**Influence of blockchain adoption on technology transfer, performance and supply chain integration, flexibility and responsiveness. A case study from IT&C medium size enterprises**

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**Abstract**: In this manuscript we intend to analyze how blockchain technology can improve supply chain variables and technology transfer in medium-sized enterprises from IT&C sector. Blockchain technology is expected to enhance the velocity and reliability of business and managerial processes and increase competitiveness for IT&C companies. We sought to see if these combined elements lead to the generation of competitive advantage, which in turn influences the firm performance. Based on the study of relevant literature, we developed a conceptual and methodological framework and test it on 383 medium-sized companies from IT&C sector, using the Confirmatory Factor Analysis. The results of the study show that blockchain technology positively influences supply chain variables and technology transfer, with direct effects on the firm performance.

**Keywords:** Blockchain, Supply chain management; Technology Transfer, IT&C

1. Introduction

Blockchain is a disruptive technology that can transfigure “business-as-usual” practices. It is a significant source of innovations in business and management by its effects of improvement, and optimization of the business processes (Ying et al., 2018).

Blockchain-enabled applications are present across diverse sectors such as business, data management, education, finances, healthcare, industry, IoT, privacy and security.

One of blockchain main applications area is supply chain networks, where this technology leads to an enhancement in visibility and responsability (Ahram et al., 2017; Kshetri, 2018; O’Leary, 2017) in three areas: visibility, optimization, and demand.

As companies focus on increased global competitiveness, supply chains are facing new problems and challenges. These include increasing pressure to reduce operational costs, improve quality, improve customer service and ensure continuity of supply (Ceptureanu et al., 2019). Nowadays, supply chains are characterized by an increased reaction to changes in customer habits, the orientation towards globalization of activities, the integration of distribution and sales channels and the widespread introduction of new communication technologies. Organizations in the supply chains are obliged to constantly restructure and re-engineer to increase their efficiency and to satisfy their customers. This requires companies to look beyond their organizational boundaries and evaluate how the resources and capabilities of suppliers and customers can be used to create exceptional value. The supply chain uses modern technology to gain a competitive advantage over competitors Modern supply chains become complex owed to business internationalization, fast growing customer demand and decreased product life cycle. The digitalization of supply chains is a solution to meet these challenges (Pereira, 2009).

Existing research on supply chain management is characterized by evolving definitions and contradictions (Van der Vaart et al., 2008). While some researches focuses on the individual dimensions of supply chain (Cousins and Menguc, 2006; Koufteros et al., 2007) others use various omnibus definitions (Rosenzweig et al., 2003), examining supply chain as a single construct. Moreover, some conceptualizations of supply chain are incomplete, which have led to inconsistent findings about the relationship between supply chain and performance (Germain and Iyer, 2006; Das et al., 2006; Devaraj et al., 2007).

In the current economic context, characterized by the internationalization of activities and a tendency to reduce costs, there is a paradigm shift from traditional IT&C to smart and sustainable IT&C (Michael, 2017). IT&C companies are looking for modern information technology solutions to simplify supply processes, coordinate the activities of the supply chain members, and as a general effect, improve the performance of the company (Scholtz- Reiter et al., 2010; Topal et al., 2018).

Blockchain offers greater transparency in transactions between members of the supply chain and synchronization of the processes between the supply chain members and has become a way to achieve competitive advantage (Yli-Huumo et al., 2016). Blockchain technology offers a transactional platform for providing members of the information supply chain with a higher speed, improved accuracy and information sharing possibilities according to knowledge-based company principles, with beneficial effects on improving the distortion, filtering, redundancy and overloading of information circuits between members.

Kshetri (2018) consider that blockchain transactions are much cheaper than by any other equivalent means. The result of this technological architecture is better traceability and resolution of reliability issues among supply chain members. The blockchain academic relevance has already been recognized for supply chain management (CSM) and logistics (Kshetri, 2018). Moreover, a substantial number of researches in the field are already published that critically investigate the blockchain (Romano et al., 2017) and its potential applications in the SCM / logistics field (Hackius et al., 2017). Blockchain can bring about improvements in transactions that can be useful to members of the supply chain (Tapscott et al., 2017). Unfortunately, blockchain has many practical challenges; namely, companies don’t invest in employee training, high implementation cost, required dedicated skills, etc. In addition, most of the entrepreneurs involved in supply chain networks are not fully aware of the benefits of the blockchain that can provide a competitive advantage both for the network and to their own companies. Poor understanding of the blockchain concepts and practices are also a reason for a lower adoption rate (Andoni et al., 2019) and empirical evidence are weak (Saberi et al., 2018). The current research will try to fill this gap by linking the blockchain with the supply chain, generating competitive advantages and organizational performance for the small and medium size enterprises from IT&C sector (Chari et al., 2008).

