interacts with the environment. The growth of high speed and reliable connections and internet have made these opportunities emerged with multiple solutions and applications in almost all economic sectors, from smartphones to wearables, or cloud systems.

The opportunities offered by cross-cutting IoT business models are growing, close to 30 billion devices – e.g, wearables, or sensors integrated in larger systems – will be connected in 2020, according to McKinsey (2015) forecast. The US has been one of the countries where IoT market opportunities have increased recently. There are many initiatives to promote autonomous vehicles, applications and use cases for the energy sector, agriculture, retail, personal wellness, smart building, clinical care for example; and across industries, e.g., manufacturing, logistics, banking, insurance, transportation, education, telecommunications, among others. The EU has started a recent strategy to promote IoT connectivity searching for the desired economic growth, and a competitive position in the global landscape. Trends regarding expected growth IoT can boost for the next years differ across the regions if current evolution persists. Asia Pacific region followed by North America take the top positions of revenue generation by IoT (IDC, 2017), Europe, on the other hand will need a few years to achieve similar numbers.

Blockchain has been defined as another disruptive technology (Bashir, 2017). Blockchain started its expansion later than IoT. Digital Distributed Ledger Technology (DLT) became known by the general public thanks to the crypto-currency bitcoin, launched in 2008. The core code of bitcoin was made public in April 2009, since then the number of projects related with blockchain has grown significantly to more than 20.000 thousand in 2017, as registered in one of the main open platforms, GitHub (Deloitte, 2017). Ethereum and other blockchains were introduced after bitcoin with new and additional characteristics, making Ethereum, e.g, a very interesting technology not only with the purpose of being another digital currency but with a wider perspective, and in that sense much better for operations management. Blockchain technology, e.g., prevents multi-operations within the supply-chain among partners and other agents, and brings high savings in time and capital expenditure in the provision of materials, products or services (e.g., technology services). Decentralization of operations, without a third party, e.g., decentralizes retailer logistics provider ledger (Polim et al., 2017); and disintermediation limits gatekeepers possible market power. At the same time cost of transactions is reduced, e.g. one suitable application is keeping custom records from shipper, to export, logistics, customs, quality and audit trail. There are many pilots and working cases

currently active on those applications. Apart from the reduction of time, the integrity of the information and records of all the steps across the SCN add high value.

Blockchain used with IoT technology can improve security compared with current IoT system working without DLT, within communications security in the transaction processes (Kshetri, 2017). But the improvements blockchain introduces go far beyond. One of the most valuable characteristics of blockchain is the smart contracts application. The automation of processes when smart contracts are applied to IoT has even major potentials (Christidis, K. & Devetsikiotis, M., 2016). Smart contracts are automatically executed when contractors' specifications are satisfied and the laws and legal requirements are applied, e.g., fulfill unfair competition law, i.e., business-to-business unfair trading practices in the retail supply chain (CEPS, 2014). Business cases in the financial sector have received increased attention by financial institutions (Bank of England, 2017) but also from non-financial industries and institutions, i.e., manufacturing, supply chain or retail (Hileman & Rauch, 2017).

The introduction of new IoT and blockchain technologies ranges from applications improving traceability, i.e., of food products (Olsen & Borit, 2018); to Supply Chain Management e.g., – procurement, certificates, maintenance repair and operations, product safety –, (Gao et al., 2018); Logistics – tracking and tracing, customs... – (Sánchez et al., 2017; DHL, 2018); Services, e.g., processing, payments; Finance, e.g., insurance, trade and asset management, capital flows (Benos et al., 2017).

Customers are at the center of supply chains (Chopra, 2015). Internet has transformed many aspects of citizen's life, and with that, demand patterns throughout the supply chain (Seethamraju, 2014). Integration and coordination among the agents has been an open issue to be continuously improved (McCrea & Bridget, 2018), due to the competitive advantages related to internal factors, e.g., efficient coordination and trust, but also for external factors, e.g., green supply chain and sustainable processes (Fu et al., 2018; Irani et al., 2017). UN Sustainable Development Goals are also introducing changes in operations management with new partnerships to achieve the goals.

Major impacts on traditional supply chain management are being introduced by consumers' preferences, and online access to markets where the Information and Communications Technology (ICT) is strategic (Boschian & Paganelli, 2016). New platforms of e-commerce with new global players and economies of long-tail have emerged. Competition is even stronger than ever as markets are becoming global. Applications of blockchain and IoT in supply chains can introduce positive effects due to some of the characteristics provided: transparent, verifiable (transactions chronological and timer stamped), efficient and decentralized (limited gatekeepers), auditable, reliable (transactions are securitized cryptographically).

