Department of Business and Management

Master Thesis in International Economics and Industrial Dynamics

Application of blockchain technologies to logistics and to container's transportation industry.

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Introduction

During the last thirty years, the international trade flows have grown widely. In particular, it has grown almost two times faster than the global output, giving more and more importance to shipping companies.

According to the World Trade Organization, the value of the global exports has shifted from $2.049 billions during 1980, to $17.707 billions in 2017. This growth of international trade has occurred mostly thanks to what Headrick sees as the greatest innovation of the 20th century: the container. On it stands the biggest part of international trade and logistics and we owe to it the efficiency leading to the actual international trade level and globalization process.

In practice, we can easily state that the processes of containerization and international trade have leveraged each other through what we known as globalization process.

For containerization we mean the adhibition of the container as the best tool used in international logistics and, also, the adaptation of all other transport means to it, giving the rise to intermodal transport. The containerization process has been a real revolution leading to decreased costs, economies of scale and reduction of the timing schedule. Today the container is used for the transportation of more than 90% of non-bulk merchandise and is the preferred tool for shipment company both national and international. The containerization process has occurred together with other important technological innovations like the ICT revolution which gave the rise to the globalization process. However, nowadays this process has been stocked and, since the container introduction, isn’t changed much into this industry.

In particular, the container transportation industry is sub-optimal and thus inefficient and, being it the point of convergence for the global logistics and supply chain, this cause a money lost for the world economy in general.

In this thesis we are going to find a solution to the industry’s issues through the application of blockchain technologies. This ground-breaking technology has the potential to be disruptive for the global logistics and solve many problems for both consumers and organizations. Thus, being the container a cornerstone for the global

logistics, we think that through it blockchain could find a way to revolutionize the whole industry and provide a greater efficiency to the global economy.

As soon as people think to blockchain they associate it to cryptocurrencies like Bitcoin or to other financial services. Instead this kind of technologies have many different applications and many big companies and organizations are investing in it. When I started this paper, in September 2018, there were just some rumors about blockchain's introduction in container industry; a few of months later, in January 2019, it was already possible to find many projects and initiatives in this direction, including one from the market leader Maersk in partnership with IBM.

During this elaborate we will see the reasons leading to these projects. First of all, we will analyze the container transportation industry, its dynamics and issues, trying to forecast the next possible scenarios. Then we will analyze blockchain technologies and its advantages and, in third and final chapter its possible applications for the container's transportation industry.

Chapter 1: Logistics activities and the containerization

1.1 Logistics activities

Logistics encompasses the activities necessary to get materials from suppliers to manufacturing facility, through the manufacturing process, and out through a distribution system to the end user. In the international business, the logistics function manages the global supply chain. The twin objectives of logistics is to manage a firm's global supply chain at the lowest possible cost and in a way that best serves customer needs, thereby lowering the costs of value creation and helping the firm establish a competitive advantage through superior customer service[1]. The potential for reducing costs through more efficient logistics is enormous. Logistics importance was already known during the Roman empire, and its first adoption was for military purposes.

There are several definitions of logistics. The Council of Logistics Management (CLM) defines logistics as

"The process of planning, implementing, and controlling the efficient, effective flow and storage of goods, services, and related information from point of origin to point of consumption for the purpose of conforming to customer requirements"[2].

Whatever definition we consider, there are always the following key purposes in logistics:

- The supply of products or services to the customer in the place, time and quality requested by customer.
- The guarantee of quality standards in compliance with customer expectations.
- The guarantee of short delivery times at the lowest possible price.

From here we can define logistics as all the activities necessary to have the needed product, in the needed quantity and in the place and time where you need it, with a price proportionate to its value.