The paper is organized as follows: In section 2, we made an extensive literature review and establish the development of hypotheses. The following section analyzes the methodology, the measurement model and the structural model analysis. Section 4 allows us to examine and discuss the main findings and contributions. Finally, Section 5 concludes the paper, current limitations and future research pathways.

2. Literature review and hypothesis development

**2.1 Blockchain overview**

A blockchain is a distributed peer-to-peer linked data structure in a format of an *append-only timestamped* database that is organized as a list of ordered blocks, where the registered blocks are unalterable. The nodes of the network are linking the blocks to each other in chronological order, every block containing the hash of the previous block (Crosby et al., 2016). The resulting distributed peer-to-peer network allows the interaction of any members without the need for a trusted authority (Christidis et al., 2016). To achieve this one can consider blockchain as a set of interconnected mechanisms which provide specific features to the infrastructure, as illustrated in Figure 1 (Casinoa et al., 2019), where:



**Figure 1**Blockchain architecture

* The lowest layer consists of***:***
	+ ***Transactions***between peers that indicate an agreement between two participants for transferring physical or digital assets, completing a task, etc. A transaction is signed minimum by one participant, and it is disseminated to its neighbors.
	+ A *node* represents an entity connected to the blockchain. The nodes that control all the rules in the blockchain are called *full nodes*. Their role is to group the transactions into ***blocks***and to establish the valid transactions that have to be kept in the blockchain.
* ***Consensus***layer has the goal to keep in the blockchain only the transactions agreed by the nodes and which will not corrupt branches or cause divergences (Vukolić, 2015; Christidis and Devetsikiotis, 2016). There are several consensus approaches depending on the blockchain type (Mingxiao et al., 2017): *Proof-of-work (PoW)* (Antonopoulos, 2014), *Proof-of-Stake (PoS)* (Pilkington, 2016), *Byzantine Fault Tolerance (BFT)* (Castro and Liskov, 2002) and its variants (Zheng et al., 2016).
* ***Compute Interface*** layer provide blockchain with an enhanced functionality by storing simple or complex states and allowing (advanced) applications to provide information to the users
* ***Governance***layer extends the blockchain architecture to cover the human interactions taking place in the physical world. It deals with how diverse actors from the physical world come together to produce, maintain, or change the inputs that make up a blockchain.

Different types of blockchain application are presented in Table 1.

**Table 1.** Types of blockchain applications



**2.2 Connections between blockchain technology, information systems and supply chain**

Recent studies have focused on effects associated with use of information systems in supply chains. There is evidence that supply chain coordination and integration are facilitated by the use of integrated information technologies (Vickery et al., 2003) and IT&C integration capabilities (Rai et al., 2006), and lead to improved firm performance. Shah et al. (2002) suggest that supply chain practices such as supply chain integration, and initiatives such as building long-term relationships with suppliers, require extensive use of web based interchange; and thus the support of inter-organizational information systems. Arguing that supply chains at different levels of integration and coordination require different levels of technology integration, they propose a conceptual framework suggesting that a high (low) level of supplier integration must be matched with a high (low) level of IT&C integration in order to achieve superior supply chain performances. Premkumar et al. (2005) examine procurement related information processing needs (from uncertainties in the product market environment and supplier relationships) and information processing capabilities (through the deployment of electronic procurement applications), and use Galbraith’s (1973) theory to show that aligning the two enhances supply chain performance. Thus, it is increasingly being recognized that the design of supply chains should include consideration of corresponding and specific information processing requirements and accompanying implications for deploying particular information systems. The supply chain literature however is largely deficient in frameworks that might facilitate such analysis.