However, there are many concerns with the adoption of blockchain regarding compliance with General Data Protection Regulation (GDPR) (Olly, 2018) and applicable laws, including competition. But there are other sorts of concerns, e.g., increasing cyber-risks in the digital environment could be a threat for its implementation in certain cases, and

other problems could emerge related with possible bugs in the code. No system is designed with complete guarantee, and Ethereum, for example, an unpermissioned public distributed ledger, that includes the smart contract application has a cryptographically verifiable process in blockchain. However, there are different sort of blockchains, i.e., mainly public or private, permissioned or unpermissioned, and the level of security and consensus mechanisms established differ, and with that, the computational consumption.

3. Emotional Analysis as linked data & IoT

The research field of analysis of feelings and emotions has attracted new interest with Internet expansion. Social media is ubiquitous, everywhere, every time. For researchers interested on customer's perception, – e.g., marketing research, psychology or socioeconomic research – social networks and the way citizens and consumers express their emotions, their satisfaction and disapproval with services, products, brands, companies, etc., is of great importance (He et al., 2015). Marketing intelligence is often applied to the development of new products and services (Trainor et al., 2013). Business Intelligence focusing on internal processes and strategy has experienced great attention in recent years and new approaches have been incorporated gathering data from different sources. Examining the roles of the different agents within the supply chain can provide a new advance towards the automation that new digital technologies like IoT can provide combining the flexibility of blockchain and smart contracts application, defined in this context as self-executing software that triggers automatically to perform certain transactions and all of them are registered and traceable. There is a lack of standard emotion representation model (Sánchez-Rada et al., 2017) that is the major reason why this research area has to evolve to provide suitable emotion languages and ontologies for the definition of better models (Cambria et al., 2012), and as a result of it be introduced in the IoT ecosystem making them interoperable.

The next frontier can be the design of new models of sentiment lexicons to be incorporated (Araque et al., 2017) in the ubiquitous IoT devices and connect them to transfer data with security and reliability in the blockchain smart contract specification (Kim & Lakowski, 2018) to trigger the processes as specified by the contractors. In this application emotional and sentiment analysis opens new opportunities of design of value-added services where customers' perception and expectations could be fulfilled with emotional and intelligence tools integrated in the digital supply-chains or DSN.

4. Research design

This paper aims to identify strengths, weaknesses, opportunities and threats of blockchain technology and the disruptive changes Operations Management, and in particular, Digital Supply Networks (DSNs) could experiment thanks to blockchain and IoT adoption with emotional intelligence tools.

To conduct the goals, the process of the research follows two steps.

Step 1, has the objective of identifying and classifying the key influential elements: Strengths, Weaknesses, Opportunities and Threats (SWOT) analysis on blockchain and IoT integration. To achieve this step a deep and large exploration analysis of the extant academic literature on technical, social and economics of blockchain, IoT, Operations Management, and Supply Chains have been done. Apart from peer-reviewed journals spanning across different disciplines, public research reports and business studies by consulting firms and think tanks have also been analyzed.

Step 2, is based on results of the previous step. In order to find objective evidences to address the research questions: What is the current state of knowledge regarding blockchain and IoT integration opportunities and challenges; and how could emotional and intelligence tools provide a cutting-edge advancement to SCNs. A target group of businesses experts, supply-chain agents in the retail sector, including SMEs, start-ups, research centers, and consulting and services firms have been interviewed to gather qualitative, and quantitative information about the impact of blockchain & IoT integration in the future business models and operations management through a questionnaire. The questionnaires have been designed to achieve the research objectives. The questionnaires were structured with closed questions but also opened ones, depending on the sort of question with the option: “Others. Please specify”; or “Optional Remarks”. The methodology proposed by Miles & Huberman (1994) was adapted to our case. Each factor – entry of the SWOT matrix – has been rated by the respondents using a scale of less important (1) to more important (5), five possible degrees.

Data

An e-mail invitation to access an online survey was sent to the experts selected. In most cases a previous contact had been established, short meeting, or phone call. The Field work (survey phase) took place during June/July 2018. The final number of valid questionnaires was 50. The sample is short; but large enough for our research purpose, according to previous research studies on cutting-edge technologies where the number of experts is much more limited than what the total population may suggest as first sight.