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[1] Vignati G., *Manuale di logistica.*

[2] Council of Logistics Management at *www.britannica.com/topic/Council-of-Logistics-Management.*

Inside companies, logistics is crucial for the global supply chain. Its main activities can be summarized as follow:

- Purchasing logistics, is all the flow of materials inside the factory, from raw materials to assembled parts.
- Production logistics, is the management of the production facilities, including manufacture activities and assembling, its timings and quality controls;
- Distribution logistics, representing the physical distribution of the final product, from stocking to post-purchase services. As we will see, these activities will be the core of this chapter[3].

Logistics can also have different shapes, depending on company's needs. Thereby we can find that logistics activities can be more or less integrated, so that we can have integrated logistics, partially integrated logistics, bipartite logistics and fragmented logistics. The difference is on the division of logistics activities and decision power inside the company. Of course, these decisions are usually driven by company's features, firstly its dimensions. That is, usually logistics functions integration is higher where there are big companies able to exploit scale economies, so that to reduce unitary costs.

1.1.1 Outsourcing of logistics activities

When a company decides to outsource some or all logistics activities there are several options. In particular, the suppliers of logistics services can be of different types depending on the grade of specialization and the number of logistics services provided. That is, we can find from First-Party Logistic Provider (1PL) to Fourth Party Logistic Provider (4PL), where 1PL provides just one logistic function and 4PL manages all the company's logistics, being in charge for all the supply chain[4]. During the last years, the trend inside companies has been to outsource one or more logistics activities. The reasons for this evidence must be found in the advantages provided by this decision. Externalize logistics can lead to a reduction of many costs, like the ones involved in

[3] Vignati G., *Manuale di logistica.*

[4] Coyle (2003), *Transportation: a supply chain perspective*, South – Western Cengage

stocking and shipping activities. In this way companies can shift fixed costs in variable, being more flexible and competitive. In addition, the service provided to the customer will be probably much better. Specialized suppliers can guarantee shorter timings and more competitive prices. Also, in logistics activities it is crucial to be technologically updated, this can be difficult to bear for not specialized company, while addressing an external provider is a way to avoid big investment and be technologically advanced at the same time. Nevertheless, there are also some cons in logistics outsourcing. First of all there is a lost of control on the supply chain; for this reason the supplier must be reliable and appropriate, with a base knowledge of the company's products. Also, outsourcing a logistics activity, the company lose the possibility to improve its know-how in that activity, leading to situations in which there is a complete dependence for the supplier. By the way, this is mostly the case of packaging or other strategic function, while in this chapter we are going to focalize on transportation and shipping functions. This is for sure one of the easier to outsource, usually together with storage and warehouse management.

After this brief introduction of logistics, now we can better analyze the focus of this chapter. That is, as said, the transportation and, in particular, shipping services.

1.2 Transportation industry

Distribution logistics encompasses all the functions involved in the physical transportation of products inside and outside a supply network. This is one of the most expensive activities inside a company, usually second only to goods purchases. As we can see in the below table, there is a different incidence of logistics and shipping costs depending on the sector. In particular, this difference is usually due to the product characteristics, like its perishability or the value to weight ratio or.

Sector	Logistics costs	Shipping costs
Food & Beverage	31%	10%
Chemical	21%	8%
Clothing & Textiles	23%	8%
Construction	25%	7%
Paper & Rubber	19%	5%
Agriculture	13%	3%
Pharmaceutical	16%	3%
Electronics	12%	2%
Average	**20%**	**6%**

Table 1.1: logistics and shipping costs' incidence on the total cost (2016)

Many analysts forecast an increased importance and incidence of logistics and shipping costs due to new trends. This has already occurred in past, firstly thanks to globalization process which has enlarger the international boundaries, but also thanks to rises in fuel cost or the spread of e-commerce and Just-In-Time practices[5].

