Analysing data from a bunch of transactions (block of a blockchain) can lead to optimisation of business decisions

Zoannos M. Nikolaos* and
Assimakopoulos Nikitas

Hellenic Society for Systemics Studies (HSSS),
University of Piraeus,
Piraeus, Greece
Email: nmzoanno@yahoo.gr
Email: assinik@unipi.gr
*Corresponding author

Abstract: Business intelligence (BI) is a technology-driven process for analysing data and presenting reports, which helps managers and executives to make better business decisions. In order to achieve a proper data analysis and an optimised visualisation, a variety of tools, applications and methodologies can be used. Those analytical results consist of the driving force of business decision-making process that is why the methodologies that are going to be used in each case must be chosen carefully. Systems science provides methodologies suitable for data analysis. So, the main purpose of our study is to present to you how the systems thinking and systemic methodologies like DCSYM, systems dynamics, etc., can be applied on blockchain technologies (BT). Also, through the different sections of this study we will present a stage of a multi-methodology that we are developing for the systemic management of blockchain technologies.

Keywords: business intelligence; blockchain technologies; ecosystems; sociotechnical systems; systemic methodologies; systems thinking; decision-making process.

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Biographical notes: Zoannos M. Nikolaos is a PhD candidate in the Department of Informatics at the University of Piraeus, Greece. He is developing a systemic multi-methodology for managing blockchain technologies. In the last 20 years he is working in the Greek public sector as an IT Administrator and as an IT Security Officer. His previous publications were in *Journal ACTA European Systemica – AES*, Nos. 8 and 9.

Assimakopoulos Nikitas is a Professor in the Department of Informatics at the University of Piraeus, Greece. His research interests include systemic methodologies, systems approaches to management and informatics, and applied operations research techniques. He has published over 150 papers in refereed journals, 120 papers in conference proceedings and has participated in over 130 conferences with papers. He is an associate editor in five international journals and reviewer in 12 well- known journals which are associated with the four international societies where he serves as an active member. He is the

founder and elected President of the Hellenic Society for Systemic Studies (HSSS) (http://www.hsss.gr). He is the founder and the coordinator of the first international Post-Graduate Professional Mastering Program Certified Systemic Analyst Professional (CSAP) (http://www.csap.gr/) which is supported by the HSSS. He is the Editor-in-Chief of *IJASS* (https://www.inderscience.com/jhome.php?jcode=ijass) and President of the European Union for Systemics [EUS] (http://www.ues- eus.eu/en/presentation/).

1 Introduction

The last few years, we have witnessed a computation power increase of informatics systems which has provided us with the proper tools (applications) not only to examine in depth the daily created data (business analytics), but also to create mental models (mathematical modelling of complex situations) for analysing and predicting possible future situations (predictive analytics). Technologies like the 'internet of things (IoT)' have contributed in creating even more data. Data which describe the situation of a product while it is being transported from the resource-side (companies/organisations) to the demand-side (consumers). Until today, companies could not predict the consumers' demand as it consisted of an undefined complex of many variables. We can find many researches in literature, which have been conducted the last decade and present a lot of Methodologies, Methods, tools, or even mathematical formulas that can be used to define and analyse such variables. The purpose of those studies is usually to understand the facts that have been recognised, to discover which variables participate on the mathematical formulas, the way that each variable influence other variables and what the possible new data from the feedback loops are going to be.

One other point of view is that the new technologies have created a global market. Consumers have access on new products and services that they previously did not have. New needs have been created and in order to be fulfilled, new combinations of sociotechnical systems have been created. Those sociotechnical systems, well known as ecosystems (Kirlik et al., 2015), are a combination of social systems (companies/organisations) and mechanical systems (technical equipment). Before the 4th Industrial evolution, the existing networks were being used to sell, buy, exchange, transport goods/products and/or services. So, they were composed of human agents only (Schneider et al., 2020). Organisations, firms and businesses were also only human driven. Nowadays, those ecosystems contain computers and/or algorithms, which although they are non-human agents, they are equal to human agents and they have been set to work on behalf of humans.