The profile of the experts participating in the survey is shown in Figure 1. There is one group of experts, those working for consulting firms that account for nearly half of the experts’ participation on the survey. The rest of participants work for public and private enterprises, large enterprises, but also SMEs and start-ups mainly working in the technology business.

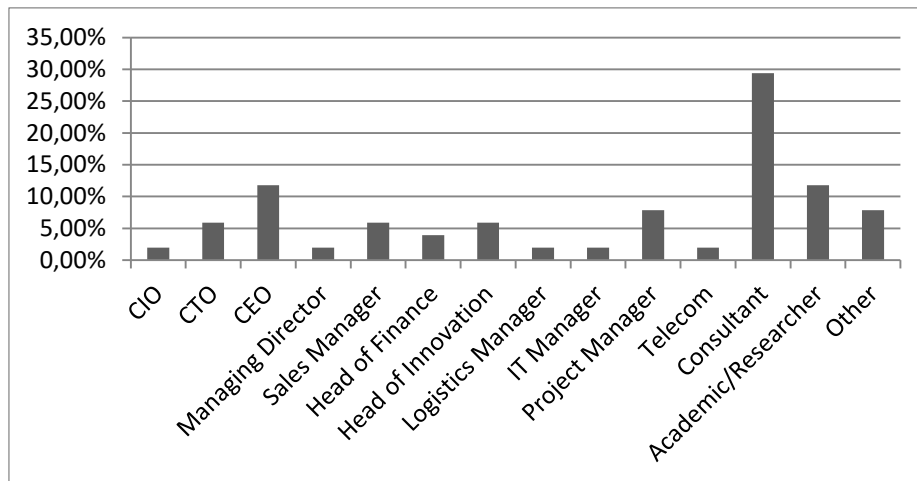


Figure 1. Interviewees Profile

Under the “Other” option there are representatives of industrial associations, and policy makers.

The main sectors and activities where the experts that took the survey work are shown on Figure 2. Consulting and technology firms are the areas where most experts work.

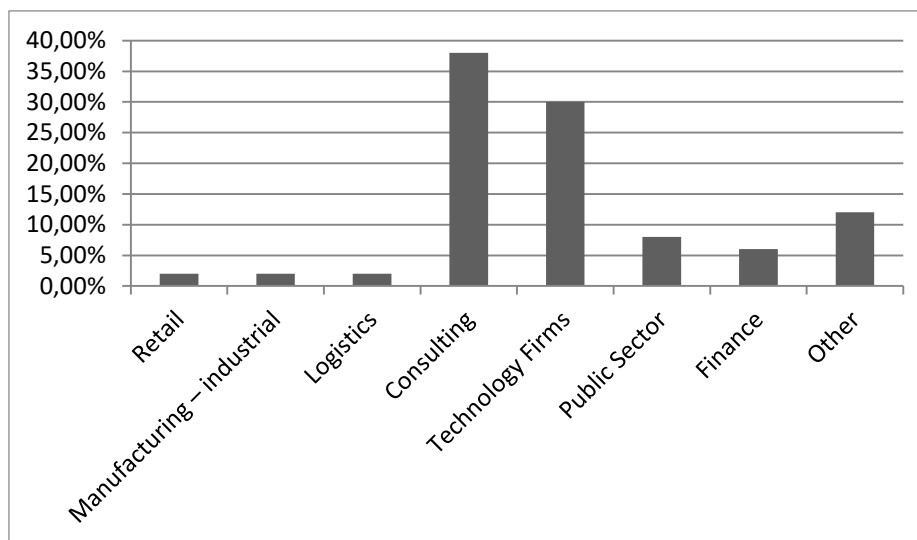


Figure 2. Main activity by sector

For “Other” sector: media, and private research centers and academia were specified by some of the respondents.

5. Results

Preliminary key findings from the interviews and surveys conducted regarding the incorporation of blockchain projects to current activities in their processes and operations is shown in Figure 3. More than 60% of the respondents said that their companies/institutions were already working on blockchain. Under “Others” respondents

said they had no visibility of that in the short time due to the character of the company, one of them pointed out that they were working on blockchain technology for their customers. There is clear vision of the opportunity that blockchain, in particular, and digital technologies, in general terms, have in the short and medium term.

