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INTEGRATING BLOCKCHAIN TECHNOLOGY INTO MARITIME LOGISTICS COMPANIES

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ABSTRACT

INTEGRATING BLOCKCHAIN TECHNOLOGY INTO MARITIME LOGISTICS COMPANIES

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MSc Thesis, LOGISTICS ENGINEERING

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With the accelerated technological developments in business life, companies are seeking opportunities to improve their way of working. In maritime logistics sector, deployment of such technologies can create advantages in order to compete with other global companies. In this research, 9 dimensions -such as organizational, environmental and technological- in which Blockchain technology adds value has been gathered. Based on these dimensions, 35 factors which needs to be considered in the adaptation of Blockchain technology has been listed. Using Total Interpretive Structural Modelling method, these factors and their dependency with each other has been evaluated. Method can also guide the maritime logistics companies in building up a road map during integration of this new technology from scratch.

Keywords: Blockchain, Total Interpretive Structural Modelling (TISM), Maritime Logistics

ÖZ

BLOCKCHAIN TEKNOLOJISNIN DENIZYOLU LOJISTIK ŞIRKETLERINE ENTEGRASYONU

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Ağustos, 2022

İş hayatında hızlanan teknolojik gelişmelerle birlikte şirketler çalışma biçimlerini geliştirmek için fırsatlar aramaktadır. Deniz lojistiği sektöründe, bu tür teknolojilerin yaygınlaştırılması, diğer küresel şirketlerle rekabet edebilmek için avantajlar yaratabilir. Bu araştırmada blok zincir teknolojisinin değer kattığı organizasyonel, çevresel ve teknolojik olmak üzere 9 boyut bir araya getirilmiştir. Bu boyutlardan hareketle blok zincir teknolojisinin adaptasyonunda dikkate alınması gereken 35 faktör sıralanmıştır. Toplam Yorumlayıcı Yapısal Modelleme yöntemi kullanılarak bu faktörler ve birbirleriyle olan bağımlılıkları değerlendirilmiştir. Yöntem aynı zamanda denizcilik lojistiği şirketlerine bu yeni teknolojinin sıfırdan entegrasyonu sırasında bir yol haritası oluşturma konusunda rehberlik edebilir.

Anahtar Kelimeler: Blok zincir, Toplam Yorumlayıcı Yapısal Modelleme (TYYM), Denizcilik Lojistiği

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I would like to sincere thank my advisor.

I also express my deepest love to my family for their unfailing support and continuous encouragement.

Burak Arifoğlu

İzmir, 2022

TEXT OF OATH

I declare and honestly confirm that my study, titled "INTEGRATING BLOCKCHAIN TECHNOLOGY INTO MARITIME LOGISTICS COMPANIES" and presented as a Master's Thesis, has been written without applying to any assistance inconsistent with scientific ethics and traditions. I declare, to the best of my knowledge and belief, that all content and ideas drawn directly or indirectly from external sources are indicated in the text and listed in the list of references.

Burak Arifoğlu

Signature

…….

August, 2022

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SYMBOLS AND ABBREVIATIONS

ABBREVIATIONS:

IoT Internet of Thing

BC BlockChain

ANP Analytic Network Process

B/L Bill of Lading

POD Port of Discharge

POL Port of Load

ICT Information and Communication Technologies

ISM Interpretive Structural Modelling

MCDM Multi Criteria Decision Making

TISM Total Interpretive Structural Modelling

SSIM Structural Self-Interaction Matrix

RM Reachability Matrix

FRM Final Reachability Matrix

MICMAC Cross-Impact Matrix Multiplication Applied to Classification

CHAPTER 1
INTRODUCTION

Technological improvements have started to dominate our lives with Industry 4.0 revolution by the integration of electrical and digital automated systems on manufacturing processes. In 2019, Computing Technology Industry Association (CompTIA) listed down the top ten new technologies as the Internet of Thing (IoT), 5/6G networks, Drones, Blockchain, Artificial intelligence, Biometrics, Server less computing, 3D printing, Robotics, Augmented Reality/Virtual Reality. Especially, Blockchain (BC), wireless communication through 6G network technologies will bevital in creation of innovative business models for Industry 4.0 (Esmaeilian et al., 2020).

Blockchain may create value to different areas of industry. In 2017, a research predicted that, blockchain technology value-added worth will be more than $176 billion by 2025 and will be $ 3.1 trillion by 2030(Fernandez-Carames&Fraga-Lamas, 2019).With the help of these technological changes, activities of supply chain members can become automatic and sustainable which increases the simplicity, efficiency, and persistency of the tasks with automation (Vaidya et al., 2018). Dramatic changes can take place in our lives since computers have become an important assistant in the recent years. Time is an important efficiency criterion so that with the reduction of System Response Time through Industry 4.0 improvements, satisfaction and productivity of workers -so as the supply chain-may increase (Barber & Lucas, 1983). Same research shows that blockchain technology can create time efficiency advantage with several other advantages. With the help of this digital technology, companies and customers can create economic, social, and environmental benefits. For instance, blockchain technology can create money transfer in a matter of seconds or minutes without paying high transfer costs (Swan, 2017).Observing several benefits of Industry 4.0, companies need to consider applying new technologies so as to be a part of globalized markets.

As a major part of the global trade, companies operating in maritime logistics should be finding ways to operate efficiently to become global players since they cannot survive as a local player in the market. According to Van de Voorde & Vanelslander (2010), based on the OECD countries port market shares data, HPH port Company which has the highest share (14%) with 66 million TEU in 2007 among top 8 companies, has the 52% of the global market share. Because of that, local players need to find different ways to become competitive and take part in the global market.

Maritime logistics companies can use evolving technologies of Industry 4.0 such as blockchain technology to earn competitive advantages; however, implementation of this new technology on this specific sector can have some barriers on Technological, Organizational and Environmental aspects which needs to be considered in detail. Even though blockchain creates high computing power to the companies, it has high investment and hardware costs. In some cases usage of the traditional system can be more flexible, since blockchain needs a minimum of 50% of the stakeholders to confirm the work and each participant of the blockchain should have a high quality infrastructure for fast confirmation (Pucihar et al., 2018).

Companies should do a detailed analysis to understand the benefits and drawbacks of blockchain technology, so that the improvements on the technological infrastructure by the help of the blockchain can cause a global benefit whereas the overall costs become cheaper despite the high investment costs. With the use of blockchain, organizations can perform operations in a rapid way and using a consistent and trustable data. Blockchain can also create environmentally friendly systems by decreasing the carbon footprint. For example, according to Pu & Lam (2021), a comparison of paper based system and a digital system in Singapore and China shows that with blockchain systems total emissions can be lowered with 99% by the reduction of shipping documents. Because of these reasons, purpose of this study is to clarify the factors in implementation of blockchain on maritime logistics sector.

In general, the aim of this study is to understand the factors that needs to be considered in the integration of blockchain technology in maritime logistics companies. By the help of the methodology used in the thesis, a roadmap will be built with the guidance of the experts in the sector in order to implement this new technology.

In the following sections, blockchain technology is introduced briefly. In chapter 2, maritime logistics sector and how it can relate with blockchain technology has been described. In chapter 3, factors that needs to be considered in the integration of blockchain technology has been gathered from existing literature. The dependencies of these factors has been analyzed using TISM method in Chapter 4. Study has been summarized shortly with future research possibilities in chapter 5.

1.1. Blockchain technology

1.1.1. What is Blockchain technology?

Blockchain (BC) can an imatable like a paper on sky like every sides can see and read easily, nobody can change anything secretly. In blockchain technology, using smart contracts, information can be shared as unchangeable and almost in real-time and issues of transparency, archive space, automation can be solved for payments and other commercial applications (Javaid et al., 2021). Blockchain contains of a combination of "Block" and "Chain". The Block is our element and shows each process of every element connecting step by step and carry last block information, this connection sequence build The Chain. The basic principle of blockchain is independent peer-to-peer network. This network explain with information sharing platform between a number of working entities (Jović et al., 2019). Nobody can be the owner of the blockchain and nobody can delete any block on chain but everybody can add information on their side (Min, 2019).

A money transfer example can shows the working logic of blockchain.

1) A and B participants decide to do their payment contract using blockchain.

2) Payment is broadcasted to the network of nodes (participants)

3) This process is represented with a block.

4) Peer-to-peer network confirm the block, confirmed blocks added to the linear chain with time mark. Linear chain has older payment blocks as well.

5) When a new block is added to the chain, this new block becomes unchangeable.

6) Process finishes when money transfer between A and B participants have been completed (Min, 2019), (Wang, 2021).

Blockchain-based platforms can be classified as private, public, and consortium. On Private blockchain platforms, limited and chosen peers have access on allowed operations like Hyperledger Fabric. Hyperledger Fabric system can be used on sharing logistics documents and information about cargos, but it should be kept in mind that system will require support during operation all the time due to update of customer portfolio or scaling the system. Public blockchain platforms work with unlimited control mechanism and all process archive is transparent like Ethereum. Ethereum system store the information uploaded from unknown different locations anonymously. Ether is crypto currency of Ethereum and normal users earn this currency with transferring and storing the data. The consortium platforms work like partially private platform without the consolidating power of one stakeholder -unlike private platform- like Quorum (Ahmad et al., 2021.So for logistics networks, private platforms seem to be the most suitable.

1.1.2. Importance of Blockchain Technology

Blockchain technology can be used on financial assets, payment methods, smart contracts, risk management and Internet of things (IoT). IoT can upgrade with blockchain and create advantages on competitive processes with smart connection and protocols on RFID sensors, Wii-Fi, Bluetooth eth. (Jović et al. 2019).On the other hand, Information centralized systems' partners can not take a lot of information about upstream or downstream process because the information / paper visible just two partner so if center be fail with cyberattack, all system take damage and all processes will be affected. Blockchain create a platform with all partners can see so more safe and can be synchronize (Pu& Lam, 2021). Moreover, blockchain reduced third-party partner’s quantity so create cost and time advantage on more simple supply chain (Min, 2019).Blockchain add a lot of advantages to supply chains by offering transparency, immutability, trustability, traceability, simplification and high-speed transaction sharing (Golosova & Romanovs, 2018).

1.1.3. Literature Review

There exists a vast number of articles about the implementation of blockchain technology on different sectors and supply chains. Table.1.1. shows the most important studies about integration of blockchain. The methods that have been employed in related

article and dimensions considered during implementation have been presented in the table.

Table 1.1. Literature Review of Blockchain Dimensions

Author	Sector	Dimension	Method
Orji et al. 2020(1)	Freight logistics industry	Technological Organizational Institutional	Analytic Network Process (ANP)
Ronaghi, 2021(2)	Agricultural supply chain	Strategy Governance Leadership Culture People Customers Operations Products Technology	SWARA
Janssen et al. 2020(3)	Blockchain technology adoption	Institutional Market Technical	Literature Review
Lu et al. 2021(4)	Elderly care industry	Technology Complexity Environment Organization	Survey / PLS-SEM Analysis
Junge & Straube, 2020(5)	Sustainable supply chains	Environment Social	Literature Review
Durach et al. 2021(6)	Supply chain Transactions	Single Use Localization Substitution Transformation	Delphi Study / Survey
Bekrar et al. 2021(7)	Reverse Logistic	Immutability Decentralization Consensus Driven Transparency	Thematic Review and Synthesis of the Literature
Badzar, 2016(8)	Transport Contracts and Supply Chain	Relative advantage Compatibility Complexity Trialability Observability	Document Analysis / Case Study / Interview
Aich et al. 2021(9)	Healthcare Industry	Organizational	ISM Model / MICMAC Analysis
Ahl et al. 2020(10)	Energy Sector	Technology Economics Society Environment Institutions	Case Analysis

Yang, 2019(11)	Maritime shipping	Customs clearance and management Standardization and platform develop Intention to use Tracking and tracing Business model and regulation Digitalizing and easing paperwork	Exploratory Factor Analysis / Item Total Correlation Analysis / Technology Acceptance Model /Survey
Ali et al., 2020(12)	Financial Sector	Transparency Data Integrity Immutability Privacy Reliability Versatility	Literature Review
Holotiuk & Moormann, 2019(13)	Organizational Adoption	People Organisational struc. Technology Business unit IT unit Project manag. Environment	Interview
Wong et al. 2020(14)	Operations and Supply Chain on SMEs	Technology Organisation Environment	*Structural model *Preliminary analyses *Importance Performance Map Analysis (IPMA) *Measurement model *Artificial neural network analysis *Common Method Bias (CMB)
Zhou et al. 2020(15)	Singapore's Maritime Industry	People External Environment Methods Technology Organization	AHP PESTEL
Carlan, 2020(16)	Maritime Supply Chain	Economic Legal and Political Technological Cultural & managerial	In-depth Case Studies
Li et al. 2021(17)	Air Industry	Payment Identity management Customs clearance Air traffic control Tracking	Survey / Structural equation model (SEM) / Technology acceptance model

Javaid et al. 2021(18)	Industry 4.0	E- Commerce and Retail Industry Manufacturing Industry Agriculture Industy Oppen ıssues&Newer application Areas Healthcare Industries Power Industry	Literature Review