Those ecosystems have created new opportunities, new values for exchange and a new digital token economy. But every time new values are being created, at the same time the complexity of those systems is being exponentially raised, new uncertainties and new risks are surfacing. If we also use the blockchain technologies (BT) on those ecosystems, then we will also observe new collaborations between firms, new supply channels, etc. Each firm, which participates in a decentralised network or in a distributed network, functionally complements this ecosystem. So, how is it possible for those firms to participate in such systems and at the same time to provide their clients with better

services/products, cheaper but without changing their quality and reducing the delivery time, without risking the integrity of their products?

Such questions, in order to be answered, critical decisions must be made by the chief executive officers (CEOs) or/and by the chief manager officers (CMOs). In each case, the data must be analysed so as to be studied in depth. Those studies are going to lead us on finding any archetypes (Kim, 1993) that may explain either the behaviour of the agents, if we study them in isolation, or the behaviour that derives from the interaction of the firms which are part of those Ecosystems. We must not forget to mention that many other techniques have also been proposed which explains how those three (3) basics targets (that we traced earlier) can be achieved. For example, having in mind that the new technologies eliminate the difference between online and offline stores, strategies, like omni-chain retailing (Cai and Lo, 2020) or marketing and advertisement methods, like electronic word of mouth (eWoM), are some of them. Since those methods do not approach those networks as systems, that is the reason why we will not study them any further.

The purpose of this paper is to explain what should be the data that must also be saved on the blocks (belonging to private or public networks), how specific data from blocks can be included in blocks of other blockchains, how data must be analysed so as to be exported in graphical charts which will lead the analysts in creating proper mental models for predictive analytics on blockchain technologies.

Our study begins with the explanation of the blockchain technologies (Section 2), continues with a brief description of our previous research (Section 3) and then we explain in detail (Section 4) the tools and the techniques that must be used for the blockchain technologies (BT). Finally, in Section 5 we extract some conclusions which will be the starting point for our next research.

2 Blockchain technologies

Up until now, in order to achieve an interaction (buy, sell exchange product or services) we had to trust an intermediate part, like banks or/and security insurance companies, due to the lack of trust between the resource-side and the demand-side. The networks were usually centralised (a central authority unit was responsible for the credentials and the rights of the users), because firms wanted to keep in private:

a their transactions

b their clients

c their patents

d their trade secrets

e their copyrights

f generally their businesses' actions.

This fact not only can be likened to silos, but also creates transaction barriers and does not provide transparency on transactions. One other fact is that these silos need the installation of proper security mechanisms to maintain the confidentiality, the Integrity and the availability of the data that are stored in the central data base. This kind of

architecture has been used for over a decade that is why we have accomplished the best possible efficiency on business processes. Business plans have been developed according to the opportunities and the eminent threats of this architecture. Also, business continuity plans have been developed according to the risks of this architecture.