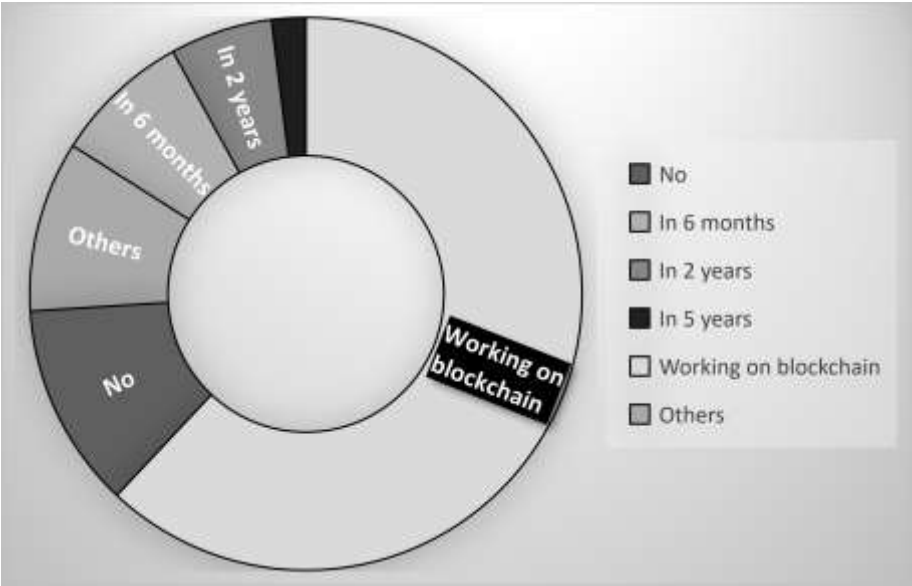


Figure 3. Status of blockchain initiatives (time-frame)

Due to the novelty of the technology, in particular, blockchain projects have been classified attending at the level of development achieved. Respondents classified what was that level for the projects they have participated in or on-going. Figure 4 shows that, most of projects are still in the first steps of development. Design of concept (idea) or Proof of concept (demo phase), followed by Pilot stage (use case, with real participants) accounted for around 80% of results.

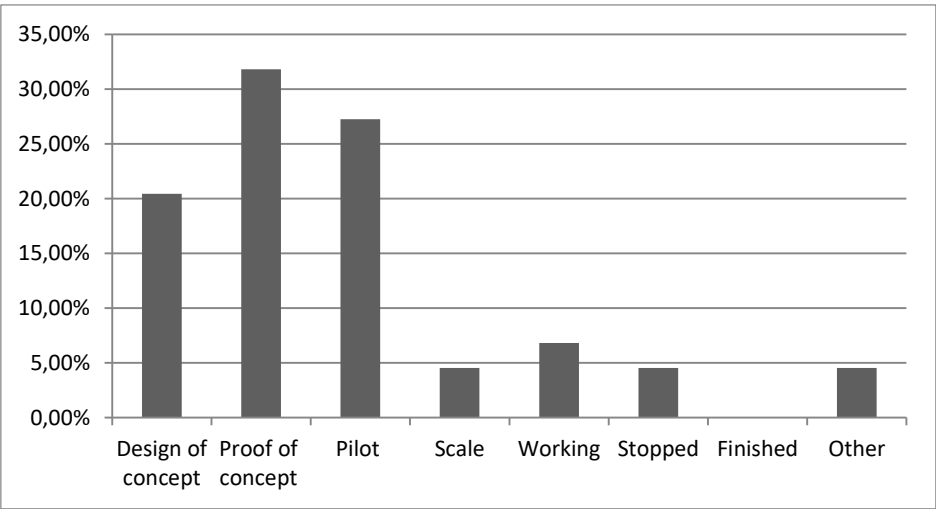


Figure 4. Level of development of the blockchain project

Much more mature projects as Scale phase, i.e., end-to-end implementation; or already Working were closer to 5%. Some of the projects have been stopped due to lack of support and/or resources.

5.1 SWOT Analysis

SWOT analysis provides in a structure way the strengths, weaknesses, opportunities and threats. The SWOT matrix have been created after the literature review process (Step 1).

In the academic, other SWOT analysis of blockchain technology can be found i.e. Gateschi, et al. (2017), however none of them, as far as we have reviewed has accomplished the second phase of the validation of the analysis with the methodology proposed.