How blockchain functions within the context of the supply chain are still open to interpretation and development. Blockchain-based supply chain networks usually require a closed, private, permissioned blockchain with multiple, limited players. But that doesn't mean that the door may still be open for a more public set of relationships. Privacy level determination is one of the initial decisions. According to Khan et al. (2018), blockchain technology is expected to enhance the velocity and reliability of business and managerial processes. Also, is useful in making a more precise demand forecast, inventory management, back-up at demand disruption and reduce informational distortion, filtering, redundancy and overloading of informational channels (Tjahjono, et al., 2017) (see Figure [2](#_bookmark3)).



**Figure 2.** Steps in blockchain information and transactions.

The role of blockchain in the supply chain will continue to be a key issue among researchers (Grover et al., 2012). The main issues to be solved involves "sharing/transaction of information and knowledge between supply chain members with reliability, velocity and accuracy, using advanced cloud environments" (Wang et al., 2012; Popescu et al., 2018). Blockchain can be connected with elaborate IT applications such as IoT, big data, artificial intelligence and do analysis of the data generated by business operations (Wu, F., et al., 2006). According to Reinartz et al. (2004) blockchain impacts both supply chain process and business/managerial transactions between different network parties. One of the most important advantages of blockchain supply chain is the disintermediation of intermediaries (Reinartz et al., 2004). This will make trading processes among partners more efficient. Reduced effectiveness and efficiency in supply chain flows can be reduced through supply chain instruments and techniques (Grover et al., 2012) saving networks millions of euros (Hofmann et al., 2018).

**2.3 Technology transfer (TT)**

Technology transfer is a “process of dissemination or retention of technologies, relevant knowledge, and the outcomes of its implementation. It generates products or other elements for the involved parties, which may include industries, individuals, institutions, or entities” (Carlsson et al., 1992).

The complexity of this type of transfer process has been examined by a growing number of researchers whose findings are beginning to impact upon technology policy decision-making (da Silva et al., 2018; Nicotra et al., 2018). The nature of the interactive process of transfer has been evolving from a relatively simple version relating the interactions between a supplier and a receiver of technology to more complex variants involving multiple actors and influences (Friedman et al., 2003; Gopalakrishnan et al., 2004; Barge-Gil, et al., 2011). More recently, intangible assets, like an idea, knowledge, experience, or a software are taking into account (Jedlitschka et al., 2007; Günsel, 2015).Therefore, it is hypothesized that blockchain will improve reliability which will result in better firm performance.

**H1.** *Technology transfer generated by using blockchain technology leads to better firm performance on IT&C MSEs.*

**2.4 Supply chain responsiveness (RE)**

Supply chain responsiveness refers to “the ability of the firm to adapt according to market change in terms of strategies, products and technologies” (Mentzer et al., 2011). Supply chain responsiveness is introduced as a primary desired performance outcome from these relationships by purchasing organizations (Qrunfleh et al., 2013). In structuring these relationships to improve responsiveness, entrepreneurs may require suppliers to comply to certain requirements- for instance detailed written contracts, dedicated human or capital assets, in order to support the relationship (Handfield et al. , 2002). However, the degree to which the supplier is willing to agree to these requirements is tempered by the level of power the supplier has over the buyer (Doney, 1997). Blockchain has the ability to rapidly integrate all processes in the supply chain and is helpful in achieving more accurate forecasting of demand, stock management and backup generation as the market situation changes (Tjahjono et al., 2017). Also, the blockchain creates new ways of adapting the company to the changes in the market through the rapid change of the suppliers, the design of the products and services realized, as well as changes in the structure of the processes carried out by the organization (Williams et al., 2013). In addition, all quality documents can be standardized and shared with all members of the supply chain that improve decision making (Abeyratne et al., 2016). Recent research confirms the orientation of companies towards the integration of IT&C processes with blockchain (Lin et al., 2018). Similarly, logistics can be better managed by the blockchain. There are vehicle tracking devices, such as GPS, that can be integrated with the blockchain. Therefore, the following can be hypothesized:

**H2.** *The improved reactivity of the improved blockchain supply chain of a company leads to a competitive advantage for IT&C MSE.*