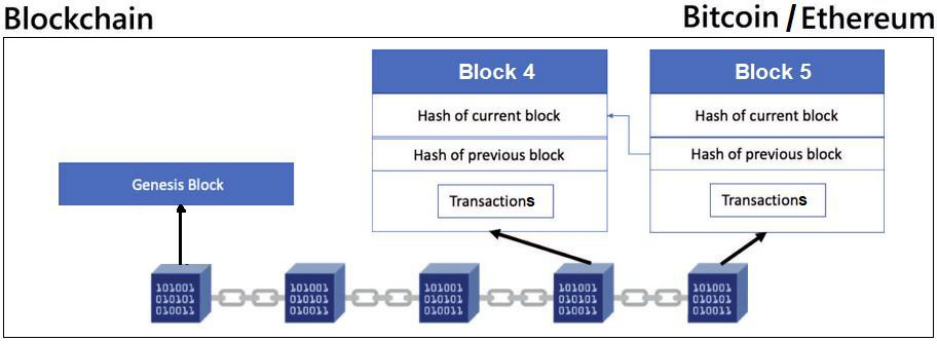
On the other hand, around 2008 Satoshi Nakamoto presented the first cryptocurrency which was called 'Bitcoin' (peer-to-peer cash system) instead of fiat currencies (Nakamoto, 2018). Fiat currencies in the past were directly connected with precious metals (gold, silver, etc.) as banks had to store the value of fiat currencies on their safes. The transactions between the resource-side and the demand-side were allowed only through those trusted parts, in order to reassure both sides that money are not going to be lost. Of course, those intermediate parts, for their services, were adding extra fees on the transactions' value. Sometimes, when a transaction was between parts from different geolocations, then more intermediate trusted parts had to be involved. That means that the final cost of a product or/and a service was increasing dramatically. Needs like: intermediation, lower cost of products, quicker transportations, transparency on transactions, immutability of transactions for legal reasons (antimoney laundering – AML) have been the motivating powers for a digital economy, in which we are going to use digital currencies (Mentsiev et al., 2019). Those currencies, like 'Bitcoin', cannot work unless we use decentralised or distributed networks.

The first alternative in network architecture is the 'decentralised' one. In this architecture there is not only one central authority, but the rights to create users' credentials and to administrate their read and write rights are shared among several entities. Each user (company, organisation, or a separate individual user) can participate freely on this network as long as he has been evaluated from those authority entities (permissioned access where each participant has a unique address). When those users/nodes/participants gain write rights, then they can evaluate data correctness (transactions data) of other participants and to store them on a 'block'. Then this block is published to the network so as to keep a copy on each server/PC. By this process we can have the transactions stored on a shared ledger and at the same time we have ensured those transactions' transparency and immutability. The nodes must be reliable as they are storing transactions, actions that prove the transportation of a value from one participant to another participant of this network (property that changes owner). At this point, a new question is being raised: 'are the existing business models capable for creating, delivering and capturing value in such Ecosystems?'. Since new risks will be discovered and new uncertainties, there is an immediate need for new decentralised business models (Chen and Bellavitis, 2019). A second need is for chief executive officers (CEO) and chief manager officers (CMO) to be educated so as to gain new skills and new officers like chief digital officers (CDO), chief IT officers (CITO), chief financial officers (CFO) and chief legal officer (CLO) must cooperate, in order to develop new and more flexible business models (Jesse et al., 2018).

The next alternative network architecture is the distributed one. In this architecture each user (company, organisation, or a separate individual user) can install a software on their PC/server in order to participate freely on this network (permissionless access). No central authority or entities with administrative rights exists. Each node of this network has a unique pseudonymous and can read and write on the blocks of the blockchain. The key points, where the distributed and decentralised networks differ, are that in distributed networks in order to reassure the data integrity, immutability and transparency (the blocks will be stored on the blockchain only after a small period of time when we are

sure that this block belongs to the longest chain – to avoid forks and side branches) we have to use a lot of computational power (the mathematical problem that each node has to solve in order to find the unique 'nonce' every time, gets harder from time to time) and a lot of electricity power (Figure 1).