Orji et al. (2020) usesanalytic network process (ANP) method with blockchain integration factors in the global logistics sector and most important factor has been decided as technological factor when compared with organizational and institutional factors. Ronaghi (2020) analyzes several dimensions with SWARA method and smart contracts has been rated as the most important one. Janssen et al. (2020) also shows that blockchain technology adoption mostly concentrate on technological aspects. Lu et al. (2021) analyses the advantages of blockchain adoption on elderly care industry in China using survey and PLS-SEM method. Junge & Straube (2020) investigates the social and environmental impact of digital transformation technologies on logistics and result of the study proves the positive impact on the way of working. Durach et al. (2021) conducted a survey with 151 manager working on machinery and equipment sector in Germany about Blockchain and Supply Chain Transactions and discusses when, where and why the companies should be using blockchain technology. Bekrar et al. (2021) analyzes transportation, the reverse logistics, and blockchain nexus, and explains the importance of new technological tools like drones, IoT, autonomous vehicles, cloud computing, the physical internet, sensors, and artificial intelligence. Findings of Badzar (2016) shows that blockchain have great potential in environmentally sustainable logistic process with traceability of cargoes and the securing of transports. Aich et al. (2021) gathers most important dimensions of healthcare sector and uses ISM and MICMAC method for analyzing13 factors and concludes that security concerns, investment cost, and compatibility are all critical at the same time. Ahl et al. (2020) work on a case study about energy sector in Japan and analysis expresses 5 critical dimensions which are the challenges and opportunities of blockchain. Yang (2019) analyzes dimensions about Maritime

shipping digitalization with blockchain. According to this study, blockchain technology can be supported by the dimensions listed as customs clearance operation, digitalizing to ease paperwork, standardization of way of working and platform development. Among these dimensions, standardization and platform development are the key dimensions on maritime logistics with Technology Acceptance Model but customs clearance related operations and digitalizing dimensions are directions which require urgent actions for application of blockchain technology into the maritime logistics supply chain.Review of Ali et al.(2020)summarizes the blockchain technology usage in financial services sector. Holotiuk & Moormann (2019) scrutinizes the adoption of blockchain technology with interview method and ended up with 7 dimensions to be considered. Whereas, Wong et al. (2020) investigates adoption of blockchain in operations and supply chain management in Malaysia and have realized that managing complexity, competitive pressure, and cost are the important dimensions; however, competitive pressure is the foremost dimension. Moreover, high level management support, regulatory changes in integration, and market dynamics seems to be less significant compared with the previously mentioned ones. Zhou et al.(2020) uses AHP method to find out important success factors of blockchain during the implementation in Singapore's maritime logistics sector and expert consultancy and assistance, the support from top management, ease of local law, support from the shipping community, sufficient capital, and sufficient staff training are the critical success factors in logistics especially. According to Carlan (2020), key contribution of blockchain technology on maritime supply chains in the increase of efficiency in operational planning and validation of product/service payments. Li et al. (2021) uses SEM method to analyze blockchain adoption in air industry in Korea and according to the findings regulation about technology, digitalized management, tracking and tracing, future improvements in governance, air traffic management can positively affect the use of blockchain technology. Javaid et al.(2021) reviews Blockchain systems applications in Industry 4.0 and digitalization is an important factor of Industry 4.0 since it can increase efficiency and improve way of working in all aspects, such as from technology and management consultancy to supply chain solutions and strategy.

CHAPTER 2
MARITIME AND BLOCKCHAIN

2.1. Maritime Logistics

Panayides & Song (2013) defined the term Logistics as, "Logistics is that part of the supply chain process that plans, implements and controls the efficient, effective flow and storage of goods, services and related information from the point of origin to the point of consumption in order to meet customers' requirements.". Similarly, Maritime industry is managing the movement of goods and information, the process of planning, and implementing(Lee & Song, 2010) and operative mission is to carry cargos with ships on rivers, channels and seas with lower cost, fuel and emission (Panayides & Song, 2013). The EU 2011 White Paper on Transport EU (2011) has a purpose of reaching 60% less greenhouse gas value about transportation from 1990 years for 2050. For achieve this aim, by 2030, 30% of the "over 300 km" road transportation processes should be altered with rail or maritime transport modes (Psaraftis, 2016). Besides carrying, maritime logistics have a number of other service activities like warehousing, inventory management, re-use, offering a distribution center, testing, repairing, assembly, inland connection, packaging, quality control, repacking, and stripping/stuffing. Another service which is transshipment port and container transfers, Nam & Song (2011) shows that Asia transshipment port volume in 2011, Singapore port have high transshipment quantity with 18.790 million TEU and this value equal to 81% of total handle volume so port can create different advantages to their area with different missions. At the same time, maritime logistics support other logistics services with pick-up service, information and intermodal services, bill of lading (B/L) for inbound/outbound transfer, delivery notification, container tracking and special handling services whenever customers require for particular occasions(Lee & Song, 2010). Such diversified operations to perform requires various number of partners in the system to operate in cooperation. Figure 1 shows the stakeholders in the network (Irannezhad, 2020).

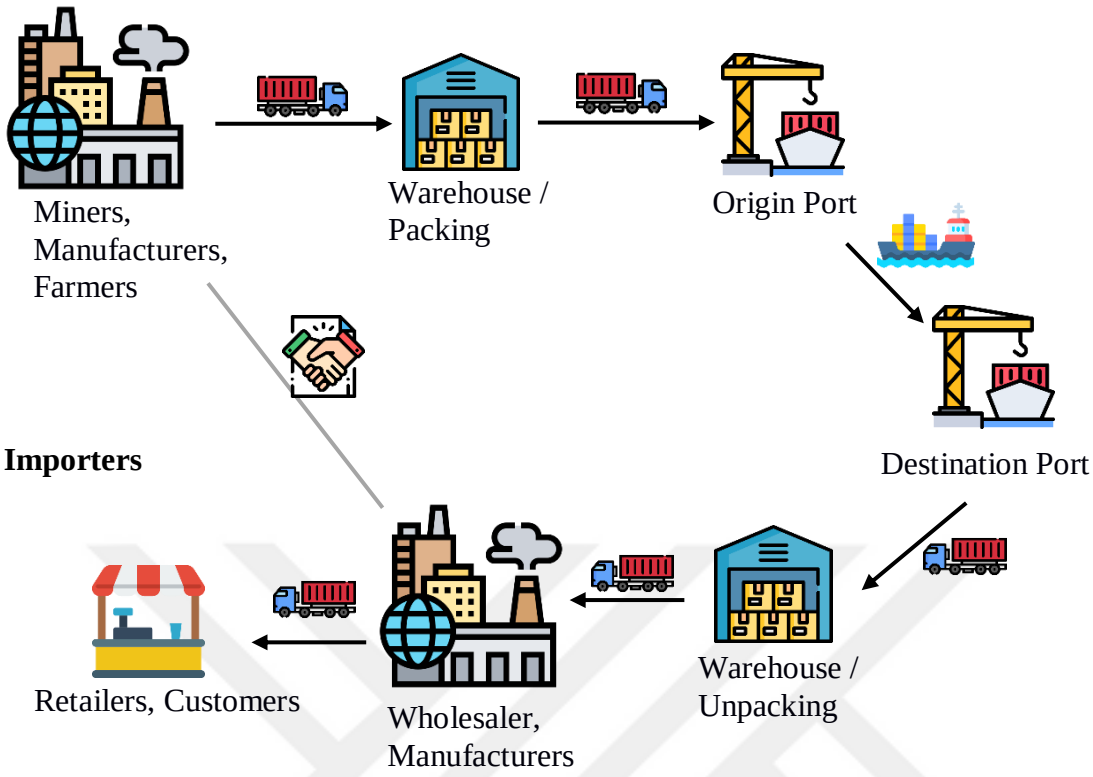

Figure 2.1. Example of international freight transportation (Irannezhad, 2020) (Icons are retrieved from https://www. flaticon.com/)

2.2. Blockchain Technology on Logistics

Logistics processes are very complex in nature due to the interaction of various stakeholders. Figure 2.2.depicts this complexity of Maritime Import Logistic process apparently since the system contains different interacting parties of Exporter, Port, Freight forwarders, Authorities, Trucker and Consignee.

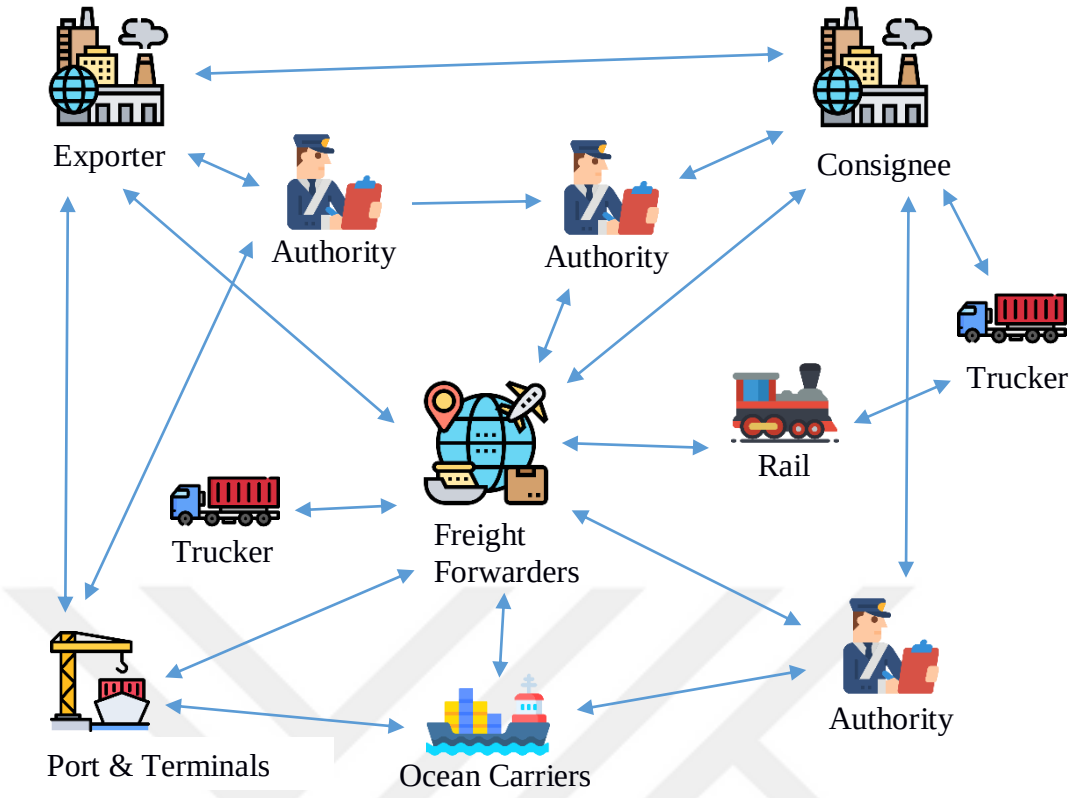

Figure 2.2. Traditionalprocess diagram in maritime logistic (Wang, 2021). (Icons are retrieved from https://www. flaticon.com/)

Currently, most of the logistics companies are struggling with extra costs, delays, and inefficiencies and the abovementioned stakeholders are seeking new methods to decrease their costs to gain competitive advantage. However, most of the time these efforts are performed without coordination and cooperation. Significant part of the inefficiency -which is approximately 15 to 50 per cent- on maritime logistics arises due tohuge effort of preparing paperwork and physical delivery of paper (Irannezhad, 2020). 75% volume and 60% value of World trade has been carried out by maritime logistics (Zhong et al.2021). Each transportation transaction requires alarge amount of paperwork that includes certificates of goods, bills of lading (B/L),contracts, customs clearance declarations, and invoices(Pu & Lam, 2021). Any mistake on documentation process can create high costs of loss and can damage all process flow (Jović et al. 2019).

Consignee side must have physically B/L to remove their cargo from destination port. There are two types of B/L: original (physical) B/L, sea waybill lading. If the

consignee is currently an active customer of the logistics company, it would be sufficient to prepare seaway bill. However, if the customer is a one time consignee and is not an active customer, original B/L can be prepared. However, before original B/L preparation, accounting departments should be confirming if the freight cost is paid. If B/L is Original, there could be some issues during delivery like delivery time, delivery cost, wrong delivery location and lost paper work in intercontinental transports. B/L can be organized with Seawaybill (Express) if the consignee is a reliable customer. Because seaway bill sent with email ensures that consignee has to pay freight before transportation or definitely should pay in the future. Therefore, companies should try to choose right customers and build trustworthy relations in competitive global market and they start to think using technologies like Blockchain to ensure long term relations with safe and fast systems. Figure 2.3.describes the B/L process step by step. Another important point is information asymmetry and visibility of process. Empty container and truck controls, human mistakes, changing in plans, and penalty fees can be possible issues in these systems (Irannezhad, 2020). Blockchain paper (on sky) can be a solution with private based systems for relevant stakeholders and carry cargo details, information or currency (Irannezhad, 2020). Blockchains can join the process with integrated database. Database of a blockchain integrates different stakeholders of current logistic systems which requires complex cryptographic verification since it contains important and confidential information should not be changed (Irannezhad, 2020). Figure2.4.represents the possible stakeholders in a maritime import process which needs to be incorporated into the blockchain technology.