Strengths	Weaknesses
<ul style="list-style-type: none"> • Speed of transfers • Low transaction costs • Lower infrastructures' costs • Security and no resilience on third party • More secure (distributed network) • Higher Efficiency (decentralized network without intermediaries) • Automation of processes (intelligence and smart contracts) • Transparency • Accessibility • Audit trail 	<ul style="list-style-type: none"> • Difficulty of scalability • Network performance • High energy consumption • Security and data privacy • Hacking risks • Dispute resolution • Volatility of cryptocurrencies as a payment method • Technology maturity • Alternative technologies • Robustness
Opportunities	Threats
<ul style="list-style-type: none"> • Business process optimization • Synergy with other digital transformation tools (IoT) • New opportunities of services and market niche • Data availability and business intelligence • Integration with other applications and uses in different sectors (e.g., insurance, finance, quality) • Privacy • Decentralization (no reliance on intermediaries) • Costs reduction (operational efficiency) 	<ul style="list-style-type: none"> • Perception of lack of secure and robust technology • Growth. Problems with Scalability & standards • Regulatory uncertainty • Legal compliance (i.e., GDPR) • Time (Technology adoption –medium, long term) • Interoperability and legacy (adaptation of processes) • Need of personal interaction among stakeholders

Figure 5. SWOT

Main findings of the questionnaires, to gather evidence on strengths, opportunities, weaknesses and threats to validate the SWOT analysis are summarized below.

Key finding. Strengths

Figure 6 shows the degree of importance of the different sources of strength. Automation of processes – using intelligence and emotional tools and the introduction of smart contracts to configure the automation – received the highest values (4-5) by 86% of the respondents. Respondents also highlighted transparency 54% of respondents valued it with the highest score, 5. And Security as a result of the distributed architecture of nodes and devices, 64% of respondents gave it a 5 score. Security in terms of resilience on third party received the highest score, 5, by 56% of respondents.

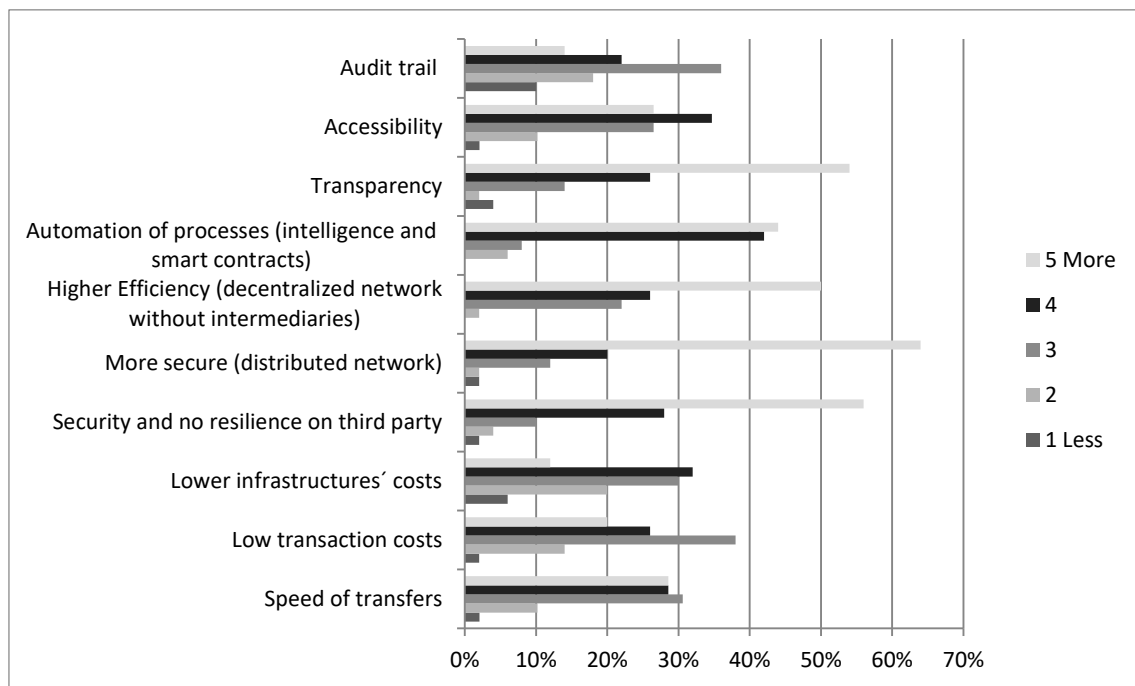


Figure 6. Strengths

Speed of transfers was highlighted with scores over 3 by 82% of respondents. Regarding Lower transaction costs in supply chain networks, respondents who scored 3 or more were nearly 84%. On the other hand, 74% of respondents considered with 3 to 5 the strength Lower infrastructures cost.