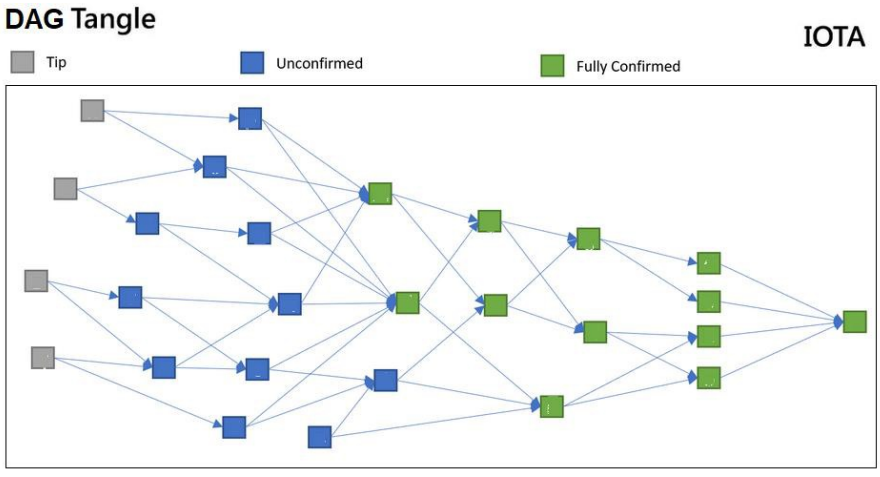
Figure 1 Blockchain (see online version for colours)



On the other hand, in decentralised networks we do not sacrifice the speed of the network for security reasons (like in distributed networks) but in order to have trusted parts/nodes we need the existence of authority nodes (no such need in distributed networks). Also, in distributed networks we have anonymity of users (each node has just a pseudonymous) instead of unique addresses (public-key cryptography is being used) which describes each node of a decentralised network. In both cases we can create 'smart contracts' which describe the financial and legal rules of the agreement between the resource-side and the demand- side. So those 'contracts' must contain well-established concepts, standards and legal rules so as to predict all the possible scenarios in case a product reaches the consumer and it is different than its description in the beginning, if it is broken or destroyed on the transportation or even if it is constructed without meeting specific rules/certifications (like CE marking). At this point, new questions may arise, like: 'who enforces the rules and the standards which must be included on a smart contract? Are there any global standards/ISOs for those smart contracts?'.

As we have seen so far, the last two (2) architectures create bunches of transactions (the transactions' rate depends on the network architecture). Those transactions are stored on a block and after a while this block is added on the blockchain (not directly so as to avoid forks and side branches). A different way to store the transaction has been proposed to the literature, which provides the same advantages with the blockchains, like transactions immutability and transparency, but also eliminates the problem of double-spends, reduces the necessary electricity amount and it does not slow down the speed of the network. It is called 'directed acyclic graph – DAG' (Zivi et al., 2020) because distributed transactions are being stored on a decentralised network (Figure 2 – Meet the DAG Tangle, https://www.iota.org/research/meet-the-tangle). Each new transaction (called 'child') is stored separately (grey vertices on Figure 2) and then it is linked with two (2) previous transactions (called 'parents') so as to be verified as valid (blue vertices on Figure 2). After a while, other newer transactions will also be linked with this particular transaction (green vertices on Figure 2) and then we can accept it as officially stored on the acyclic graph (so is immutable).

Figure 2 Directed acyclic graph (DAG tangle) (see online version for colours)



This power-of-work (PoW) mechanism needs smaller effort than in distributed networks (for consensus mechanism the random walk Monte Carlo (RWMC) algorithm is being used). Also, any attempt to spam or to fork (malicious modification) the Tangle is much more expensive than the real worth of the stored transaction. Reading this idea, we have started thinking that a firm which is member of a blockchain network, could participate at the same time on other blockchains. For example, a company/organisation could participate in a permissioned network (decentralised) with its' suppliers and the partners who are responsible for the transportation of those products/goods over the supply channel and at the same time it could participate in a permissionless network (distributed) with its consumers. So, part of the data of the blocks of the first blockchain, must also be stored on the blocks of the second blockchain. In fact, those common data must be enriched with new information so as the final consumer could check the origin of the product (especially when it is a food item), the conditions of its' storage and transportation (temperature, exposition to chemicals or to radiation), even to check whether a product with such QR code or barcode has already been sold or been consumed by another person (replica product or fraud product). For those data and the systemic tools and/or methodologies (that must be used) we will speak on Section 4.