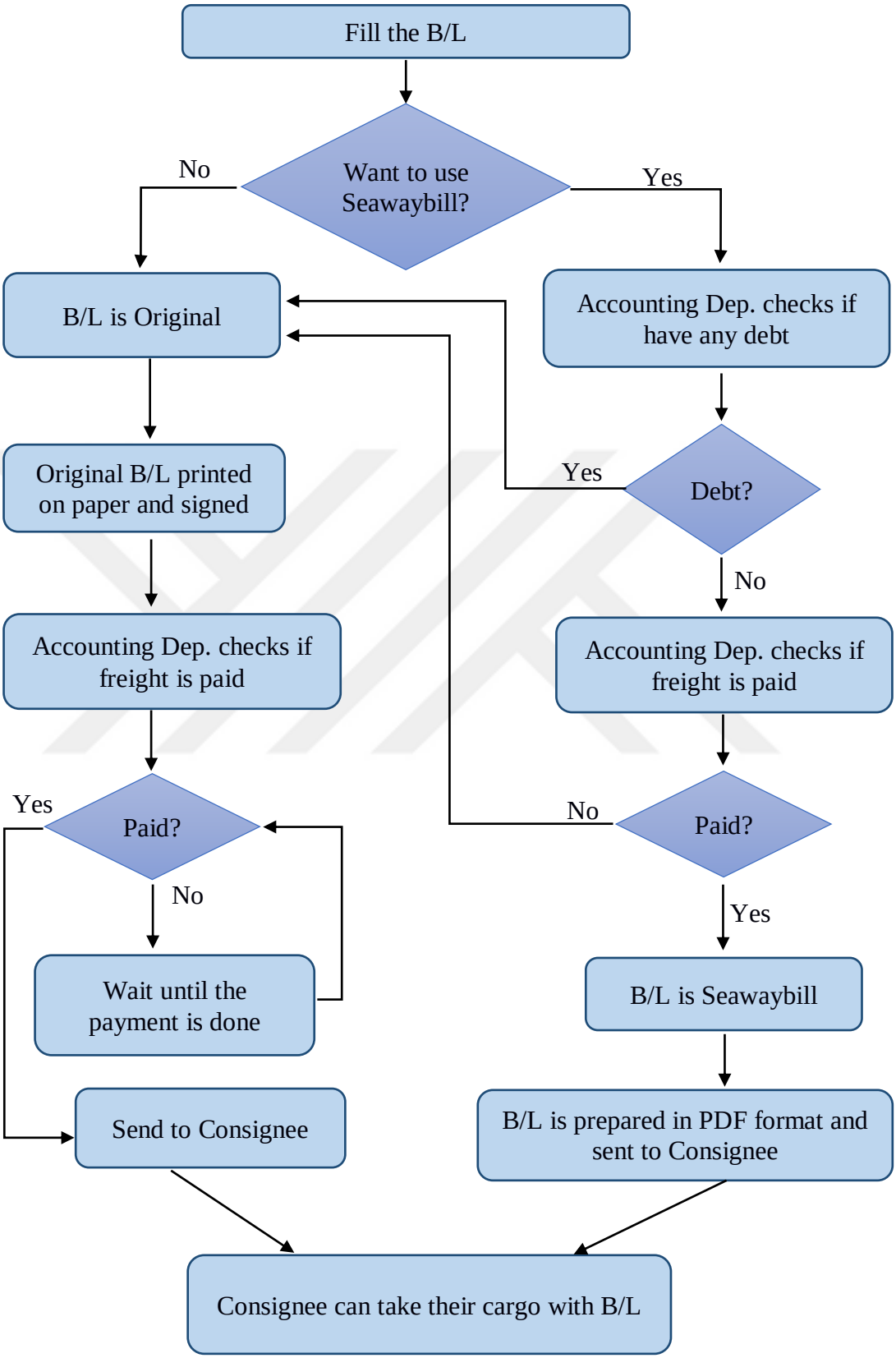

Figure 2.3. Maritime Bill of Lading (B/L) process.

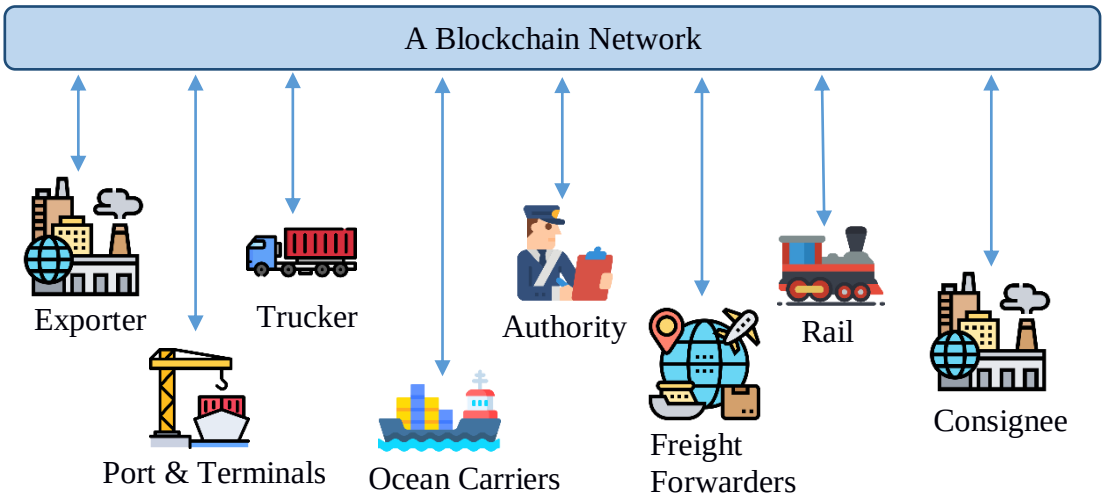

Figure 2.4.BC process diagram in maritime logistic (Wang, 2021). (Icons are retrieved from https://www. flaticon.com/)

Companies will see a lot of challenges when they want to modernize their systems or processes. Technologies that require high integration like blockchain can impact the whole way of working throughout the logistic network. In the next chapter, factors that needs to be considered during the implementation of blockchain technology in maritime logistics will be listed.

CHAPTER 3
DIMENSIONS OF IMPLEMENTATION OF BLOCKCHAIN IN MARITIME LOGISTICS

3.1. Dimensions and Related Factors to Consider in Blockchain Implementation

Existing literature on blockchain technology and implementation on various sectors have been analyzed in order to gather the dimensions and related factors to be considered in the integration of this new technology in maritime logistics. These dimensions and related factors have been provided in Table3.1.

Table 3.1. Dimensions and Related Factors to consider in integration of Blockchain

Dimension	Factors
Technological	*** Cybersecurity**(Security and privacy (1), Information security (4), Cybersecurity (10)) *** Reliability of technological standards**(Suitability of technological standards (2) Reliability of technology (15) Tec. Trust (4)) *** Flexible and advanced infrastructure**(Flexible infrastructure (13), Sensors, Utilization of mobile devices (2), Effective usage of iBeacons or WiFi, RFID,NFC-tags and QR-codes (8),) *** Hardware performance**(High speed connectivity (10)Scalability and accessibility (9), Scalability (15), Data storage (10)) *** Development of BC technology** (In-house/ internal development (13))

Organizational / Operations	*** Selection of processes moving to blockchain**(Decentralization of processes (2), Transfer of contracts, bonds, deeds, or stocks (6), Centralized decision-making (10)) *** Confidentiality of information**(Free access within the supply chain to necessary information (8) Private and public access to multiple active platforms (8), Transparency, Knowledge sharing (2), Privacy protection (10)) *** Compliance of stakeholder transactions**(Procedures to Document-signing processes (6) Ease of being tried and observed (1)) *** Company's ability to manage the process**(Organizational readiness (4), Ability of the organization to train and up skill their employees (15), Management competences and methods (2))
Governance / Institutional	***Attitude of company management**(Institutional based trust (1) Internal cooperation (13) High level management support (14) Absence of management commitment and support (16), Government support (4)) ***Attitude of system stakeholders**(Stakeholders pressure (1) Willingness of leaders (2) Trust among stakeholders (9) Encouragement of integration (9), Incompatibility between traditional business processes and blockchain technology (3), Uncertain stakeholder roles (10), Trust (among partners and in new technology) (16)) *** Preparation of the company**(Dedicating enough time and resources to support the project (15), Arranging meetings to discuss new technology with internal and external users (15), Capability of human resources (1), Firm size (1))
Environment	*** Measuring resource efficiency**(Resource efficiency (5)) *** More environmentally friendly process**(Process energy (5) Process emissions (5), environmental regulation in smart contracts(10)) *** Decreasing wastes**(Waste, Pollutions (5) Switching to hashes instead of physical document to execute transactions (8) Emissions reduction scheme uncertainty (10)) *** Traceable product lifecycle**(Enabling easier tracking, tracing and recycling of the product lifecycle (8))
Social / Cultural	*** Fear from new technology**(Due to changeless data after upload, increased fear of making mistakes (15), Feeling uncomfortable due to switching into a new management and operating structure (15), Hesitation to convert to new systems (16)) *** Being ready for new technology** (Lack of blockchain knowledge (15), Lack of understanding of blockchain technology (3), Openness of employees to new technology (2)Internal know-how (13)) *** Attitude of people**(Cultural resistance (3), Resistance to change (16), Organizational culture (1), Public acceptance (10)) *** Corporate social responsibility** (Development benefits (5), Skill development (10), Corporate Social Responsibility (4))

Economic	*** Investment cost**(Perceived costs of investment (1) Initial adoption and implementation cost of blockchain technology (3) Cost, financial constraints (16) High investment cost (9) Network consignment fees (10)) *** Alternative currencies**(6) (Reduction of transaction costs (8)) *** Financial stability of the stakeholders**(Requirement of financial stability of the partners to support high costs of implementing blockchain (15)) *** Finding investing stakeholder involvement**(Lack of investing stakeholder involvement (16))
Legal / Political	*** Legal loophole**(New law requirement (3), Multiple jurisdictions involved: no consistent legal/regulatory (16), Lack of governmental policies (16) New way of working for law enforcement agencies to handle fraudulent activities (3) Risk created by market manipulation and unfair practices (3), Cybercrime (3), Government losing control (3), Reducing risk of fraud or counterfeit goods (8), Protection of intellectual property (2)) *** Unclear concepts**(Describing the difference of Bitcoin in blockchain technology to policymakers (3), Explaining smart contracts to related partners (3), Confusion of smart contracts with e-contracts (3) Framework (16), Switching from existing contracts to new blockchain technology methodology (3)) *** Government incentive**(Government policy and support (1), Lack of rewards and encouragement programs (16))
Market	*** Selection of stakeholders** (Market turbulence (1) Low market maturity (13) Lack of experienced partners (15)) *** Equipment supply problem**(The need of high degree of computerization to handle market volatility (3)) *** Market competition**(Competitive Pressure (4) Market competition and uncertainty (16)) ***Support from shipping community (15)**

Customers	***Digitalization of services**(Digitalization of services (2) Product integration into other systems (2) Increase in the ability of customers to evaluate the product or supplier before making a decision (8) Easy access to the network as if using a smart phone (8)) *** Information sharing**(User's ability to determine the extent of participation and information sharing (8) Cooperation with partners in determining the extent of participation and information sharing (13) Information disclosure policy to be agreed between the partners in the supply chain (16)) *** Process traceability**(Customers to trace product origins and the freight route (8) Blockchain to enable monitoring, tracking and tracing transportation of the goods (8)) *** Incorporating end customers**(Encouraging the choice of buying sustainable products and transports (8) Improving the decision making process of the customers by enabling the ability to evaluate the product or supplier (8) Utilization of customer data (2) Lack of customer awareness and tendency about new technologies (16))

3.1.1. Technological

Factors related with Technological dimension have been gathered under 5 headings.

F1 – Cybersecurity

It is difficult to create a cyber-safe structure in the digital world where everything spreads very quickly and is accessible. Companies need to be sure that their information will be safe against cyber-attacks. It is an important factor for organisations to use blockchain systems and protection of their valuable data by the help of the blockchain is an important advantage (Lu et al. 2021).Maritime sector needs safe and secure environment due to sharing lots of confidential data like Bill of Ladings (BL), Manifest and Invoice documents between buyer and seller.

F2 – Reliability of technological standards

Blockchain assures high level of technological standards which increases the trust of employee to system and which in turn increases the performance of the people. Lu et al. (2021) states that "As technology-oriented trust, the technical trust of blockchain is more trustworthy than the traditional institutional trust". Interviews conducted with maritime experts in Zhou et al. (2020) showed that they view the complication of the technology as a concern with 76.7% in maritime sector.

F3 – Flexible and advanced infrastructure

People in the sector want to use different types of technological equipment with new system so the system should be adaptable. The system should be flexible enough to easily switch with changing working conditions (Holotiuk & Moormann, 2019). Adaptable equipment can be WiFi or iBeacons, QR-codes, NFC tags and RFID software or technologies (Badzar, 2016) and mobile devices (Ronaghi, 2021) which can be integrated to the blockchain system. These types of flexible infrastructure systems can also be integrated on Maritime sector. Companies and customers can track their container on their mobile applications with GPS technology. NFC tags can be used on containers if customs officers or final destination process (rail, truck or barge) workers want to reach container information like hazardous cargo details, weighing information and port of load/discharge details.

F4 – Hardware performance

In order to run the new system with high productivity, hardware of all stakeholders should be ready for the new system requirements. Scalability is important for efficient performance and investment for blockchain can be expensive while adapting to a large scale system (Aich et al. 2021).When expanding the system, data storage, high-speed connection, high quality technological hardware should be considered in detail for large-scale blockchain environment (Ahl et al. 2020). In maritime sector with global partners in the network, data transfer can be huge if one can imagine the data requirement of high volume handling numbers on system. For example a big container vessel can carry 20.000 TEU (1 TEU = 20' Container) so this container information that needs to be shared on system to customers, producers, customs at the same time.

F5 – Development of BC technology

Stakeholders in the system may not have enough knowledge to develop and change the existing system to integrate blockchain technology. In order to adopt blockchain technology, companies should have knowledgeable IT employees with blockchain technology information. Companies can acquire internal and external trainings to increase blockchain knowledge and attract employees' attention, and hire external ITpersonnel (Holotiuk & Moormann, 2019) because every stakeholder may not have

IT developers .It should be kept in mind that in maritime logistics operating rules are changing frequently which requires rapid adaptation to new ways of working. For example, Port of Discharge (POD) customs rules are changeable so the system have to be adapted. If POD customs want to see new information about cargo, the system should be developed to transfer the information and technological requirements should be changed which shows the need for trained IT personnel all the time in the network.

3.1.2. Organizational/Operations

Factors related with Organizational/Operations dimension have been gathered under 4 headings.

F6 – Selection of processes moving to blockchain

Every business model cannot be suitable to blockchain technology so companies should be analyzing their processes carefully before the change. For example, Durach et al.(2021) shows that, moving some processes to blockchain can be related with existing regulations and formal rules rather than technical implementation. For example, Bill of Lading is the an important document after cheques so when B/L to be digital, every stakeholders should to be ready to this process by means of technology and regulations. Since maritime logistics sector has partners all over the world, considering the regulations of every country is a complicated process.