From here, it is easy to understand the importance of transportation systems and shipping costs for all the businesses. Companies need to select a correct strategy in order to distribute raw materials and products along the whole supply network, bearing in mind the trade-off between direct shipping costs and indirect storage costs. In fact,

[5] Vignati G., *Manuale di logistica.*

shorter shipment times will ask higher prices, but at the same time there will be less necessity for storage and, thereby, less stocking costs. Conversely, cheaper transportation systems will ask for longer shipment timings, leading to higher levels of stocking and, consequently, higher storage costs. The solution to this trade-off needs to be found in the company's own characteristics, nevertheless we can consider the following general rules:

- Expensive and fast transportation systems are feasible for products with an high value to weight ratio, for which their prices can bear higher transportation costs and there is the necessity to reduce the quantity in stock.
- Cheap and slow transportation system are more suitable for low value to weight products, for which it is important to reduce shipment costs[6].

For this reason, the providers of transportation services should be able to offer differentiated services in order to better accomplish customer's needs. For companies, as said before, the best transportation system depends by many variables involved in shipping and storing costs and by the trade-off between these two main cost components. That is, the service's characteristics depend by the means of transportation selected. Air transportation has shorter transit times than trail systems, but at an higher cost, so that it will be suitable only in particular situation, in example with high storing costs, asking for Just In Time shipments and shorter transit times. Now we will see the different transportation systems, analyzing their features and characteristics in terms of costs and advantages.

1.2.1 Transportation systems

The main transportation systems are:

- Air transportation
- Road transportation
- Rail transportation

[6] Stopford M. (2009), *Maritime economics 3th edition,* Routledge.

- Sea transportation

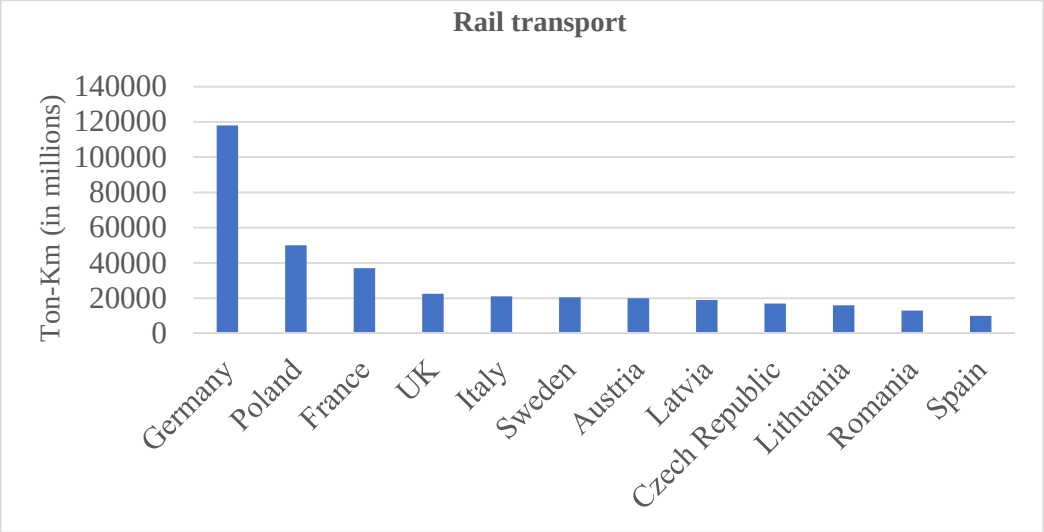
Each of these systems can then be combined in multimodal transportation systems.

Air transport is the fastest system, but also the most expensive. For this reason, it is feasible with small and light products, with an high unitary value. It usually uses specific cargo airplanes, but also normal commercial flights; since airline companies need to bear their fixed costs, they usually offer freight forwarding services in addition to the normal passenger transport.