3 Previous research

Many firms, in order to have access on a global market, have already been digitally transformed or they are on the phase of their transition. Their existing technologies are being replaced with new technologies, like blockchain. New processes are going to be added and the old ones either they are going to be disarmed, or they must be redesigned. Also new technologies, like 5G networks, are going to be used combined with microprocessors, who are dedicated to control a set of sensors (IoT), to send alarms and trigger events on the smart contracts. On this ecosystem, companies that in the past were antagonists, now they are nodes of the same network and they have the same common purpose (to verify the transactions and to store them with a non-modifiable/immutable

way). Previously, executive officers or/and managers had to set a common vision for their employees and to develop a strategic plan with a specific vision. Business plans, every two years, were being developed according to the results of the data analysis, data which represent the company's achievements. Also, business analytic methods were being used to create charts in order to explain the progress on the consumers' service and the behaviour of the firm on possible alternations of the global economy. Now that each company is not a separate entity (system) but it is an essential part of a bigger system, we need to use systemic methodologies like DCYSM Methodology (Nikitas, 2009) to depict the structure of this sociotechnical system.

We have already developed the way which describes how nodes of a decentralised network, their communications and their control relationships must be designed using the DCSYM methodology (Zoannos and Nikitas, 2019). Also, the firms that consist of the essential parts of this ecosystem must function with a specific way, not only in order to ensure their viability, but also to accelerate the viability and the progress of the whole ecosystem. We have defined the way that Stafford Beers' viable system model (VSM) must be used in order to design and explain systems 1 to 5. At the same time, we have outlined the communications of CEOs, CMOs, CFOs, CLOs and CITOs so as to be detailed, defining the way that those officers must act in a decentralised network.

At this point of our research we must stop and think whether those officers are ready to take on their new duties, or if they must be educated on new techniques and new ways of thinking. They must all use the 'systems thinking' techniques as they consist of an essential part of a bigger system/of an ecosystem. New business models must be developed which will define the way of acting on a decentralised token economy (Lee, 2019), where tokens can be used:

a as a payment method (to sell or buy products and/or services and AML can be applied)

b as a utility token (for example to pay and use functions/services of a Dapp or of an online game/music, etc.)

c as an asset token (represents a real tradable asset, like the traditional process where we use fiat money).

In order to develop those new business models, we can use business model canvas, but first we must specify new categories and redesign the nine (9) pillars of this model. Thus, this will be the starting point for our next study in the next few months.

4 Data on blocks

In Section 2, we have mentioned that a firm can participate simultaneously on different blockchains. In this context, this Firm can belong to an ecosystem and interact with its suppliers and other transportation firms. This network should be a permissioned network (decentralised architecture) so as some entities with authority rights can exist. Those entities will not only be responsible for the node's credentials, but, most importantly, they will be responsible for developing rules, regulations and standards that must be followed from all the nodes of the network. Let us suppose that the firm we are talking about merchandises food supplements (for example protein products, multivitamins, etc). Those

products in order to be produced, specific rules/regulations must be applied about the substances/ingredients contained in such products, which must be safe for human's health. Until today, factories were building their products according to the rules of the country that they are situated in. In some cases, the rules for food supplements are different from country to country (for example in Greece the only rule about food supplements is that they must not contain anabolic). So, there is a need to follow either the same rules, or to produce a product according to the health rules of the country that it is going to be sold and consumed.

At this point, we suggest that the authority entity should be, first of all, the World Health Organization (WHO) and secondly each health organisation of the countries that these products are going to be consumed. The reason that we have made the previous suggestion is in order to have the same rules, regulations and standards about food and food supplements all over world or at least all over the European Union (if there were the same food regulations all over world, phenomena like the epidemic of COVID-19 – which probably began from the consumption of bat meat – would have been avoided). The data, accustomed to be stored from the resource-side, should not only be the unique 'address' of the company (firm's identity as a node of the network – combination of private and public cryptographic key) that has built the product, but also data about the source of the ingredients and the exact amount of each ingredient that has been used for each product. Those data can be used for future audits from each country's 'court of audit'. Next, data that must also be stored are the unique address of the company (set of cryptographic keys) that has bought the product and it is going to merchandise it. The price and the quantity of those products should be stored on the blocks, but it must not be accessible from the consumers of these products (data access according to the access rights of the nodes). Other data that must also be stored are:

a the unique address of the transportation company or companies

b any information about alarms or events that has been triggered and refers to the temperature, the humidity and other measurements from the network of the sensors (IoT) while the product is being transported.