F7 – Confidentiality of information

Important decision in blockchain is to determine the transparency of information to the selected stakeholders. Blockchain technology can support the customers to take information about product of suppliers and transportation process (Badzar, 2016) and this technology contributes to data security, immutability and traceability between customer and consumer (Ahl et al. 2020).But on the other hand, companies may want to hide some confidential information from competitors. Maritime sector contain important confidential information about shipper, cargo and consignee so transparency of this information should be considered very carefully.

F8 – Compliance of stakeholder transactions

Compliance of stakeholder transactions is an important for system to work because the inputs and outputs of the stakeholders must be compatible with each other and

should not be an obstacle to work together. For example, document-signing operation have several parties to be in coordination and sale cycles have long process. Cross-border processes and different law systems in building contracts can be expensive and complex sometimes (Durach et al. 2021). Blockchain architectures do not have a certain standard and it needs high customization so Blockchain is not simple and cheap to try (Orji et al. 2020).Compliance in Maritime sector can be an issue since Port of Load (POL) and POD countries can have huge differences in regulations and they need to be considered in the integration process.

F9 – Company's ability to manage the process

Companies should be prepared to changes after switching to blockchain system in order to take least damage. To be ready to survive in a changing world, organizational readiness is important with sufficient financial resource, technical infrastructure and human resources when adopting the blockchain (Lu et al. 2021).

3.1.3. Governance/Institutional

Governance/Institutional Dimension have 17 different factors, but they have been compiled under3 main headings which are listed below.

F10 –Attitude of company management

Company management needs to be faithful to the project in the long term. Companies may encounter low profit in short term during the integration process, but high profits in the long term, so top level management should stay neutral (Carlan, 2020).

F11 – Attitude of system stakeholders

Blockchain cannot be run standalone without stakeholders so all stakeholders should work together and should trust each other and be targeted to the purpose. In the short term blockchain implementation can be expensive due to adaptation of large existing back office processes and complex legacy IT systems, and moreover it can create some additional standards(Janssen et al. 2020).So stakeholders should not give up on this process due to these problems. When the barriers of information and communication technologies innovation faces in the supply chain are summarized, most widespread ones are lack of trust and lack of collaboration between supply chain stakeholders (Carlan, 2020).

F12 – Preparation of the company

Companies should be ready for this revolution with organization, financial, human resources. Companies should to allocate enough time and resources for project. Companies need financial stability for adoption of blockchain technology. Besides, companies should provide training for develop their employees (Zhou et al. 2020).

3.1.4. Environment

Factors related with Environment dimension have been gathered under 4 headings.

F13 – Measuring resource efficiency

Blockchain create a transparent supply chain so resource efficiency can be traceable on the production and distribution stages. Non-renewable resources consumption is a sustainability criterion. On maritime sector, logistics companies can analyze resource consumption on their vessels or trucks for optimization (Junge & Straube, 2020).

F14 – More environmentally friendly process

Blockchain can be more environmentalist with digitalization which can decrease paper work/transfer quantity. Digitalization can decrease energy requirements on processes which in turn decreaseCO2 and other greenhouse emissions (Junge & Straube, 2020).P2P prosumer markets can work on smart contracts so blockchain can create cost efficiency and support P2P energy-trading (Ahl et al. 2020).Maritime sector can be greener after using blockchain technology due to decrease of paper documents on daily basis.

F15 – Decreasing wastes

Blockchain can help to decrease waste with digitalization. Stakeholders can reduce their cost and create environmental benefits with low paper and transportation work. Digital technologies can change quantity of recyclable waste and quantity of air, noise and water pollutions for sustainable supply chain (Junge & Straube, 2020). Blockchain can create benefit about resource coordination and energy flexibility with smart contracts (Ahl et al.2020).Paper work which is crucial in maritime logistics can decrease sharply with blockchain so this issue can help to reduce carbon foot print, earn labour time and reduce delivery costs (fuel, car and worker).

F16 – Traceable product lifecycle

Blockchain create a transparent supply chain if products are traced using the system. Its can give information about product lifetime. Stakeholders can analyze product lifecycle with blockchain so they can track and record production, usage and maintenance stages(Badzar, 2016).For example, customers can trace their containers and can see container age, produced country and what type of cargoes carried so this option can create an advantage for logistics companies.

3.1.5. Social/Cultural

Factors related with Social/Cultural dimension have been gathered under 4 headings.

F17 – Fear from new technology

Technological innovations can create fear on employees. Mostly people don't want to leave the old system andwant to use the system they are expert in. For example, already working maritime industry people can be conservative about new management structure/system and adopting new technology/knowledge (Zhou et al. 2020). This can be because of fear of losing their job due to not adapting to the new technology.

F18 – Being ready for new technology

Employees should have enough information and be enthusiastic about blockchain technology for use on their work area. Many articles explain that businesses, consumers and authorities have a lack of knowledge about potential use of new technologies, how to work and what advantages they carry(Janssen et al. 2020).

F19 – Attitude of people

People can have bad experience about new technologies so people can defend the old system for use. Businesses can experience cultural resistance for blockchain adoption and this can endanger the blockchain integration process (Janssen et al, 2020).

F20 – Corporate social responsibility

Companies have social responsibility on their employees by increasing their knowledge level by trainings, offering development opportunities in the company. Also, ecological impact of their ways of working should be considered. Blockchain technology can increase the capabilities of the work force in the system while offering environmentally friendly outcomes.

3.1.6. Economic

Factors related with Economic dimension have been gathered under 4 headings.

F21 – Investment cost

Blockchain technology have high investment cost like equipment, setting up the system, cost of adoption, network consignment fees and lots of other expenditures so this factor is an important for systems. For developed countries, companies in freight logistics can implement digital technologies perfectly but in economically struggling countries, logistics companies cannot effort to pay the high investment cost of blockchain adaptation (Orji et al. 2020).

F22 – Alternative currencies

Digital currency can help to companies make payments all over the world fast and easy. Blockchain based currencies can be an alternative of physical currencies with security, anonymity, fast and lower transaction fees. International trade can be cheaper without intermediaries (Durach et al.2021).Maritime sector operate with different countries having their own currencies, so a single digital currency can be more useful and safe for shipper, carrier and consignee.

F23 – Financial stability of the stakeholders

Every stakeholder cannot have same budget so financial stability be important for system use, development and flexibility of risks. Organizations need to have economic stability to overcome cost of applying blockchain so this stability is difficult for have maritime industry in economically underdeveloped countries (Zhou et al. 2020). If undeveloped countries POL company sink or want to back old system because of costs, other stake holders like carrier, customs and customers will take damage about it.

F24 – Investing stakeholder involvement

In the system, stakeholders should be willing to be the part of the blockchain integration process. It will impact the ways of working throughout the system, so partners should be ready to pay the high investment cost of the new technology. This new IT infrastructure will also require companies to take consultancy from software companies as well which will increase initial cost and future operating costs (Carlan,

2020).Maritime sector which has a complex system connecting various stakeholders should be dedicating enough time to convince all the parties in advance.

3.1.7. Legal/Political

Factors related with Legal/Political dimension have been gathered under 3 headings.

F25 – Legal loophole

Current law systems are not ready for new technology methods so governments may not able to take action or provide protection against frauds. Policymakers and regulators needs to focus on blockchain subject to avoid taxation issues and criminal activities. New laws and regulations can support the businesses to track and guide for sector compliance (Janssen et al. 2020).

F26 – Unclear concepts

Governments can start removing unclear subjects by organizing legal regulations in order to reduce confusion in businesses. Moreover, businesses should be informed by the policymakers about the blockchain technology to clarify misunderstandings. Blockchain should be reviewed against banking laws, commodities laws and securities laws (Janssen et al. 2020).Maritime sector which has global stakeholders is also critical since it needs to be checked against the laws of many different countries and unclear concepts can create high costs for stakeholders in the future.

F27 – Government incentive

Government can increase blockchain integration project quality and quantity with incentives, tax deductions and policies, and prevent frauds with new regulations. Government have ability for give support and enact rules and regulations for blockchain integration in the logistics sector (Orji et al. 2020). For example, The European Court of Justice (ECJ) rules crypto currency process going without VAT Janssen et al. (2020).Due to various advantages of blockchain technology in maritime logistics, governmental support can be initiated on adaptation projects.

3.1.8. Market

Factors related with Market dimension have been gathered under 4 headings.

F28 – Selection of stakeholders

Blockchain technology is a long term process which requires high initial investment and dedication; therefore, stakeholders have to stay strong on market share and economically (Orji et al. 2020).In logistics services, stakeholders can change from time to time due to variable and unstable nature of the sector. Before integration project, feasibility should be examined very carefully.

F29 – Equipment supply problem

When starting integration, stakeholders start to request technological equipment so current market should have enough supply in terms of value or quality. For example, developing or under developed countries may face difficulty in gathering required technological devices (Janssen et al. 2020).On maritime logistics sector, this could be a possible concern since logistic operations can happen in very different types of countries.

F30 – Market competition

Companies have to increase their business quality to survive in the competitive market. Companies can initiate new technologies to keep or attract customers. This competitive pressure can encourage managers for understanding new technologies (Lu et al. 2021).Maritime sector which has giant players can be also willing to use new technologies like blockchain to compete.

F31 – Support from shipping community

Shipping community can increase blockchain adoption with meetings in the industry. Community can support participation rate among supply chain members by the help of training organizations (Zhou et al. 2020).

3.1.9. Customers

Factors related with Customers dimension have been gathered under 4 headings.

F32 – Digitalization of services

Customers of a product can be integrated in to digital platform with blockchain technology so they can have access to the transparent information about the product so that they can evaluate the buying decision. Customers can see the origin or the

shipment information of their purchases with the help of the blockchain technology by maybe just simply using their smart phones.

F33 – Information sharing

Customer can control the extent of information sharing about themselves in order to protect their security and privacy using blockchain. Technology can be designed with two different types of keys: public key and private key. Public key can be used between stakeholders but private key can be used to enable a receiver like seal-of-approval (Badzar, 2016).In maritime logistics with lots of confidential information, these keys need to set properly.

F34 – Process traceability

Transparent system enabled by the blockchain technology makes it possible to track all supply chain stages by end customers. They can take any information about production, distribution, logistics, etc. (Badzar, 2016).

F35 – Incorporating end customers

End customers integration into the system creates advantages in all parties. End customers will be able to realize the supply chain process and evaluate their buying decision with a lot more data which will increase customer awareness. Producers will be encouraged to have sustainable system to attract customer attention. They will also access and understand their potential customers.

CHAPTER 4
TOTAL INTERPRETIVE STRUCTURAL MODELLING

The interpretive structural modelling (ISM) proposed by J. Warfield in 1974 for understanding multidimensional and multi perspective problems. Interpretive structural modelling name describes the purpose of this method in general. "Interpretive" explains the connections between the components of a complex system, "structural" decomposes the complex problem into basic parts based on the relationships and lastly "modelling" describes hierarchical structure and dependencies picturally to convey explicitly (Sharma &Kumar, 2020). Furthermore, ISM supports managers for decision making with systematically looking at the interlink ages and forming a diagraph (Sharma & Kumar, 2020).ISM can be used in several areas to model different complicated issues and systems (Yadav et al. 2020).

Cross-impact matrix multiplication applied to classification (MICMAC) was developed by Duperrin &Godet (1973) to categorize the factors with their drive potential and dependence (Singh, Singh & Khamba, 2020). ISM and MICMAC has been used together in many studies and as MICMAC being part of ISM, driving power potential and dependencies of the components of the model can be used to show contextual interactions (Rana et al. 2021).

ISM is a part of multi criteria decision making (MCDM) but ISM is suitable for thesis because of its features listed below:

1) Allows analyzing the differences between elements and understanding of what criteria are based on hierarchically (Mandic et al. 2015).

2) Supports to understand the order and direction of relationships among various elements of a complex system (Sindhwani & Malhotra, 2017).

3) Produces a structured graphical representation of the complex system which can be communicated more effectively to others (Attri et al. 2013).

The total interpretive structural modelling (TISM) is a developed form of ISM with more increased knowledge base between the factors. Compared to ISM, TISM is a more transparent form and decreases wrong interpretations (Sharma & Joshi, 2021). TISM is a more powerful method to show causal relationships and to overcome the vagueness generally faced while dealing with qualitative criteria (Rajesh, 2017). TISM answers the question "why" in addition to the ISM answering “what" and "how". On the other hand, TISM help the users with decreasing redundant comparison numbers (Hasan, Dhir & Dhir, 2019). Because of complex relationships and high number of factors to be considered, TISM method seems to be suitable for applying on this study.

Due to their advantages, ISM/TISM methods has been used in many researches to analyze barriers and criteria. Table 4.1. shows some research examples that employed ISM and TISM method on Blockchain technology.

Table 4.1 ISM and TISM applications on Blockchain

Method	Research Topic	Reference
ISM	Blockchain Integration on Healthcare Industry	Aich, et al. (2021)
ISM	Blockchain Cybersecurity Barriers on Supply Chain	Etemadi, Van Gelder & Strozzi (2021)
ISM+DEMATEL	Blockchain integration obstacles in agricultural supply chain	Yadav, et al. (2020)
ISM	Blockchain adoption challenges on Indian public sector	Rana, Dwivedi & Hughes(2021)
ISM+DEMATEL	Blockchain integration obstacles in the engineering and construction sector	Xu, Chong & Chi (2021)
TISM	Obstacles to the integration of blockchain systems in business supply chain	Mathivathanan, et al.(2021)
TISM	Blockchain-based efficient communication for food supply chain industry	Tayal, et al.(2021)
TISM	Obstacles to blockchain integration in health-care sector	Sharma & Joshi (2021)

4.1 Methodology

TISM method steps have been explained in below10 steps (9 Steps from; Sushil (2018), 1 Steps from; Xu, Chong and Chi (2021)).