**2.5 Supply chain integration (I)**

Despite the numerous conceptual and empirical papers within the field of SCM, there are neither well-established definitions, nor constructs and scales that unambiguously measure supply chain integration. Frohlich et al., 2001) stated “Our knowledge is relatively weak concerning which forms of integration companies use to link up with suppliers and customers”. Similar statements have been made in a number of review papers regarding definitions of supply chain integration (Giannakis et al., 2004) or related to its measurement and constructs (Chen et al., 2004). There are many different interpretations, types and classifications of supply chain integration. Van der Vaart et al. (2008) distinguished over 20 constructs that have been used to measure supply chain integration in survey research. A well-known distinction is between internal and external integration (Gimenez et al., 2005). Another distinction is between upstream and downstream integration – integration with suppliers or buyers- (Flynn et al., 2010).In the literature, supply chain integration has been analyzed from different perspectives (van der Vaart et al., 2008). Some authors have studied integration with suppliers and customers (Salvador et al., 2001; Gunasekaran, et al., 2004; Flynn et al., 2010). Others have focused on upstream integration, analyzing the integration with suppliers (Das et al., 2006). A final group of authors have studied the integration with buyers (Fynes et al., 2005; Gime´nez et al., 2005; Rai et al., 2006; Prajogo et al., 2012).

Blockchain has “the capacity to integrate all supply chain processes of member partners and also increases the speed of execution of business processes with greater accuracy and reliability” (Salvador et al., 2001). Hence, it can be hypothesized that:

**H3.** *Blockchain-enhanced supply chain integration of a firm leads to competitive advantage on IT&C MSEs.*

**2.6 Supply chain flexibility (F)**

Most of the previous research on flexibility has focused on internal IT&C flexibility. The components of IT&C flexibility play an important role in supply chain flexibility (Ueno et al., 2017; Shishodia et al., 2019; Nguyen et al., 2020).However, as the supply chain extends beyond the company, supply chain flexibility must also extend beyond one firm’s internal flexibility (Park, C.-W. et al., 2017; Yu et al., 2017; Tipu et al., 2019). Flexibility is “the ability of the supply chain to meet with unexpected changes in the market demand and convert them into business opportunities” (Vickery et al., 2003). A limited number of authors have begun to discuss flexibility from a supply chain perspective. For instance, in his paper on matching the supply chain to the marketplace, Mason-Jones et al. (2000) highlighted the importance of matching supply chain improvements initiatives to customer demand. Others stress the importance of combining the lean concepts of eliminating waste with the flexibility concepts of exploiting opportunities in a volatile market (Soon et al., 2011; Dey et al. 2019). Vickery et al. (2003) defined five supply chain flexibilities based on previous operations literature- product and volume flexibility, new product flexibility, distribution flexibility and responsiveness flexibility. The author states that supply chain flexibility should be examined from an integrative, customer- oriented perspective”. Flexibilities viewed as directly impacting a firm’s customer- and the responsibility of two or more functions, whether internal or external to the firm, are included (Tjahjono et al., 2017). Therefore, it can be hypothesized that:

**H4.** *Blockchain-enhanced supply chain flexibility of a firm leads to competitive advantage on IT&C MSEs.*

Dynamic capabilities are important intangible resources that enable businesses to generate performance in a changing environment (Pezeshkan et al., 2016), where product and business model life cycles are short (Svensson, 2000). Hence, firms need to constantly search for new opportunities (Prahalad et al., 2008). Integration, responsiveness and flexibility are important capabilities which give a competitive advantage (Mentzer et al., 2011). Dynamic capabilities of the firm are intangible and valuable resources which can generate/explain firm competitiveness. It also enables medium size enterprises to “create, allocate and protect the intangible assets that support superior long run business performance” (Winter, 2003). Previous studies (Dyer et al., 1998) has shown that improvement in competitive advantage generate superior firm performance. Hence:

**H5.** *Competitive advantage generated by blockchain technology positively affects MSEs performance*.

Based on literature review we propose a conceptual model presented in Figure 3:



**Figure 3.** Proposed conceptual model

**3. Methodology and results**

The present study sought responses from entrepreneurs from Romanian medium size enterprises (enterprises who fulfil at least one of the following criteria: a) staff headcount between 50-249 employees; b) turnover less than 50 mil. EUR; c) balance sheet total < 34 mil EUR) from IT&C sector. The responses from the participants were collected via an email survey, and the participation was kept voluntary with follow up emails, with the support of Romanian National Institute of Statistics (RNIS). From a sample of 583 entrepreneurs from Romanian IT&C MSEs, after data collection and initial analysis, 383 valid responses were obtained which were used for further analysis. The survey period lasted for more than sixteen months from 5th of September 2018 to 10th of December 2019.