Those measurements are going to include any possible kind of proof, if a product was exposed to chemicals or other harmful elements, if it was unpacked without authorisation or destroyed. As we have seen so far, a lot of data must be stored and be interconnected with the unique identity of each transaction (hash string).

The firm that is going to merchandise these products, although it's an essential part of the permissioned network that we have analysed earlier on, it can simultaneously participate in a permissionless network (distributed architecture) with its retailers and its consumers. In this case, data about those products should be copied from the blocks of the permissioned network and after being combined with other data, only then they must be saved on the blocks of the permissioned network. For example, the firm that has imported these products to a country which is a member of the European Union (for instance Greece) should store in the blocks data about the unique address of the transportation companies (set of cryptographic keys) that have been used inside this country, measurements from the sensors of the local network (in case of alarm or event triggering) and the unique address (set of cryptographic keys) of the store that is going to sell this product. So, when the final consumer (demand-side) will buy a food supplement from a store, if he has the ability to scan the barcode or the QR code from this product

(using his smart phone) and to upload the photo on a decentralised application (Dapp), then he can check the origin of the product, whether the conditions of the transportation of this product were according to the regulations about food and food supplements and if it contains harmful ingredients.

Let us suppose that a part/entity/node/firm of this chain acts maliciously and not according to the common rules of the ecosystems. It duplicates the products, or it mixes the products with other ingredients so as to create more products for selling. If the Dapp, which the final consumer will use, provides him with the ability to enter information like 'this product has been consumed' or 'this product has been sold to X from the store Y', then when the product will be sold, the final consumer will be able to trace that this product is fake/replica or fraud product (due to the fact that the barcode or the QR code of this product would have been deactivated when another consumer would have bought the original product with the same barcode or QR code). Another possibility for the second product is that the final consumers will not find any information for it stored on the blocks of the blockchain, so it is obvious that it is a fake product. Do not forget that the data on the blockchain are immutable (resistant to tampering).

The question that may trouble the reader so far is how data from different Dapps with different structures and different way of storage can be combined? Well, such questions and the problems that we are going to face when we will try to copy those data from the one Block of the first blockchain to the block of the second blockchain have already started to worry the scientists. Projects like Cosmos and other remarkable efforts, like those from some firms that are trying to build proper applications (APIs) to interconnect 'smart contracts' between permissioned and permissionless blockchains, Falazi et al. (2019) have been already proposed. New business processes are going to be designed (in which sometimes unknown parties are involved) in order to achieve a main goal. For those processes, there have been some suggestions until now, for example Viriyitavat and Bi (2019) have proposed to divide the blockchain-based business processes into four (4) different layers:

a the IoT layer: it describes the network, the sensors and the software interface

b the service layer: here we have the protocols which will support the interoperability, the API's, etc.

c the workflow modelling layer: this layer refers to the tools, the models and the software's that we are going to use for designing the processes that contains services which do not use for designing the processes that contain services which do not necessarily refer to a System but it may have phases in which different systems take part

d the blockchain layer: in this layer the smart contracts are the key tool for ensuring that processes between different parties are going to be fulfilled and decisions that have already been taken will be implemented according to specific rules.