Step1: Identify and define elements

Step 2: Define contextual relationships between elements by pairwise comparisons like “Factor i is influencing/enhancing Factor j”.

Step 3: Construct contextual intercourses between blockchain factors (Xu, Chong and Chi, 2021). Experts answer the question with “Yes (Y)” and “No (N)”. If answer is “Y”, experts should comment about relationship between factors. Aggregated matrix shows total of answers. These relationships build up the “Knowledge base”.

Step 4: Build Reachability Matrix (RM) based on the Knowledge Base. “Y” is equal to value “1” and “N” equal to value “0” on RM. In order to combine the knowledge base from various experts, the answers of at least two-thirds of the correspondents should be consolidated. Combined matrix that has been formed from (1, 0) values are called as an Aggregated matrix. This RM can be converted into structural self-interaction matrix (SSIM) to understand the factor comparisons of users.

On ISM/TISM, responses of the users can be represented using letters (V, A, X, O) and they can be converted easily to numbers (1, 0) based on these letters (Baykasoğlu & Gölcük, 2017);

SSIM table is prepared with "V","A","X" and "O" letters, these letters explain the relationship between factos (Yadav et al. 2020). In order to represent a relationship between factor i and j, these letters are used as;

V: Factor (i) effects Factor (j)

A: Factor (j) effects Factor (i)

X: Factor (i) and Factor (j) effect each other

O: Factor (i) and Factor (j) do not have influence on each other

In order to convert SSIM table to RM following rules are used:

- If entry for factor (i,j) is V, entry(i,j) value takes "1" numerical value &entry(j,i) takes "0" numerical value on RM.
- If entry for factor (i,j) is A, entry (i,j) value takes "0" numerical value &entry (j,i) takes "1" numerical value on RM.
- If entry for factor (i,j) is X, entry (i,j) value takes "1" numerical value &entry (j,i) takes "1" numerical value on RM.
- If entry for factor (i,j) is O, entry (i,j) value takes "0" numerical value &entry (j,i) takes "0" numerical value on RM.

This context has been explainedalso in Table4.2. (Singh, Singh & Khamba, 2020).

Table 4.2. V, A, X, O values with numerical version

	V	A	X	O
Entry (i,j)	1	0	1	0
Entry (j,i)	0	1	1	0

Step 5: Control the transitivity of the RM to get the final reachability matrix (FRM).

If factor F1 influence F2 and F2 influence F3, F1 must influence F3. Figure 4.1. can do more understandable this step. RM matrix must be revised for transitivity. This revision is shows as "1*" on FRM.

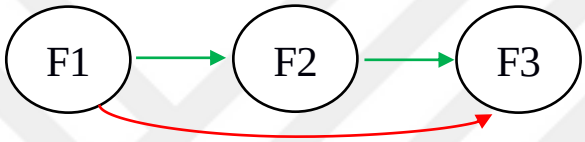

Figure 4.1. Transitivity process on F1, F2 and F3. (F1 must influence F3 on Table FRM)

Step 6: Chamber the FRM into different levels.

In order to see factor hierarchy, using the method factors are partitioned into levels using FRM. Reachability set and Antecedent set guides in the partitioning process. The reachability set of a factor contains the factor itself and the other factors influenced by this factor. Whereas, the antecedent set of a factor contains the factor itself and the other factors that influences this factor. Intersection of Reachability set and Antecedent sets builds up the Intersection set (Bux, Zhang & Ahmad, 2020). When reachability set and intersection sets are equal for a factor, that factor has been classified for that level and removed from the main table. As factors eliminated, level number increases and higher level be the most important level on TISM model that influencing other factors.

Step 7: Build TISM diagram with FRM. Direct Links are shown with "straight line" using1 values on FRM. Transitive Links are shown with "dashed line" using 1* values on FRM. Some transitive links may be dropped except the ones having distinct interpretation.

Step 8: Construct diagraph using direct links of FRM which is direct interaction diagraph.

Step 9: Use expert interpretations to develop Total interpretive structural model.

Step 10: Conduct MICMAC analysis (Xu, Chong and Chi, 2021).

Dependence powers and driving (or facilitating) powers are used on MICMAC analysis which are derived from FRM matrix. In MICMAC analysis, the factors are classified into 4 Categories which are autonomous, dependent, linkage and independent elements. Autonomous Factors (Category 1) have low dependence and driving power. Dependent Factors (Category 2) have high dependence power but have powerless driving potential. Linkage Factors (Category 3) have powerful dependence and driving power. Independent Factors (Category 4) have high driving power but have low dependence power (Singh, Singh & Khamba, 2020).

4.2 Application of the Method

In Chapter 3, factors that need to be considered in the integration of blockchain in Maritime Sector have been gathered and explained. In this study, aim is to analyze these factors using TISM. Abovementioned steps will be applied for these factors.

Step.1

To find the factors that impacted the blockchain transition in maritime logistics sector, various articles have been analyzed and 9 dimensions with 35 factors have been gathered which were explained in Chapter 3.

Step.2-3

Factors were evaluated by Logistics Specialists to be used on TISM method. Answers from 5 maritime logistics specialists collected on Aggregated matrix (Table A1.1. - APPENDIX 1). Table 4.3. shows, background information of the participant specialists.

Table 4.3. Background information of Experts

	Expert.1	Expert.2	Expert.3	Expert.4	Expert.5
Gender	Male	Male	Female	Male	Male
Education Level	Bachelor	Bachelor	Bachelor	Bachelor	Bachelor
Experience (Year)	3	1	5	2	2
Focus Area	Operation	Document-ation	Customs	Document-ation	Document-ation

Step.4

Aggregated matrix has been converted to RM matrix (Table A2.1. - APPENDIX 2). In consolidation of the answers, to agree on a relationship existence at least two-third of the respondents should be accepting. For example, F1→F7 is 4, which means that 4 of the 5 respondents agree that F1 influences F7. Since 4 is greater than 3.33 (5*2/3), in the RM, F1→F7 is equal to "1". With conversion rules mentioned above, RM is converted to SSIM matrix (Table A3.1. - APPENDIX 3).

Note: Since F26 does not contain any connection with other factors, three-fifth of the respondent have been considered as agreement on building a relationship.

Step.5

Using transitivity relations, RM has been converted to FRM (Table A4.1. - APPENDIX 4).For example, F1→F7 = 1, F7→F10 = 1 so F1→F10 = 0 value must be "1*".

Step.6

Levels have been calculated using FRM (Table A5.1. - APPENDIX 5).

Step.7-8

Direct interaction diagraph (Figure A6.1 - APPENDIX 6) prepared with direct and distinctive connections.

Step. 9

Expert interpretations added to direct interaction matrix for reaching TISM. Figure 4.2. and Figure 4.3. shows TISM diagraph.

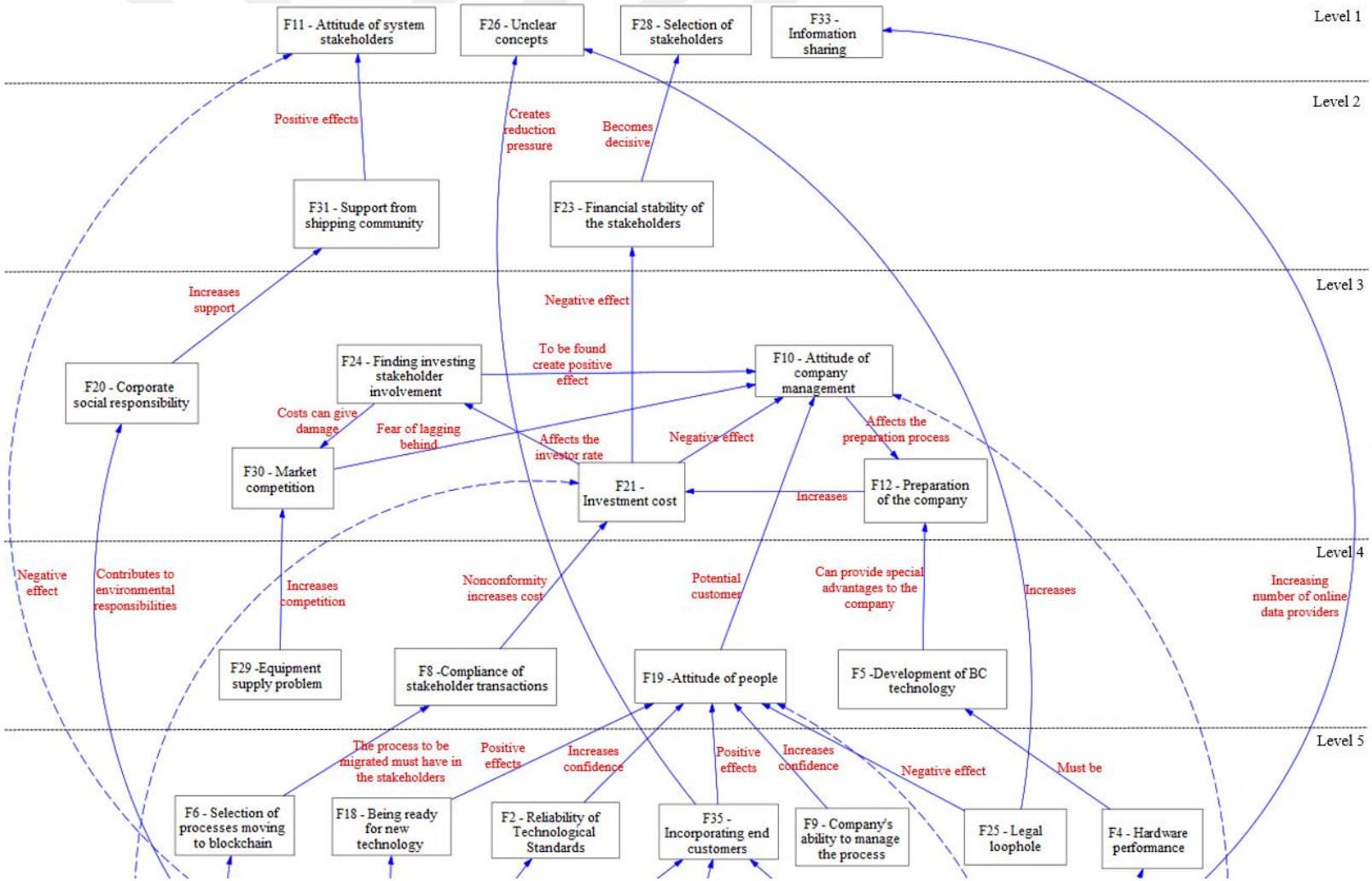

Figure 4.2. shows TISM model.(1/2) (On Vensim Program)

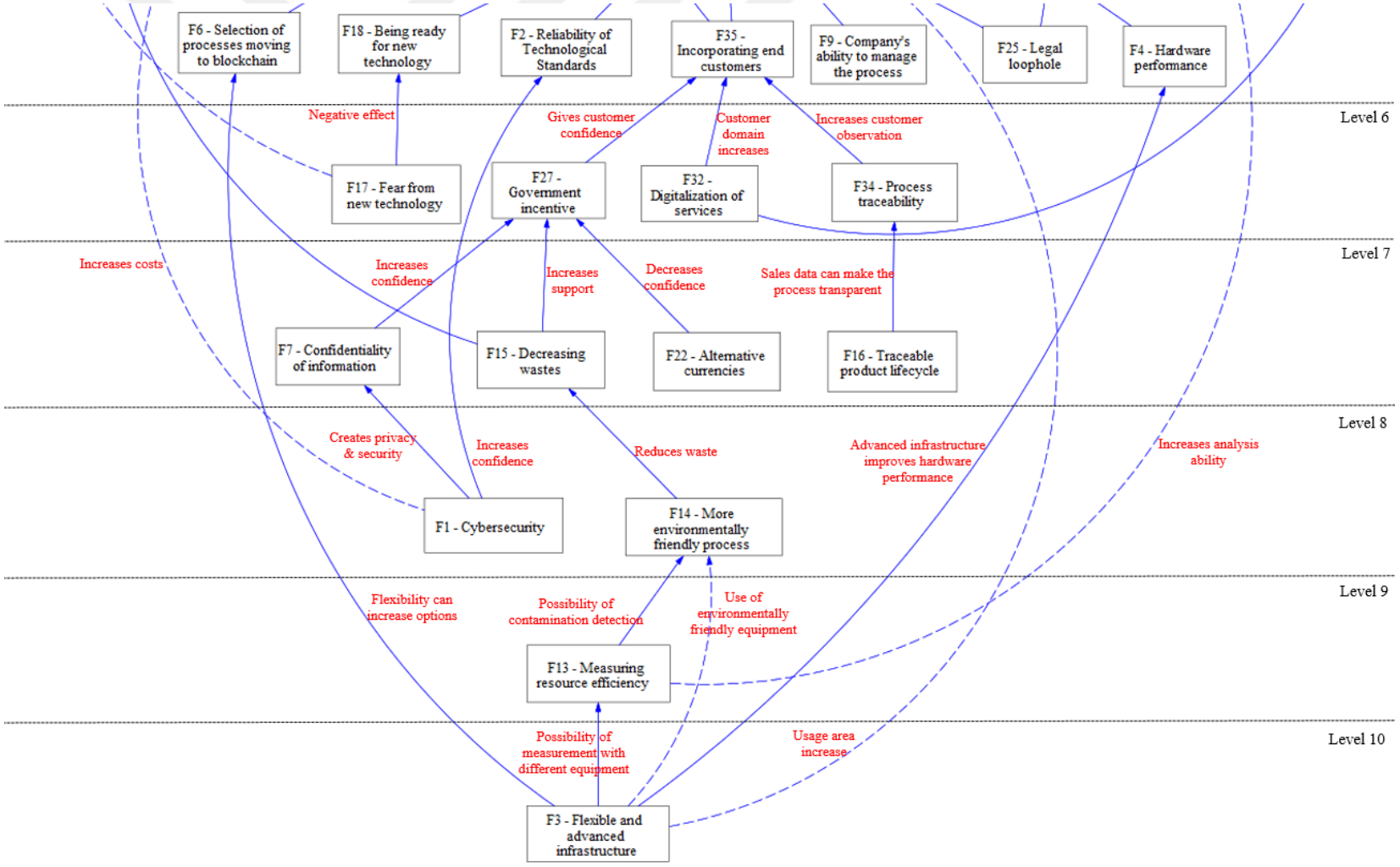

Figure 4.3. shows TISM model.(2/2) (On Vensim Program)

Step.10

Based on FRM, on MICMAC, sum of dependence powers and driving powers values of factors have been provided Figure A7.1 - APPENDIX 7.