The questionnaire was developed in English language and the statements measuring all the constructs were anchored on five-point Likert scale. The questionnaire comprises 36 questions, with the first section comprising general questions regarding the companies involved in the study (5 questions); the second section comprises questions regarding the objective of the study (26 questions); finally, the last section covered the recommendations (5 questions); The scales were subjected to content validity. Although, the items used were adopted from the previously done studies and were modified for studying blockchain effect on these constructs, still, it was pretested with subject experts to ensure that questions are relevant with respect to blockchain technology implementation in the supply chain. The measures used and their sources are shown in Table 2.

**3.1. Measurement model**

We used an older version of IBM SPSS AMOS (v24) in order to conduct CFA with the aim to obtain information on convergent validity, compound reliability and discriminant validity of the measures used.

Firstly, confirmatory factor analysis was conducted to get information about convergent validity, composite reliability and discriminant validity of the measures used. The six constructs demonstrate satisfactory convergent validity, all the factor loadings are statistically significant (Table 2), composite reliability of all the constructs is greater than 0.70 and average variance extracted is greater than 0.50 (Hair et al., 2017) (Table 5).

The fit indexes (CFI – comparative fit index, RMSEA – root mean square error of approximations) of the measurement model are also within the acceptable limits as per Hair et al. (2017) (Table 3).

Table 5 shows the average variance extracted and composite reliability for all the constructs.

Discriminant validity was checked by comparing the square roots of the AVE’s with the correlation for each of the constructs, using the Fornell and Larcker (1981) criterion. The square root AVE of the selected construct should be higher than the correlations between a construct and all the other constructs in the model. The diagonal items in the table represent the square root of AVE’s, which is a measure of variance between the construct and its indicators, and the off-diagonal items represent the correlation between constructs (Kamble et al., 2018). It is observed from Table 4 that the square root of AVE is higher than the correlation between the constructs indicating that all the constructs exhibit discriminant validity. The measurement model obtained is shown in Figure 4.

Table 6 summarizes the descriptive statistics (mean and standard deviation) for each of the constructs. The measurement model is shown in Figure 4.

**Table 2.** Confirmatory factor analysis

|  |  |  |  |
| --- | --- | --- | --- |
| **Variables** | **Source of items used** | **Items** | **Factor loading (standardized)** |
| SC flexibility (F) | Ueno et al. (2017) | F1: BKC increase product/service customization | 0.652 |
| Nguyen et al. (2020) | F2: BKC increase volume flexibility | 0.629 |
| Shishodia et al. (2019) | F3: BKC improve incidence of introducing new product/service | 0.617 |
| Tipu et al. (2019)  | F4: BKC reduce R&D time | 0.661 |
| Park, C.-W. et al. (2017) | F5: BKC adjust market needs | 0.620 |
| Yu et al. (2017) | F6: BKC increase customer service | 0.619 |
| Dey, et al. (2019) | F7: BKC reduce product/service development cycle time | 0.609 |
| Soon et al. (2011) | F8: BKC increase delivery capabilities | 0.631 |
| SC integration (I) | Gunasekaran, et al. (2004) | I1: Process integration capability will be ameliorate by using BKC | 0.696 |
| Flynn et al. (2010) | I2: Integration management, logistics and other internal areas capability will be ameliorate by using BKC | 0.825 |
| Prajogo et al.(2012) | I3: Face-to-face communication with internal and external stakeholders will be ameliorate by using BKC | 0.878 |
| Rai et al. (2006) | I4: In coordinating our activities or exchanging information with stakeholders formal and informal communication channels are followed and this will be improved by using BKC | 0.683 |
| SC responsiveness (RE) | Handfield et al. (2002) | RE1: Short lead- times per market requirement by using BKC | 0.742 |
| Williams et al. (2013) | RE2: Outstanding on time delivery record by using BKC | 0.788 |
| Qrunfleh et al. (2013) | RE3: Ability to modify products/services to meet requirements by using BKC | 0.781 |
| MSE performance (MSEP) | Hudson et al. (2001) | MSEP1: Service level will be ameliorate by using BKC | 0.719 |
| Bahri et al. (2011) | MSEP2: Operation cost of supply chain processes will be reduced by using BKC | 0.608 |
| Sidik (2012) | MSEP3: Added value creation in the supply chain will be enhanced by using BKC | 0.692 |
| Michna, A. (2009) | MSEP4: Rapidity of supply chain operations will be enhanced by using BKC | 0.547 |
| Technology Transfer (TT) | Barge-Gil, et al. (2011) | TT1: BKC positively influence Research Phase  | 0.958 |
| Nicotra et al. (2018) | TT2: BKC positively influence Development Phase | 0.978 |
| Friedman et al. (2003) | TT3: BKC provides benefits on Production Phase  | 0.956 |
| Jedlitschka et al. (2007) | TT4: BKC reduce probability of unsuccessful technology transfer  | 0.960 |
| Competitive advantage (C) | [Flamholtz](https://www.emerald.com/insight/search?q=Eric%20G.%20Flamholtz) et al. (2012) | C1: BKC will help to ameliorate capability to respond according to customer needs | 0.970 |
| [Sigalas](https://www.emerald.com/insight/search?q=Christos%20Sigalas) et al. (2013)  | C2: BKC will improve capability to integrate internal and external processes | 0.958 |
| Chiou, T.Y. (2011) | C3: It will become easier to capitalize opportunities and competitive advantage to the firm  | 0.941 |