At this point, it is clear that we must use business process management (BPM) tools for designing the new processes. But those processes must be designed differently, we need to define for each phase of the process which system is responsible and how it interacts with the systems of the previous phase and the next phase of this specific process. Professor Mr. Assimakopoulos has already referred in the past to how each phase of a process can be implemented on the DCSYM methodology. It is obviously clear to the

reader that BPM can lead to business process excellence (BPE), by monitoring and reporting the performance of each process (in each phase) all over the blockchain network. Thus, by using BPM we can achieve the triangle of *time-cost-quality*. Collections of different models and methodologies have already been proposed (Ori and Szabo, 2019) for the inter-domain architecture, which will help CEOs and CMOs to define, to analyse, to evaluate and to calculate the performance of each process, aiming to discover possible dysfunctions and to propose interventions for further improvement. In a System, in which we have eliminated any dysfunctions (on its essential parts or on the communications of those essential parts), systems' stability, optimisation and progress (business excellence) of the ecosystem will be some of the phenomena we will observe.

Every time that we use new technologies, new data are going to be created, new opportunities are going to be realised, new assets will be generated, but also new risks to tackle. Those risks can be divided into two (2) main categories (Griffy-Brown et al., 2020):

a upside risks: those are the opportunities for growth

b downside risks: the risks that we must face in order to eliminate any loses.

Earlier on, we have mentioned that we need to use business process management tools, but how to design processes on ecosystems when we do not have the necessary knowledge? We must use system dynamics theory and we must educate the CEOs and the CMOs, so as to use such techniques to establish those processes as best as possible and at the same time having in mind the risks that must be addressed. System dynamics theory will help those officers to recognise the variables that are involved in complex Ecosystems and that affect the ecosystem's behaviour. Causal loop diagrams must be created according to the archetypes that we will have traced and those diagrams must be converted into stock and flow diagrams. The purpose of this action is to create risk identification and risk evaluation models, which through simulations will dynamically trace and evaluate the direct and the indirect impact of those risks on the ecosystem. A basic model has already been developed (Griffy-Brown et al., 2020) which can give the executive officers the ability to trace and measure the impact of those risks in order to help them with the decision-making process. But this model is the prototype and it still needs a lot of improvements.

Summarising all the above and having in mind that the blocks of the blockchain are immutable, we can safely come to the conclusion that there is an immediate need to study the existing implementations of the blockchains so as to decide on the structure and the content of the data that are going to be stored on the blocks of future blockchain implementations. Also, we must study the risks that have already been traced and create new dynamically risk identification and risk evaluation models so as to design the new processes to be as invulnerable as possible. Then and only then the decision makers will be able to address early-on possible conflicts, barriers, risks or/and long-term uncertainties and at the same time to translate the new opportunities (attributes of the environment on SWOT analysis) into tangible benefits (Hackius and Petersen, 2020).

5 Conclusions

In this paper, we started talking about the firms that previously were independent entities and their networks were embodied by their suppliers and clients only. Then, we talked about the new technologies, like the IoT, 5G networks and BT which have created the sociotechnical systems. So, those firms, which nowadays have already expressed interest in accessing a global market, must be digitally transformed in order to become an essential part of a bigger system, of an ecosystem.

Network architectures, like the centralised one, the distributed and the decentralised, were analysed so as the reader to understand their differences, their strong points, and their weaknesses. It is not a rule that a firm will belong only to a specific network, but it can belong simultaneously to different ecosystems. That is the reason why new processes are going to be designed, some of the old ones are going to be rejected, new business models must be developed and new techniques must be used for identifying and evaluating the impact of the risks that we may have to tackle. For these ecosystems, to be properly organised, we must, first of all, use systems thinking to understand their complexity, to trace the interoperability not only of the essential parts, but also of the ecosystem and its environment. We must also develop new rules, regulations, and standards so as to have a solid foundation for this endeavour.

Finally, in order to help the decision makers, we have detected the immediate need for their education, so as to use systems thinking, not only to read charts that have been developed using business analytics methods, but also to understand mental models (that are going to be developed with system dynamics methodologies) and to be able to define their future plans/movements with less risk. The fact that they have recognised early-on the risks, the uncertainties and the barriers that may occur is the most critical step currently.

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