4.3 Results

Based on TISM method, 35 factors impacting the adoption of blockchain technology have been categorized into 10 levels. The tenth level containsF3 “Flexible and advanced infrastructure”factor which is the starting point of blockchain integration project. To start this project after designing a flexible infrastructure, companies want to hear how this new technology will be able to measure the efficiency of the resources. For example, maritime logistics companies would appreciate the data collected in the system for the whole logistics supply chain to discover the improvement opportunities like “How well the distribution planning operated”, “what are the causes of delays”, etc. Next level shows that logistic companies are concerned about the security of the data and how this new technology would be environmentally friendly. Level 7 is mostly interested with information transparency, traceability, new payment methods and decreasing wastes. In level 6, end customer integration and increasing the awareness of people is of a concern which could be handled by new regulations and training. It could be seen that using the diagraph generated by TISM, companies can build road maps to convert their existing systems to blockchain technology. Until this point, factors are about increasing awareness and understanding feasibility of blockchain integration. After Level 5, factors are more like steps of taking necessary actions in this conversion period which requires development of Blockchain technology, gathering budget for the integration, etc. Finally in Level 1, if the companies are ready to take these actions, they could be selected for the project and attitudes of the stakeholders will be clear.

Based on MICMAC, only factor 3- Flexible and advanced infrastructure- is the independent factor which highly drives the integration process but does not depend on any other factor. Factors like, attitude of stakeholders, company top managers and employees, investment cost of implementation, stakeholder selection are dependent factors, which means that they will eventually be decided based on the other factors. Any issues on these factors can be handled by increasing the awareness about the connected factors and blockchain integration. All other factors are

autonomous factors which could be handled separately and may not have disruptive effect on the other factors.

CHAPTER 5
CONCLUSION

Blockchain create numerous advantages in economic, environmental and social aspects. There is vast amount of literature about the implementation of blockchain in various sector. Maritime logistics which is crucial part of the distribution network of the global supply chains can also be possible application area for blockchain. It has stakeholders located all around the world and global players are holding the biggest share of the market. In order to survive in the existing market or to attract customers as a newly emerging company, using new technologies like blockchain can create advantage. It can support companies to understand their inefficiencies, to decrease their wastes, to avoid frauds, to increase visibility among other companies.This thesis analyzes the factors affecting blockchain technology integration on maritime logistics sector. According to existing literature 9 dimensions and 35 related factors about these dimensions have been gather which could have impact on integration of blockchain. TISM methodology has been applied to figure out the interactions between these 35 factors. The TISM diagraph can be used in the blockchain implementation road map for maritime logistics companies.

As a future study, a detailed analysis on the data of a maritime logistics company can be performed. By scrutinizing existing way of working, possible inefficiency points, which data to be transparent or to be confidential can be decided.

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APPENDIX 1 –TABLE A1.1. AGGREGATED MATRIX

F	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
1	5	5	1	2	2	2	4	2	2	3	4	3	2	0	0	1	1	3	4	1	3	3	3	2	2	3	2	1	1	3	1	3	4	3	0
2	2	5	3	2	3	2	3	2	2	3	3	2	2	0	1	1	3	2	5	1	2	1	2	2	0	2	2	1	1	3	3	3	2	3	1
3	2	3	5	5	5	5	2	3	1	1	1	1	4	3	3	3	1	0	1	1	4	2	3	2	1	0	3	2	2	2	1	2	3	5	2
4	1	2	1	5	4	3	3	2	1	1	2	3	2	1	1	2	1	2	3	1	4	2	3	2	1	1	2	1	2	1	3	3	2	2	2
5	1	2	1	0	5	3	2	2	3	2	3	4	3	1	1	0	0	1	2	2	4	2	2	1	0	2	1	2	2	2	2	1	2	2	1
6	2	1	1	0	1	5	3	4	2	3	4	3	2	0	0	1	1	2	2	1	4	2	3	2	1	2	1	3	2	1	1	3	2	2	2
7	0	2	1	0	1	0	5	2	2	4	4	1	1	0	0	0	1	2	4	2	3	2	2	1	1	1	4	2	2	3	4	2	4	3	2
8	2	2	0	0	1	1	1	5	1	2	4	3	3	2	0	1	0	0	3	1	5	2	3	2	0	2	2	3	3	3	4	3	3	2	3
9	2	1	2	2	0	1	1	1	5	5	4	4	3	1	1	0	2	1	4	2	5	1	3	2	2	2	2	2	2	2	1	2	3	2	2
10	1	0	2	2	2	1	1	0	0	5	4	4	0	1	2	1	2	3	3	3	2	3	2	2	1	1	2	0	1	0	1	1	1	2	1
11	2	1	2	2	0	1	1	0	1	1	5	2	1	2	1	2	3	3	1	2	3	2	1	3	1	1	2	2	3	2	1	2	3	3	2
12	1	1	3	1	2	0	1	0	1	2	1	5	2	1	2	0	2	1	1	2	4	2	2	1	1	1	2	2	1	2	1	1	1	1	0
13	1	1	1	0	2	0	2	1	1	2	2	1	5	4	2	2	1	0	3	2	3	3	3	2	1	0	4	2	1	2	2	2	3	2	2
14	0	0	1	0	0	1	0	2	0	2	3	1	0	5	4	3	2	2	5	5	3	2	2	2	0	1	5	1	0	2	4	2	3	2	0
15	0	0	1	0	0	1	0	0	0	3	2	0	1	2	5	3	1	2	4	4	2	3	2	2	0	1	4	1	2	2	3	3	2	3	2
16	2	0	1	1	1	1	1	1	0	3	0	1	1	1	1	5	1	1	2	2	4	1	3	3	2	1	3	2	2	1	2	3	3	5	2
17	2	1	1	2	2	1	2	1	1	3	1	3	3	1	2	2	5	4	4	3	3	3	1	1	1	1	2	2	3	2	2	2	3	3	3
18	0	2	2	1	2	1	1	1	2	2	2	3	3	0	0	2	2	5	5	3	3	3	3	2	1	0	2	0	1	2	2	2	2	1	1
19	2	1	0	1	2	2	1	1	1	4	3	1	3	1	1	1	3	2	5	3	3	3	3	3	1	2	3	1	1	1	2	3	3	1	1
20	1	0	1	1	1	1	1	1	1	1	2	1	3	1	2	2	2	1	1	5	3	1	1	0	1	1	3	3	2	3	4	2	1	2	2
21	2	2	1	1	1	2	2	2	1	4	3	1	1	2	2	1	1	0	1	1	5	3	4	5	2	2	3	3	3	2	3	1	3	2	1
22	2	1	1	2	1	1	1	1	0	1	3	2	2	1	1	0	1	0	1	2	2	5	3	3	2	2	4	2	1	1	1	1	1	3	2
23	1	1	2	1	1	3	2	1	1	1	3	2	2	2	2	1	1	2	1	2	3	2	5	2	1	2	2	4	3	2	3	1	0	2	2

F	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
24	1	1	2	1	2	2	2	1	0	4	2	2	3	2	0	1	1	1	1	3	3	2	1	5	3	2	1	3	3	4	3	2	1	1	1
25	1	2	0	1	1	1	0	1	1	2	2	1	1	1	1	1	2	0	4	1	2	2	1	0	5	3	3	2	0	1	4	2	2	1	1
26	1	1	2	1	0	1	0	1	2	3	2	1	2	1	2	2	1	1	3	2	2	1	1	0	1	5	2	0	1	2	2	1	2	2	1
27	1	1	1	1	1	2	2	1	0	4	3	2	1	1	2	0	1	1	3	3	1	1	1	2	2	1	5	3	3	2	4	3	3	3	4
28	2	0	2	2	0	2	2	1	0	2	3	1	2	2	1	1	2	1	1	2	0	1	3	2	0	1	1	5	3	2	3	3	2	2	2
29	1	3	1	3	1	2	2	2	3	3	1	2	1	1	1	0	3	3	2	2	1	1	1	2	3	1	1	1	5	5	4	3	3	3	3
30	1	0	2	2	3	2	2	1	1	5	4	2	1	1	2	2	1	1	3	1	2	3	0	1	2	0	0	1	0	5	3	2	2	2	2
31	1	0	2	1	1	2	1	0	2	2	4	2	1	2	2	2	1	1	1	2	1	3	1	1	1	2	0	1	0	1	5	2	2	2	2
32	2	0	1	0	1	1	2	1	2	1	1	2	1	2	0	2	1	1	2	3	2	2	0	2	2	2	1	1	0	2	0	5	4	3	4
33	1	2	0	1	1	1	1	1	2	3	1	2	0	1	2	1	1	2	1	2	1	2	2	1	2	2	1	2	0	2	0	1	5	3	3
34	1	2	0	1	1	1	1	2	2	1	1	2	2	1	1	0	0	2	4	1	2	1	1	2	2	0	2	2	0	1	2	2	1	5	4
35	2	2	2	2	1	1	2	2	1	2	1	2	2	2	1	1	2	1	4	1	2	1	1	2	2	3	1	2	1	2	3	1	1	2	5

APPENDIX 2 – Table A2.1. RM matrix

F	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
1	1	1	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0
2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	1	1	1	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0
4	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	1	0	1	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	1	0	0	1	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	1	0	1	0	0
8	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0
9	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0

F	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
14	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	1	1	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
21	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0
25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	1	0	0	0	0	1	0	0	0	0
26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
27	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	1
28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0
30	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
31	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1
33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
34	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1

APPENDIX 3 – TABLE A3.1. SSIM matrix

F	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
1	-	V	O	O	O	O	V	O	O	O	V	O	O	O	O	O	O	O	V	O	O	O	O	O	O	V	O	O	O	O	O	O	V	O	O
2	-	-	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	V	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
3	-	-	-	V	V	V	O	O	O	O	O	O	V	O	O	O	O	O	O	O	V	O	O	O	O	O	O	O	O	O	O	O	O	V	O
4	-	-	-	-	V	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	V	O	O	O	O	O	O	O	O	O	O	O	O	O	O
5	-	-	-	-	-	O	O	O	O	O	O	V	O	O	O	O	O	O	O	O	V	O	O	O	O	O	O	O	O	O	O	O	O	O	O
6	-	-	-	-	-	-	O	V	O	O	V	O	O	O	O	O	O	O	O	O	V	O	O	O	O	O	O	O	O	O	O	O	O	O	O
7	-	-	-	-	-	-	-	O	O	V	V	O	O	O	O	O	O	O	V	O	O	O	O	O	O	O	V	O	O	O	V	O	V	O	O
8	-	-	-	-	-	-	-	-	O	O	V	O	O	O	O	O	O	O	O	O	V	O	O	O	O	O	O	O	O	O	V	O	O	O	O
9	-	-	-	-	-	-	-	-	-	V	V	V	O	O	O	O	O	O	V	O	V	O	O	O	O	O	O	O	O	O	O	O	O	O	O
10	-	-	-	-	-	-	-	-	-	-	V	V	O	O	O	O	O	O	A	O	A	O	O	A	O	O	A	O	O	A	O	O	O	O	O
11	-	-	-	-	-	-	-	-	-	-	-	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	A	A	O	O	O	O
12	-	-	-	-	-	-	-	-	-	-	-	-	O	O	O	O	O	O	O	O	V	O	O	O	O	O	O	O	O	O	O	O	O	O	O
13	-	-	-	-	-	-	-	-	-	-	-	-	-	V	O	O	O	O	O	O	O	O	O	O	O	O	V	O	O	O	O	O	O	O	O
14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	V	O	O	O	V	V	O	O	O	O	O	O	V	O	O	O	V	O	O	O	O
15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	O	O	O	V	V	O	O	O	O	O	O	V	O	O	O	O	O	O	O	O
16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	O	O	O	O	V	O	O	O	O	O	O	O	O	O	O	O	O	V	O
17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	V	V	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
18	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	V	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	O	O	O	O	O	A	O	O	O	O	O	O	O	O	A	A
20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	O	O	O	O	O	O	O	O	O	O	V	O	O	O	O
21	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	O	V	V	O	O	O	O	O	O	O	O	O	O	O
22	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	O	O	O	O	V	O	O	O	O	O	O	O	O
23	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	O	O	O	O	V	O	O	O	O	O	O	O

F	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	O	O	O	O	O	V	O	O	O	O	O
25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	V	O	O	O	O	V	O	O	O	O
26	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	O	O	O	O	O	O	O	O	A
27	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	O	O	O	V	O	O	O	V
28	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	O	O	O	O	O	O	O
29	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	V	V	O	O	O	O
30	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	O	O	O	O	O
31	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	O	O	O	O
32	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	V	O	V
33	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	O	O
34	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	V
35	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