**Table 3.** Fit indexes for the measurement model

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Fit index**  | **CFI** | **TLI** | **RMSEA** | **PCLOSE** |
| *Acceptable value* | >0.90 | >0.90 | <0.06 | > 0.05 |
| *Obtained value*  | 0.960 | 0.957 | 0.044 | 0.690 |



**Figure 4.** Measurement model

**Table 4.** Discriminant validity

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Variables** | **A** | **B** | **C** | **D** | **E** | **F** |
| *A. Supply chain flexibility* | **0.742** |  |  |  |  |  |
| *B. Supply chain integration* | 0.181 | **0.873** |  |  |  |  |
| *C. Supply chain responsiveness* | 0.288 | 0.371 | **0.876** |  |  |  |
| *D. MSE performance*  | 0.475 | 0.294 | 0.163 | **0.798** |  |  |
| *E. Technology Transfer* | 0.101 | 0.181 | 0.247 | 0.247 | **0.850** |  |
| *F. Competitive advantage*  | 0.253 | 0.287 | 0.320 | 0.345 | 0.318 | **0.957** |

**Table 5.** Reliability

|  |  |  |  |
| --- | --- | --- | --- |
| **Variables** | **AVE** | **CR** | **Cronbach’s alpha** |
| *Supply chain flexibility*  | 0.552 | 0.8039 | 0.8415 |
| *Supply chain integration* | 0.771 | 0.8580 | 0.8522 |
| *Supply chain responsiveness* | 0.772 | 0.8172 | 0.8153 |
| *MSE performance*  | 0.641 | 0.7400 | 0.7402 |
| *Technology Transfer* | 0.724 | 0.9699 | 0.9821 |
| *Competitive advantage*  | 0.957 | 0.9720 | 0.9718 |

Table 6 outlines the descriptive statistics for each of the variables. The structural model is shown in Figure 5.



**Figure 5.** Structural model

**3.2. Structural model analysis**

In the next table we present the results of the structural model analysis for testing the hypotheses of the current study and summarize the results of the path analysis and hypothesis testing result.

The structural model has an overall acceptable fit with CFI: 0.952; RMSEA: 0.052; PCLOSE: 0.123, indicating that the proposed model fits the observed data well (Hair et al., 2017). All five hypotheses are accepted (p < 0.05) (see Table 6).

**Table 6.** Descriptive statistics

|  |  |  |
| --- | --- | --- |
| **Variables** | **Mean** | **Standard deviation** |
| Supply chain flexibility  | 4.023 | 0.6051 |
| Supply chain integration  | 4.271 | 0.6171 |
| Supply chain responsiveness  | 4.253 | 0.6672 |
| MSE performance  | 3.943 | 0.6556 |
| Technology Transfer  | 4.282 | 0.6970 |
| Competitive advantage  | 4.410 | 0.5749 |

The results of the analysis of the structural model are presented in Table 7.