Less than 28% of respondent gave less importance (1-2) to Audit trail and around 12% considered Accessibility not so important (1-2).

Key Findings. Weaknesses

The low level of maturity of technology is a major weakness by 18% of respondents, followed closely by Volatility of cryptocurrencies, to be used as method of payment a major weakness risk (5) by 16% of respondents. Scalability of the proposal is the third weakness for respondents the highest value (5) was given by 15% of respondents.

On the other hand, hacking risks are the less important weakness by 48% of respondents, what is aligned with the security perceived by the experts when they scored strengths. Followed by mechanisms of Dispute resolution i.e., the absence of an intermediary role in the event of needing advice or problems, that received the less score (1) by 30% of respondents; similar numbers apply to alternative technologies (32%) or high energy consumption (34%) – due to the computational power, related with hashing cryptography and mining –.

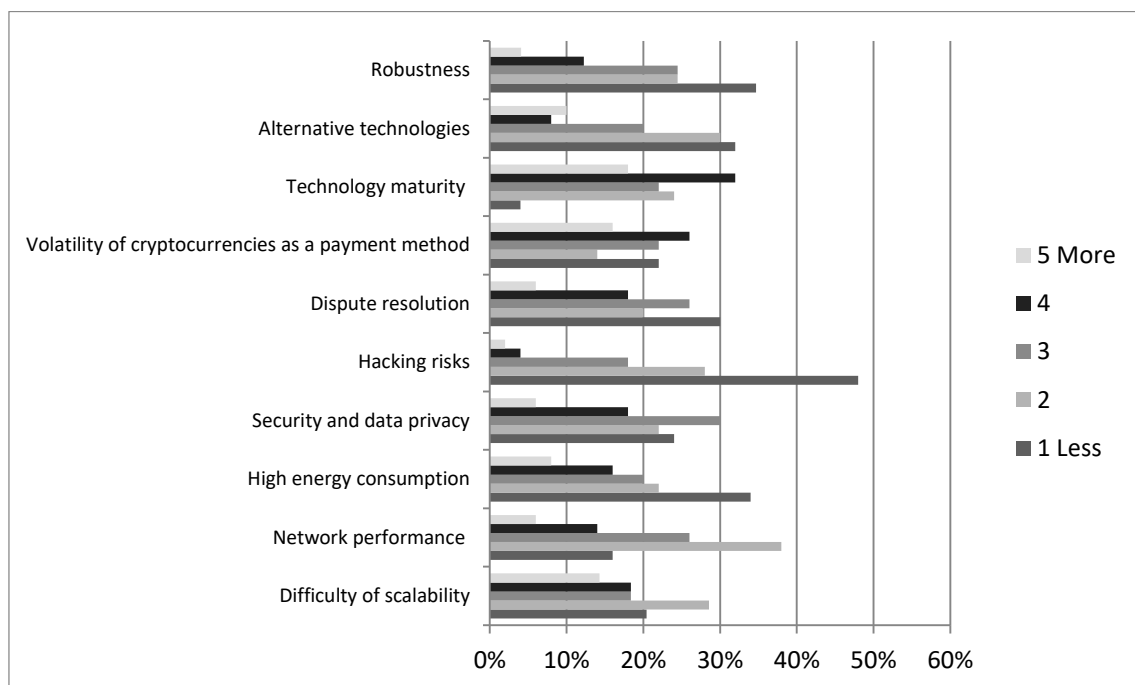


Figure 7. Weaknesses

Other issues respondents identified as weaknesses were Interoperability, and the Speed of the transactions that could become problematic in terms of massive and global platforms; or the lack of global cases working for now. Literature review showed some less potential weaknesses, e.g., Lack of qualified professionals (labor); and also problems that could emerged regarding updates and infrastructure costs and maintenance.