APPENDIX 4 – TABLE A4.1.FRM matrix

F	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	Dri. P.
1	1	1	0	0	0	0	1	0	0	**1***	1	**1***	0	0	0	0	0	0	1	0	**1***	0	**1***	**1***	0	1	**1***	**1***	0	**1***	**1***	0	1	0	**1***	17
2	0	1	0	0	0	0	0	0	0	**1***	**1***	**1***	0	0	0	0	0	0	1	0	**1***	0	**1***	**1***	0	0	0	**1***	0	**1***	0	0	0	0	0	10
3	0	0	1	1	1	1	0	**1***	0	**1***	**1***	**1***	1	**1***	**1***	0	0	0	**1***	**1***	1	0	**1***	**1***	0	**1***	**1***	**1***	0	**1***	**1***	0	0	1	**1***	23
4	0	0	0	1	1	0	0	0	0	**1***	**1***	**1***	0	0	0	0	0	0	0	0	1	0	**1***	**1***	0	0	0	**1***	0	**1***	0	0	0	0	0	10
5	0	0	0	0	1	0	0	0	0	**1***	**1***	1	0	0	0	0	0	0	0	0	1	0	**1***	**1***	0	0	0	**1***	0	**1***	0	0	0	0	0	9
6	0	0	0	0	0	1	0	1	0	**1***	1	**1***	0	0	0	0	0	0	0	0	1	0	**1***	**1***	0	0	0	**1***	0	**1***	**1***	0	0	0	0	11
7	0	0	0	0	0	0	1	0	0	1	1	**1***	0	0	0	0	0	0	1	0	**1***	0	**1***	**1***	0	**1***	1	**1***	0	**1***	1	0	1	0	**1***	15
8	0	0	0	0	0	0	0	1	0	**1***	1	**1***	0	0	0	0	0	0	0	0	1	0	**1***	**1***	0	0	0	**1***	0	**1***	1	0	0	0	0	10
9	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0	1	0	1	0	**1***	**1***	0	0	0	**1***	0	**1***	0	0	0	0	0	10
10	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	**1***	0	**1***	**1***	0	0	0	**1***	0	**1***	0	0	0	0	0	8
11	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
12	0	0	0	0	0	0	0	0	0	**1***	**1***	1	0	0	0	0	0	0	0	0	1	0	**1***	**1***	0	0	0	**1***	0	**1***	0	0	0	0	0	8
13	0	0	0	0	0	0	0	0	0	**1***	**1***	**1***	1	1	**1***	0	0	0	**1***	**1***	**1***	0	**1***	**1***	0	**1***	1	**1***	0	**1***	**1***	0	0	0	**1***	17
14	0	0	0	0	0	0	0	0	0	**1***	**1***	**1***	0	1	1	0	0	0	1	1	**1***	0	**1***	**1***	0	**1***	1	**1***	0	**1***	1	0	0	0	**1***	16
15	0	0	0	0	0	0	0	0	0	**1***	**1***	**1***	0	0	1	0	0	0	1	1	**1***	0	**1***	**1***	0	**1***	1	**1***	0	**1***	**1***	0	0	0	**1***	15
16	0	0	0	0	0	0	0	0	0	**1***	**1***	**1***	0	0	0	1	0	0	**1***	0	1	0	**1***	**1***	0	**1***	0	**1***	0	**1***	0	0	0	1	**1***	13
17	0	0	0	0	0	0	0	0	0	**1***	**1***	**1***	0	0	0	0	1	1	1	0	**1***	0	**1***	**1***	0	0	0	**1***	0	**1***	0	0	0	0	0	11
18	0	0	0	0	0	0	0	0	0	**1***	**1***	**1***	0	0	0	0	0	1	1	0	**1***	0	**1***	**1***	0	0	0	**1***	0	**1***	0	0	0	0	0	10
19	0	0	0	0	0	0	0	0	0	1	**1***	**1***	0	0	0	0	0	0	1	0	**1***	0	**1***	**1***	0	0	0	**1***	0	**1***	0	0	0	0	0	9
20	0	0	0	0	0	0	0	0	0	0	**1***	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	3
21	0	0	0	0	0	0	0	0	0	1	**1***	**1***	0	0	0	0	0	0	0	0	1	0	1	1	0	0	0	**1***	0	**1***	0	0	0	0	0	8
22	0	0	0	0	0	0	0	0	0	**1***	**1***	**1***	0	0	0	0	0	0	**1***	0	**1***	1	**1***	**1***	0	**1***	1	**1***	0	**1***	**1***	0	0	0	**1***	14
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	2

F	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	
24	0	0	0	0	0	0	0	0	0	1	**1***	**1***	0	0	0	0	0	0	0	0	**1***	0	**1***	1	0	0	0	**1***	0	1	0	0	0	0	0	8
25	0	0	0	0	0	0	0	0	0	**1***	**1***	**1***	0	0	0	0	0	0	1	0	**1***	0	**1***	**1***	1	1	0	**1***	0	**1***	1	0	0	0	0	12
26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1
27	0	0	0	0	0	0	0	0	0	1	**1***	**1***	0	0	0	0	0	0	**1***	0	**1***	0	**1***	**1***	0	**1***	1	**1***	0	**1***	1	0	0	0	1	13
28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
29	0	0	0	0	0	0	0	0	0	**1***	**1***	**1***	0	0	0	0	0	0	0	0	**1***	0	**1***	**1***	0	0	0	**1***	1	1	1	0	0	0	0	10
30	0	0	0	0	0	0	0	0	0	1	1	**1***	0	0	0	0	0	0	0	0	**1***	0	**1***	**1***	0	0	0	**1***	0	1	0	0	0	0	0	8
31	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	2
32	0	0	0	0	0	0	0	0	0	**1***	**1***	**1***	0	0	0	0	0	0	**1***	0	**1***	0	**1***	**1***	0	**1***	0	**1***	0	**1***	0	1	1	0	1	13
33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
34	0	0	0	0	0	0	0	0	0	**1***	**1***	**1***	0	0	0	0	0	0	1	0	**1***	0	**1***	**1***	0	**1***	0	**1***	0	**1***	0	0	0	1	1	12
35	0	0	0	0	0	0	0	0	0	**1***	**1***	**1***	0	0	0	0	0	0	1	0	**1***	0	**1***	**1***	0	1	0	**1***	0	**1***	0	0	0	0	1	11
Dep. P.	1	2	1	2	3	2	2	3	1	28	31	28	2	3	4	1	1	2	18	5	28	1	29	28	1	14	8	30	1	28	14	1	4	3	12	

APPENDIX 5 –TABLE A5.1 Levels

Factor	Reachability set	Antecedent set	Intersection	Level
F1	1-2-7-10-11-12-19-21-23-24-26-27-28-30-31-33-35	1	1	
F2	2-10-11-12-19-21-23-24-28-30	1-2	2	
F3	3-4-5-6-8-10-11-12-13-14-15-19-20-21-23-24-26-27-28-30-31-34-35	3	3	
F4	4-5-10-11-12-21-23-24-28-30	3-4	4	
F5	5-10-11-12-21-23-24-28-30	3-4-5	5	
F6	6-8-10-11-12-21-23-24-28-30-31	3-6	6	
F7	7-10-11-12-19-21-23-24-26-27-28-30-31-33-35	1-7	7	
F8	8-10-11-12-21-23-24-28-30-31	3-6-8	8	
F9	9-10-11-12-19-21-23-24-28-30	9	9	
F10	10-11-12-21-23-24-28-30	1-2-3-4-5-6-7-8-9-10-12-13-14-15-16-17-18-19-21-22-24-25-27-29-30-32-34-35	10-12-21-24-30	
F11	11	1-2-3-4-5-6-7-8-9-10-11-12-13-14-15-16-17-18-19-20-21-22-24-25-27-29-30-31-32-34-35	11	**1**
F12	10-11-12-21-23-24-28-30	1-2-3-4-5-6-7-8-9-10-12-13-14-15-16-17-18-19-21-22-24-25-27-29-30-32-34-35	10-12-21-24-30	
F13	10-11-12-13-14-15-19-20-21-23-24-26-27-28-30-31-35	3-13	13	
F14	10-11-12-14-15-19-20-21-23-24-26-27-28-30-31-35	3-13-14	14	
F15	10-11-12-15-19-20-21-23-24-26-27-28-30-31-35	3-13-14-15	15	
F16	10-11-12-16-19-21-23-24-26-28-30-34-35	16	16	

F17	10-11-12-17-18-19-21-23-24-28-30	17	17	
F18	10-11-12-18-19-21-23-24-28-30	17-18	18	
F19	10-11-12-19-21-23-24-28-30	1-2-3-7-9-13-14-15-16-17-18-19-22-25-27-32-34-35	19	
F20	11-20-31	3-13-14-15-20	20	
F21	10-11-12-21-23-24-28-30	1-2-3-4-5-6-7-8-9-10-12-13-14-15-16-17-18-19-21-22-24-25-27-29-30-32-34-35	10-11-12-21-22-24-30	
F22	10-11-12-19-21-22-23-24-26-27-28-30-31-35	22	22	
F23	23-28	1-2-3-4-5-6-7-8-9-10-12-13-14-15-16-17-18-19-21-22-23-24-25-27-29-30-32-34-35	23	
F24	10-11-12-21-23-24-28-30	1-2-3-4-5-6-7-8-9-10-12-13-14-15-16-17-18-19-21-22-24-25-27-29-30-32-34-35	10-12-21-24-30	
F25	10-11-12-19-21-23-24-25-26-28-30-31	25	25	
F26	26	26	26	**1**
F27	10-11-12-19-21-23-24-26-27-28-30-31-35	1-3-7-13-14-15-22-27	27	
F28	28	1-2-3-4-5-6-7-8-9-10-12-13-14-15-16-17-18-19-21-22-23-24-25-27-28-29-30-32-34-35	28	**1**
F29	10-11-12-21-23-24-28-29-30-31	29	29	
F30	10-11-12-21-23-24-28-30	1-2-3-4-5-6-7-8-9-10-12-13-14-15-16-17-18-19-21-22-24-25-27-29-30-32-34-35	10-12-21-24-30	
F31	11-31	1-3-6-7-8-13-14-15-20-22-25-27-29-31	31	
F32	10-11-12-19-21-23-24-26-28-30-32-33-35	32	32	
F33	33	1-7-32-33	33	**1**
F34	10-11-12-19-21-23-24-26-28-30-34-35	3-16-34	34	
F35	10-11-12-19-21-23-24-26-28-30-35	1-3-7-13-14-15-16-22-27-32-34-35	35	

Factor	Reachability set	Antecedent set	Intersection	Level
F1	1-2-7-10-12-19-21-23-24-27-30-31-35	1	1	
F2	2-10-12-19-21-23-24-30	1-2	2	
F3	3-4-5-6-8-10-12-13-14-15-19-20-21-23-24-27-30-31-34-35	3	3	
F4	4-5-10-12-21-23-24-30	3-4	4	
F5	5-10-12-21-23-24-30	3-4-5	5	
F6	6-8-10-12-21-23-24-30-31	3-6	6	
F7	7-10-12-19-21-23-24-27-30-31-35	1-7	7	
F8	8-10-12-21-23-24-30-31	3-6-8	8	
F9	9-10-12-19-21-23-24-30	9	9	
F10	10-12-21-23-24-30	1-2-3-4-5-6-7-8-9-10-12-13-14-15-16-17-18-19-21-22-24-25-27-29-30-32-34-35	10-12-21-24-30	
F12	10-12-21-23-24-30	1-2-3-4-5-6-7-8-9-10-12-13-14-15-16-17-18-19-21-22-24-25-27-29-30-32-34-35	10-12-21-24-30	
F13	10-12-13-14-15-19-20-21-23-24-27-30-31-35	3-13	13	
F14	10-12-14-15-19-20-21-23-24-27-30-31-35	3-13-14	14	
F15	10-12-15-19-20-21-23-24-27-30-31-35	3-13-14-15	15	
F16	10-12-16-19-21-23-24-30-34-35	16	16	
F17	10-12-17-18-19-21-23-24-30	17	17	
F18	10-12-18-19-21-23-24-30	17-18	18	
F19	10-12-19-21-23-24-30	1-2-3-7-9-13-14-15-16-17-18-19-22-25-27-32-34-35	19	
F20	20-31	3-13-14-15-20	20	
F21	10-12-21-23-24-30	1-2-3-4-5-6-7-8-9-10-12-13-14-15-16-17-18-19-21-22-24-25-27-29-30-32-34-35	10-12-21-22-24-30	

F22	10-12-19-21-22-23-24-27-30-31-35	22	22	
F23	23	1-2-3-4-5-6-7-8-9-10-12-13-14-15-16-17-18-19-21-22-23-24-25-27-29-30-32-34-35	23	**2**
F24	10-12-21-23-24-30	1-2-3-4-5-6-7-8-9-10-12-13-14-15-16-17-18-19-21-22-24-25-27-29-30-32-34-35	10-12-21-24-30	
F25	10-12-19-21-23-24-25-30-31	25	25	
F27	10-12-19-21-23-24-27-30-31-35	1-3-7-13-14-15-22-27	27	
F29	10-12-21-23-24-29-30-31	29	29	
F30	10-12-21-23-24-30	1-2-3-4-5-6-7-8-9-10-12-13-14-15-16-17-18-19-21-22-24-25-27-29-30-32-34-35	10-12-21-24-30	
F31	31	1-3-6-7-8-13-14-15-20-22-25-27-29-31	31	**2**
F32	10-12-19-21-23-24-30-32-35	32	32	
F34	10-12-19-21-23-24-30-34-35	3-16-34	34	
F35	10-12-19-21-23-24-30-35	1-3-7-13-14-15-16-22-27-32-34-35	35	

Factor	Reachability set	Antecedent set	Intersection	Level
F1	1-2-7-10-12-19-21-24-27-30-35	1	1	
F2	2-10-12-19-21-24-30	1-2	2	
F3	3-4-5-6-8-10-12-13-14-15-19-20-21-24-27-30-34-35	3	3	
F4	4-5-10-12-21-24-30	3-4	4	
F5	5-10-12-21-24-30	3-4-5	5	
F6	6-8-10-12-21-24-30	3-6	6	
F7	7-10-12-19-21-24-27-30-35	1-7	7	
F8	8-10-12-21-24-30	3-6-8	8	