Road transport is currently one of the most used in Europe. This is characterized by floating costs, depending on what modality is selected, but in general it is cheaper than air transportation and more expensive than the sea and rail ones. It has many advantages, being the most flexible system there is no necessity for a backward planning because there are not straight schedules. Also, this is the only system able to reach any point, for this reason it is largely used in multimodal transportation, connecting port and airport's hubs with the farms. Nevertheless, this system has some cons. It can lead to slow transit times because of inefficient road systems and traffic. It is also the most polluting system, for this reason, in fact, the European Union is promoting alternative transportation means. As said before, road transportation can be exploited in two modalities, on which depends its cost. These are the Full Truckload (FTL) and the Less than Truckload (LTL). The first one is characterized by the fact that the customer rents the entire truck, so that there will not be intermediate stops and transit times will be shorter. Conversely, LTL is a system that allows to share the space available between more customers, so that each firm will pay just for the space and the distance covered by its goods. This is the best system when the quantity to transport is not enough to fill the whole truck.

Rail transport is characterized by high cost-effectiveness but long transit times. This second feature is due particularly to its loading operations, in fact, conversely to passenger trains, this kind of trains have not straight schedules and is more appropriate for not perishable and heavy items. According to the quantity of goods to move, it is possible to rent all the train or just some wagons. The main issue of this kind of transportation is the connection between the train station and the firm. For this reason,

rails are mainly used together with other means, in multimodal and intermodal transportation. On rare cases, it can occur that large companies have their own rail network, connecting the firm with the nearest station. Globally speaking, USA, China and Russia are largely adopting this kind of transportation, while Europe is still distant from their levels. Here, the best performing country is Germany, as we can see in the next graph.



Graph 1.1: Rail transportation in Europe (year 2015).

Sea transport is the cheapest system to move goods on big distances and among different continents. During the last decades, sea shipping has raised increasingly, this is due firstly to the container introduction, but also thanks to the development of Asiatic economies, like China and India. This evidence is largely confirmed by statistics, highlighting that the most performing ports are all in Asia.

Ranking	Port	MTEU
1	Shanghai, CN	36,54
2	Singapore	30,92
3	Shenzen, CN	24,20
4	Ningbo, CN	20,63

5	Hong Kong	20,07
6	Busan, KR	19,45
7	Qingdao, CN	17,47
8	Guangzhou, CN	17,22
9	Jebel Ali, UAE	16,60
10	Tianjin, CN	14,11

Table 1.2: Top 10 ports for number of containers moved[7]. (2015, data in millions of TEU per year)

Sea shipping can be distinguished in two types: short sea shipping and deep sea shipping. The first one is characterized by short distances, usually inside the boundaries of one continent or one nation. One of the functions of this kind of shipment is the so called 'transshipment', that is the redistribution of containers from a big port hub to regional harbors. Transshipment operations are usually accomplished by small ships, mainly Feeder (small container ships with a capacity of 50-500 TEU) or RoRo vessels (Roll on – Roll off). Short sea shipments have an high frequency and lower transit times, for these reasons are more reliable and almost always on time. On the other hand, deep sea shipping is the transportation of goods among long distances, through different continents and over the oceans. This is the most important transportation system in terms of quantities moved. It is characterized by the lowest rate per kilogram, but it also has longer transit times. This is because of the great distances combined with the low speed of vessels. Also in this case, companies need to organize the haulage between the port and the farm. It is in this occasions that the container reveals his efficiency. Before to see the container's introduction and its key role in this industry, in the next pages we are going to deeply analyze the sea shipping sector, having it a key role on container's transportation industry[8].

[7] Tongzon J.L. (1995), *"Determinants of Port Performance and Efficiency"*.

[8] Coyle (2003), *Transportation: a supply chain perspective*, South – Western Cengage