Key Findings. Opportunities

Decentralization is valued as one of the more attractive opportunities of this new technology according to 50% respondents that gave it the maximum score (5). In supply chain networks the absence of intermediaries and gatekeepers has been one of the traditional challenges in terms of efficiency gains and costs reduction but also related with competition advantages. 44% of respondents considered that opportunities of new services and markets could emerged more easily (5) with the introduction of the technology. Synergy with other digital transformation tools in IoT and new artificial intelligence (AI) developments is very good opportunity (4-5 scores) by 70% of respondents.

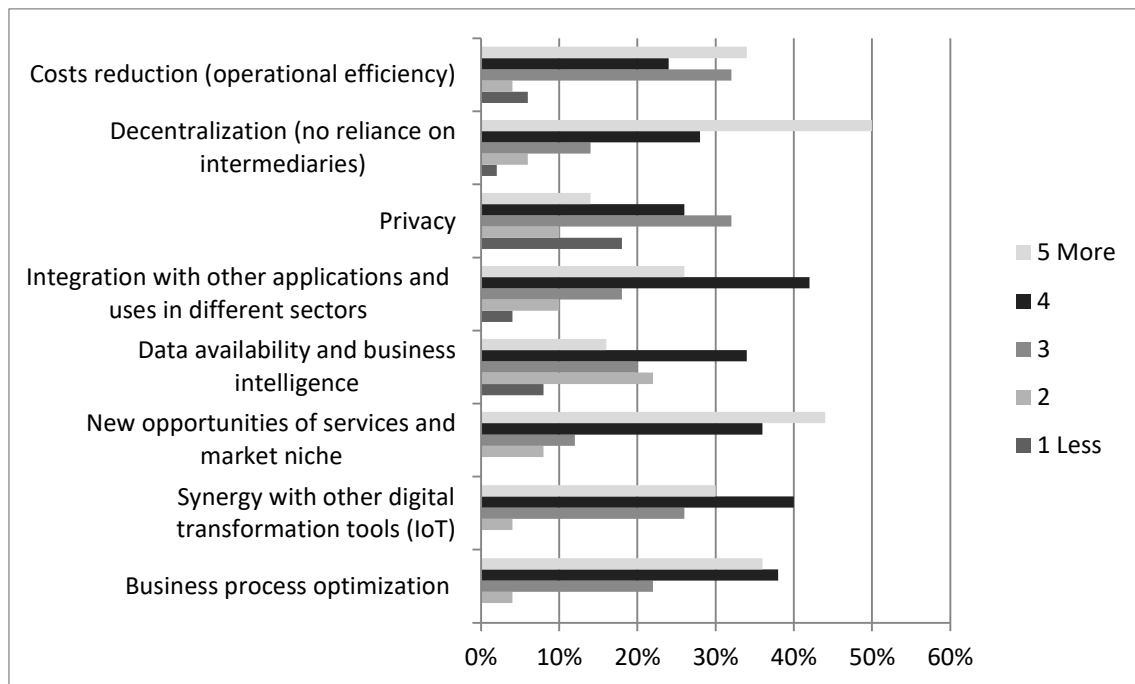


Figure 8. Opportunities

Integration with other applications or uses in different sectors (e.g., insurance, finance, transportation, energy, telecommunications, education) was valued over 4 by 68% of respondents.

Privacy, in terms of anonymity is one of the elements that blockchain introduces by design, 28% respondents considered it is not so good opportunity (score 1-2).

Data availability and possible uses for business intelligence is considered a good opportunity (over 4-5) by 50% of respondents.

Key Findings. Threats

Main threats in importance, that respondents highlight with max. importance (5), are regulatory uncertainty by 32%, followed by legal compliance by 20%, and by far the rest of threats, i.e., Growth and problems related with scalability and standards, by 6%. The other threats are valued only by around 4% of respondents with such degree of importance.