F9	9-10-12-19-21-24-30	9	9	
F10	10-12-21-24-30	1-2-3-4-5-6-7-8-9-10-12-13-14-15-16-17-18-19-21-22-24-25-27-29-30-32-34-35	10-12-21-24-30	**3**
F12	10-12-21-24-30	1-2-3-4-5-6-7-8-9-10-12-13-14-15-16-17-18-19-21-22-24-25-27-29-30-32-34-35	10-12-21-24-30	**3**
F13	10-12-13-14-15-19-20-21-24-27-30-35	3-13	13	
F14	10-12-14-15-19-20-21-24-27-30-35	3-13-14	14	
F15	10-12-15-19-20-21-24-27-30-35	3-13-14-15	15	
F16	10-12-16-19-21-24-30-34-35	16	16	
F17	10-12-17-18-19-21-24-30	17	17	
F18	10-12-18-19-21-24-30	17-18	18	
F19	10-12-19-21-24-30	1-2-3-7-9-13-14-15-16-17-18-19-22-25-27-32-34-35	19	
F20	20	3-13-14-15-20	20	**3**
F21	10-12-21-24-30	1-2-3-4-5-6-7-8-9-10-12-13-14-15-16-17-18-19-21-22-24-25-27-29-30-32-34-35	10-12-21-22-24-30	**3**
F22	10-12-19-21-22-24-27-30-35	22	22	
F24	10-12-21-24-30	1-2-3-4-5-6-7-8-9-10-12-13-14-15-16-17-18-19-21-22-24-25-27-29-30-32-34-35	10-12-21-24-30	**3**
F25	10-12-19-21-24-25-30	25	25	
F27	10-12-19-21-24-27-30-35	1-3-7-13-14-15-22-27	27	
F29	10-12-21-24-29-30	29	29	
F30	10-12-21-24-30	1-2-3-4-5-6-7-8-9-10-12-13-14-15-16-17-18-19-21-22-24-25-27-29-30-32-34-35	10-12-21-24-30	**3**
F32	10-12-19-21-24-30-32-35	32	32	
F34	10-12-19-21-24-30-34-35	3-16-34	34	
F35	10-12-19-21-24-30-35	1-3-7-13-14-15-16-22-27-32-34-35	35	

Factor	Reachability set	Antecedent set	Intersection	Level
F1	1-2-7-19-27-35	1	1	
F2	2-19	1-2	2	
F3	3-4-5-6-8-13-14-15-19-27-34-35	3	3	
F4	4-5	3-4	4	
F5	5	3-4-5	5	**4**
F6	6-8	3-6	6	
F7	7-19-27-35	1-7	7	
F8	8	3-6-8	8	**4**
F9	9-19	9	9	
F13	13-14-15-19-27-35	3-13	13	
F14	14-15-19-27-35	3-13-14	14	
F15	15-19-27-35	3-13-14-15	15	
F16	16-19-34-35	16	16	
F17	17-18-19	17	17	
F18	18-19	17-18	18	
F19	19	1-2-3-7-9-13-14-15-16-17-18-19-22-25-27-32-34-35	19	**4**
F22	19-22-27-35	22	22	
F25	19-25	25	25	
F27	19-27-35	1-3-7-13-14-15-22-27	27	
F29	29	29	29	**4**
F32	19-32-35	32	32	
F34	19-34-35	3-16-34	34	
F35	19-35	1-3-7-13-14-15-16-22-27-32-34-35	35	

Factor	Reachability set	Antecedent set	Intersection	Level
F1	1-2-7-27-35	1	1	
F2	2	1-2	2	**5**
F3	3-4-6-13-14-15-27-34-35	3	3	
F4	4	3-4	4	**5**
F6	6	3-6	6	**5**
F7	7-27-35	1-7	7	
F9	9	9	9	**5**
F13	13-14-15-27-35	3-13	13	
F14	14-15-27-35	3-13-14	14	
F15	15-27-35	3-13-14-15	15	
F16	16-34-35	16	16	
F17	17-18	17	17	
F18	18	17-18	18	**5**
F22	22-27-35	22	22	
F25	25	25	25	**5**
F27	27-35	1-3-7-13-14-15-22-27	27	
F32	32-35	32	32	
F34	34-35	3-16-34	34	
F35	35	1-3-7-13-14-15-16-22-27-32-34-35	35	**5**

Factor	Reachability set	Antecedent set	Intersection	Level
F1	1-7-27	1	1	
F3	3-13-14-15-27-34	3	3	
F7	7-27	1-7	7	
F13	13-14-15-27	3-13	13	
F14	14-15-27	3-13-14	14	
F15	15-27	3-13-14-15	15	
F16	16-34	16	16	
F17	17	17	17	**6**
F22	22-27	22	22	
F27	27	1-3-7-13-14-15-22-27	27	**6**
F32	32	32	32	**6**
F34	34	3-16-34	34	**6**

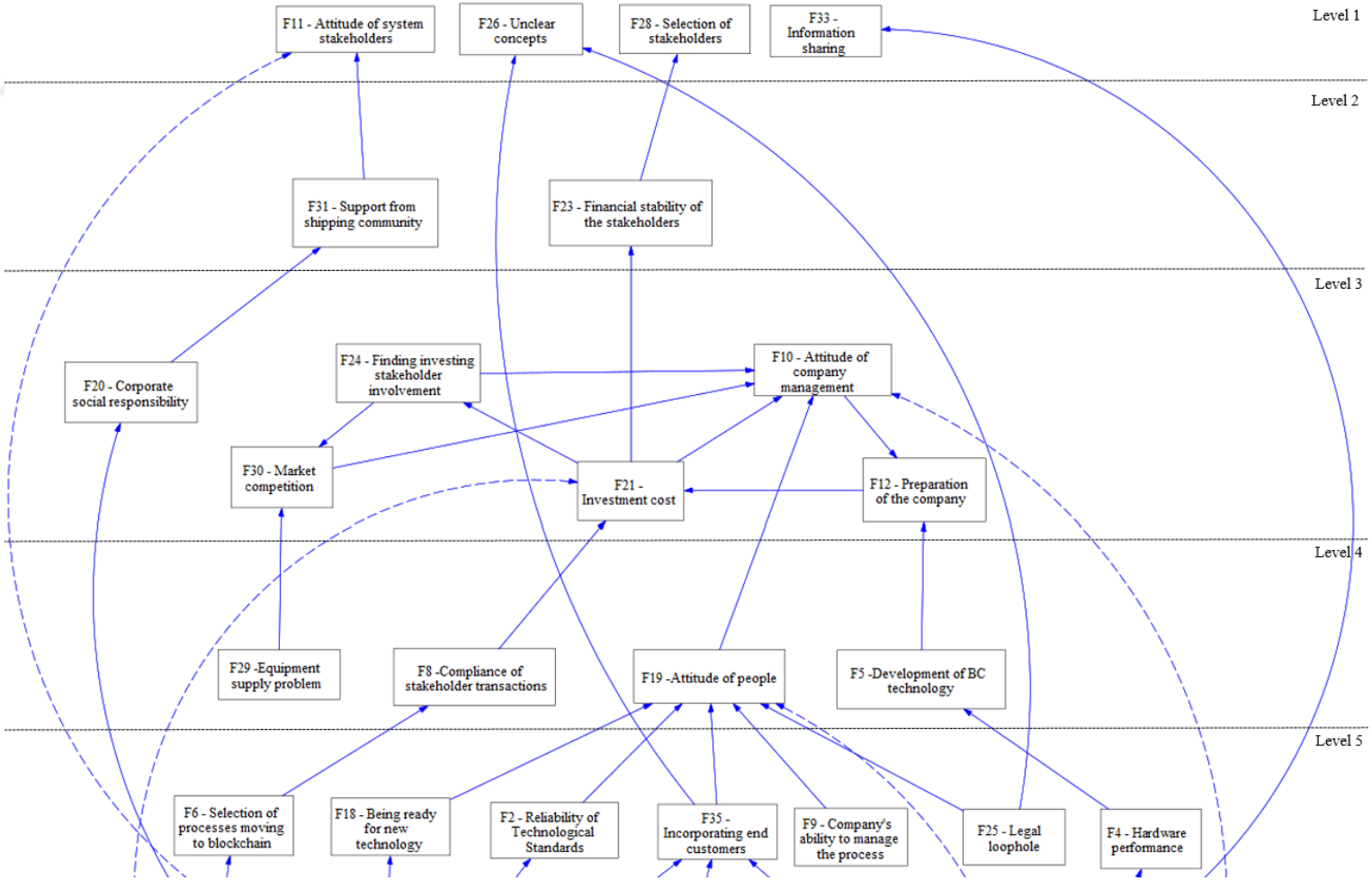
Factor	Reachability set	Antecedent set	Intersection	Level
F1	1-7	1	1	
F3	3-13-14-15	3	3	
F7	7	1-7	7	**7**
F13	13-14-15	3-13	13	
F14	14-15	3-13-14	14	
F15	15	3-13-14-15	15	**7**
F16	16	16	16	**7**
F22	22	22	22	**7**

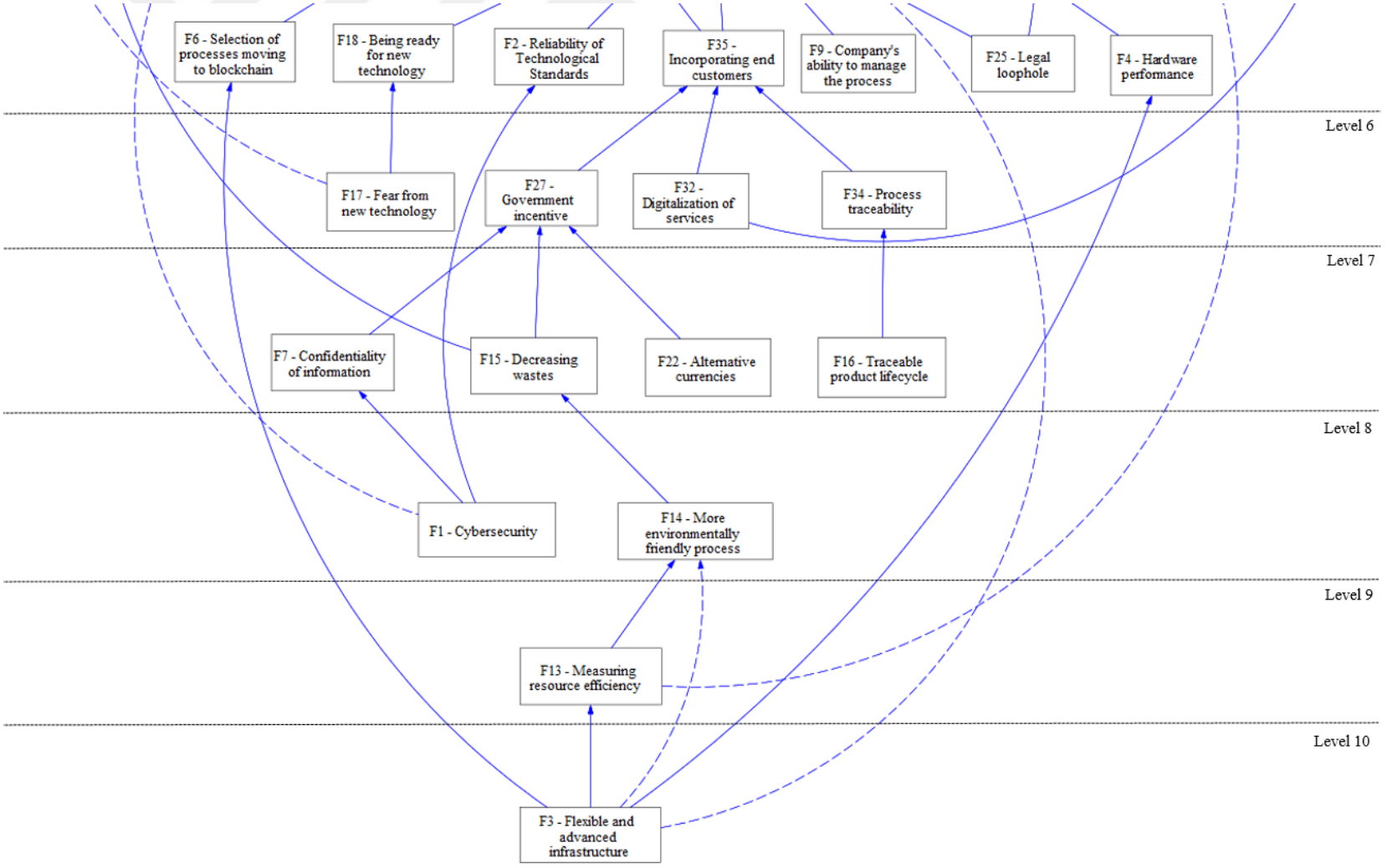
Factor	Reachability set	Antecedent set	Intersection	Level
F1	1	1	1	**8**
F3	3-13-14	3	3	
F13	13-14	3-13	13	
F14	14	3-13-14	14	**8**

Factor	Reachability set	Antecedent set	Intersection	Level
F3	3-13	3	3	
F13	13	3-13	13	**9**

Factor	Reachability set	Antecedent set	Intersection	Level
F3	3	3	3	**10**

APPENDIX 6 –FIGURE A6.1.Direct interaction matrix




F6 - Selection of processes moving to blockchain
F18 - Being ready for new technology
F2 - Reliability of Technological Standards
F35 - Incorporating end customers
F9 - Company's ability to manage the process
F25 - Legal loophole
F4 - Hardware performance
Level 6
F17 - Fear from new technology
F27 - Government incentive
F32 - Digitalization of services
F34 - Process traceability
Level 7
F7 - Confidentiality of information
F15 - Decreasing wastes
F22 - Alternative currencies
F16 - Traceable product lifecycle
Level 8
F1 - Cybersecurity
F14 - More environmentally friendly process
Level 9
F13 - Measuring resource efficiency
Level 10
F3 - Flexible and advanced infrastructure

APPENDIX 7 –FIGURE A7.1.MICMAC