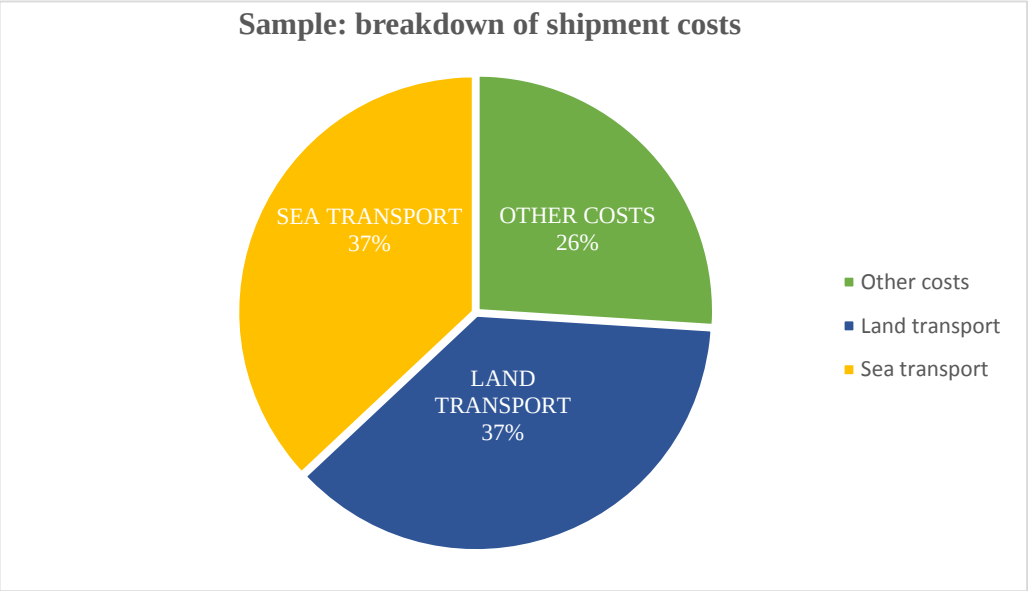
1.3 Sea shipment

The goal of this section is to explain the different phases of sea shipping, analyzing its costs and issues. In this way we will try to find a solution to them in the last chapter, through the application of block chain technology.

When a company decides to outsource transportation tasks, it is usually done with a tender, that is a request to third parties to satisfy a specific task and provide a service to the company upsetting the tender. In this way the company can evaluate different offers and choose the most appropriate to its necessities. The reasons leading to externalize transportation tasks have been already explained in section 1.1.1 (Outsourcing of logistics activities). Now we will see what the costs for the providers of these services are, in particular, of sea shipping services, being these the most significant good's transportation means in the world, and also for the scope of this elaborate.

As said previously, in the most of cases sea shipping is exploited in a multimodal system, that is, combined with rail or / and road transports. In fact, because of its own nature, seaborne transportation systems are not able to reach areas far away from the coast, so that it needs to be combined with other transportation means. In this way, it is possible to break down the shipment in different legs, with their own costs and issues. In order to understand the importance of this evidence, we need to figure out that seaborne shipment represents, on average, just the 30 – 40% of the total transportation cost, as we can see in the below graph[9].

[9] Jugovic A. (2015), Factors influencing the formation of freight rates on maritime shipping markets, Scientific journal of maritime research.



Graph 1.2.: Cost's breakdown of a typical sea shipment.

For this reason, in order to analyze the rates of an overseas shipment we need to wonder which the different steps and components of this service are. These are the following:

- First leg: transportation of materials from the supplier's farm to the port. It is possible to stop by a warehouse in case of a groupage LCL system;
- Second leg: sea shipment. Following port operation, the vessel can leave from the port. This is the longest phase, requiring some days or more than a month;
- Third leg: transportation from the port to the customer's farm. Also in this case the materials can stop by a warehouse[10].

[10] Y.H.V. Lun (2015), *Shipping and logistics management*.

Image 1.1: The shipping process

From this image it is possible to figure out the struggle of a sea shipment and the cost's components of an ocean freight. Sometimes, operators can themselves outsource first and third leg phases, so that to be focused on their core business. Anyway, their rates are usually determined by a logic of supply and demand, in relation with other factors, like world economy, political factors, international maritime trade, average profit and, of course, transportation costs[11].