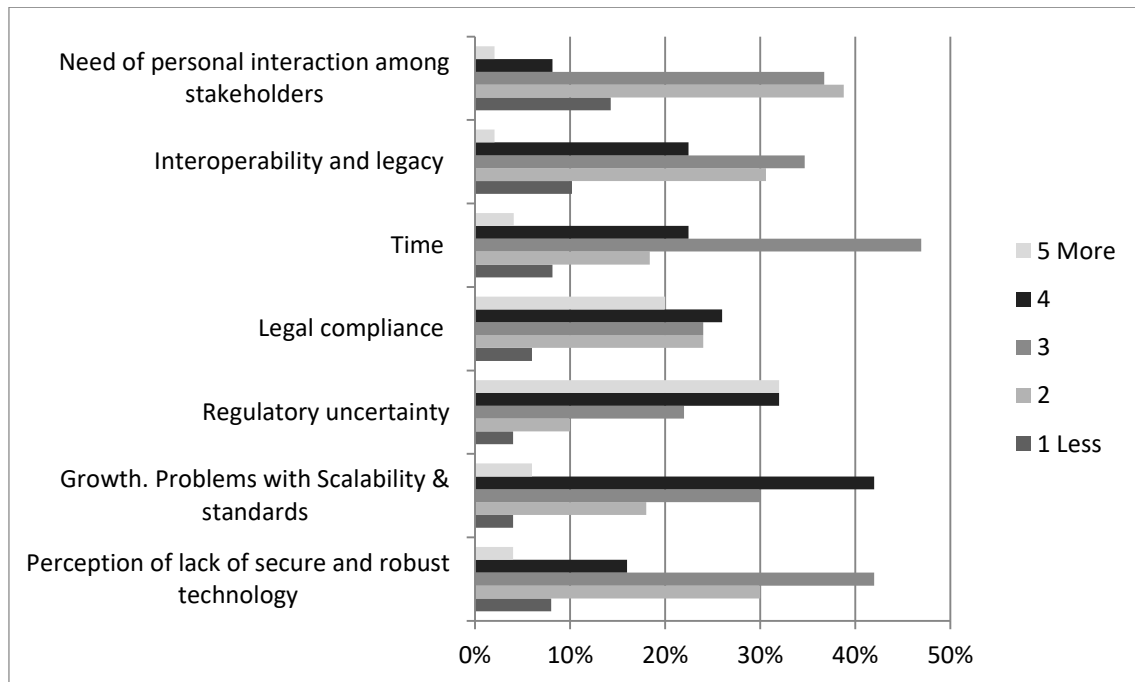


Figure 9. Threats

Legal compliance (i.e., GDPR), is a complex problem according to the respondents 70% consider that it is an important threat (score 4 or 5).

Regarding Time (Technology adoption – short, medium, long term –) most respondents, 47%, consider the importance is relative in terms of threats as the technology will be much more mature and the uncertainty will be reduced.

Interoperability and legacy, i.e., the adaptation of processes is considered by 59% of respondents an important threat (score 3 to 5).

Perception of lack of security, or not robust enough technology, though it is not valued as a high important factor, however is considered by 42% of respondents a factor to consider (score 3).

The need of personal interaction with stakeholders is considered by 52% less important (1-2) against those that considered it important but not so much 37% (rated 3) only the 11% left considered it much more important. Communication with other agents, e.g., in

the supply chain network, its related with social codes and cultural aspects, behavior that can be a barrier in terms of interaction man-to-machine, is a threat nowadays, but in the future could be solved by machine-to-machine interfaces with the aid of emotional integrated in the interfaces.

6. Conclusions and Future work

IoT and blockchain are some of the main technological trends of the moment. The flexibility of IoT – that can be incorporated in all sort of devices and sensors – combined with the potential of blockchain, thanks to the different designs and applications, may provide automated responses validated or authorized with the nodes of the network and in the future taking advantage of AI emotional and sentiment analysis, major disruptions in a complex digital ecosystem of devices, individual, organizational and even artificial actors. The introduction of IoT technology, and more recently blockchain technology – initially associated to digital cryptocurrencies – have brought new elements for a large disruption at all-levels within the productive enterprises. A new level of organizing and a better simplification of operations with a cost reduction that can enable more agents to benefit of the early adoption of IoT devices and blockchain technology with emotional tools.

The contributions of this research have focused on identifying main strengths, weaknesses, opportunities and threats related to blockchain and IoT as new tools providing applications for value creation, planning and executing in operations management and supply chain networks.

The identification of relevant factors has been done through literature review, and has gone further with the validation of those factors with a panel of technology and industry experts. The definition of categories previously established has been supported with the empirical results. There are great opportunities and strengths but there are also some challenges mainly related with the uncertainty of what the future may bring. Regulatory challenges, Blockchain, IoT and AI implementations will need a new global regulatory framework, competition, security and data protection policies. The challenges of blockchain & IoT, are at the same time opportunities to better introduce cooperative solutions against global threats. Like happened with the Internet it will be difficult to set barriers in the digital space, or global legal frameworks.

Disclosure statement

No potential conflict of interest by the authors

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