**Table 7.** Structural model analysis

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Hypothesis** | **Path** | **Estimate** | **Std. Error** | **z** | **Sig.** | **Result** |
| *H1* | MSEP- TT | 0.149 | 0.049 | 2.953 | 0.003 | Accepted |
| *H2* | C-RE | 0.207 | 0.056 | 3.601 | 0.000 | Accepted |
| *H3* | C-I | 0.189 | 0.057 | 3.218 | 0.001 | Accepted |
| *H4* | C-F | 0.161 | 0.055 | 2.898 | 0.004 | Accepted |
| *H5* | MSEP- C | 0.327 | 0.062 | 5.173 | 0.000 | Accepted |

**4. Discussion and contributions**

The result of data analysis (Table 7, Figure 5) shows that blockchain-enhanced supply chain variables such as supply chain integration (0.189, p<0.05); supply chain responsiveness (0.207, p<0.05) and supply chain flexibility (0.161, p<0.05) are having a significant positive effect on competitive advantage.

It means the entrepreneurs are having a perception that blockchain will help them in making their business competitive by reducing R&D times and development cycle, improve incidence of introducing new product/service, increase product/service customization and deliver capabilities, increase customer service, volume flexibility and adjust changing market needs. Regarding integration, entrepreneurs are also certain that by adoption of blockchain technology they will be better able to improve integration management, integrate process, logistics and other internal capabilities, as well as direct communication with internal and external stakeholders. With regards to responsiveness, it is obvious that entrepreneurs holds the perception that adopting blockchain technology will help them to have a better time to delivery record, ability to modify services/products to meet requirements and short lead-times per market requirements. Overall, we can conclude entrepreneurs have high hopes of efficiency with regards to using blockchain-based IT applications in the supply chain. Responsiveness, integration and flexibility are essential elements which deliver a competitive advantage to an organization Consequently blockchain improves competitive advantage to the organization.

Technology transfer generated by using blockchain is also having a significant positive effect on firm performance (0.149 p<0.05). As result indicates entrepreneurs have the perception that adoption of blockchain technology will help in increasing technology transfer, they will have better traceability of research, development and production phases and reduce probability of unsuccessful technology transfer which lead to better firm performance.

The present study contributed the literature in couple of ways. Till date, there is no empirical study in Romania which connects blockchain with supply chain performance variables. The present model connecting integration, flexibility and responsiveness is new, overall fit is satisfactory (CFI: 0.960, RMSEA: 0.044) and was developed by authors after a comprehensive study of literature review and based on their practice for more than 10 years in consultancy. Future studies should probe in detail specific supply chains on how blockchain technology can improve such supply chains.

**5. Conclusions, limitations and future research**

Our research contributes to the development of specialized literature in multiple ways. To date, there is no empirical study linking blockchain, technology transfer with supply chain integration, flexibility and responsiveness in order to generate competitive advantage and organizational performance. The findings of the current study indicate that MSEs should increase cooperation with IT companies committed to developing blockchain-based supply chain solutions so that supply chain decision makers' expectations can be met with respect to blockchain technology and its utility for managing the supply chain. (Abeyratne et al., 2016). The present study will increase decision makers' interest in the associated technologies, like IoT or Big Data, to improve its application. Finally, supply chain decision makers and IT companies wishing to embrace and develop blockchain-based IT solutions for the supply chain should start pressuring regulation actors to develop a legal framework for controlling blockchain technology. To date, timid attempts have been made to regulate the domain in Romania, through the Blockchain Association Romania, but unfortunately the results are not satisfactory. As without a legal framework, technology will remain very risky in terms of adoption. Entrepreneurs, managers, as well as IT&C companies involved in design and implementation of system for supply chain, as well as academics should increase cooperation in order to study and develop a framework for regulating blockchain technology and to suggest improvements to policy makers.

Our research presents a number of limitations that can be resolved in future research. First, respondents do not have / have very little practical experience in using blockchain technology. Their responses were based on their knowledge of the blockchain they obtained from various public sources. Second, the present study presumes that government regulations on blockchain technology are favorable and that all regulatory frameworks are created to support blockchain technology. However, in Romania, at present, there is no official framework to regulate and govern blockchain technology and its applications. Finally, the study targets medium-sized firms in the production sector, where blockchain technology is in the early stages of its implementation. More developed are the financial services and trade sectors. However, important steps are being taken in the production sector in implementing these modern technologies.

In our opinion, the effects of the blockchain on the important variables of the supply chain need to be studied further. The success of blockchain technology in improving supply chain management should be studied in the future through longitudinal studies or by the integration of the blockchain with IoT, RFID, Big Data and artificial intelligence.

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