1.3.1 Cost components of sea shipments

World economy is probably primarily responsible on fluctuations in demand of sea freight. In fact, from the trend in the global production and exportations depends also international trade. In order to better understand this point we can remind the notion of 'trade elasticity'. That is the positive correlation between global production and sea shipments. In this way, the better are the conditions of the global economy, the higher will be the demand of sea freight.

Political factors have the ability to deeply influence international trade and sea shipments. Protectionist measures, conflicts and wars, revolutions, but also mass strikes and protests, are able to make drop exportations in that country.

[11] Jugovic A. (2015), *Factors influencing the formation of freight rates on maritime shipping markets*, Scientific journal of maritime research.

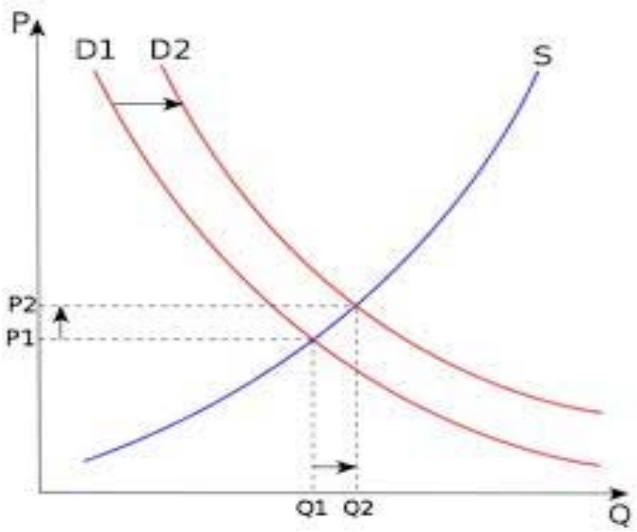
International maritime trade is another factor of influence on sea freight demand. This is caused by the seasonality of some goods, which leads to the short term fluctuations. Examples of this evidence can be found in fuel transportation, which is lower during summer and higher in winter.

With average profit we mean the distance covered by the vessel. This factor is so important that is included in the tariff's calculation together with the weight of goods. Its importance on the demand depends by the fact that the longer is the demand, the longer the vessel will be committed, leading to a lower supply. This is what happened in China when its imports exceeded the productive capacity of its nearest suppliers, like Australia. In this way China started to import raw materials from Africa and South America, employing its vessels for more time and lowering the supply.

The last component affecting the relation between supply and demand of sea freight is transportation cost. Thanks to technological developments of the last decades, sea shipping has become more and more efficient, leading to a strong decrease in its costs. This has been of great importance for companies, which now have the possibility localize their production activity where it is more efficient, and then transport the output in the global market[12].

Finally, the curves of supply and demands represent the relation between quantity moved and transportation price. As we can see in the below graph, the curve of demand is almost vertical. This is because of the absence of alternatives, so that even if the price will increase, the quantity demanded is not affected proportionally or not at all. What can happen, instead, is a translation of the demand's curve, to left or right. On the other hand, what happens to the supply's curve is that below a certain price, the curve is horizontal. This is due to the fact that if the price is below the break even point, which represent the convergence between the vessel's operating costs and the revenues from the shipment, it is no more convenient to accomplish that shipment.

[12] Jugovic A. (2015), *Factors influencing the formation of freight rates on maritime shipping markets*, Scientific journal of maritime research.



Graph 1.3: Supply and demand in sea freight.

The supply's curve is also affected by factors which cannot be seen in the graph:

- Number of vessels in the local fleet,
- Productivity of the fleet,
- Construction of new vessels,
- Dismantling of old vessels.

As said previously, over the transportation cost itself, in a seaborne shipment we have other cost components. These represent a big portion of the total cost and are mainly composed by bureaucratic and administrative issues. That is, over than sea and land transportation, the additional costs in a shipment are represented by a large number of documents and controls, sometimes unnecessarily duplicated, which all together affect the total cost in a significant way. These are, in example, the Automated Manifest System (AMS), the ACI fee, the Anti–Terror Compliance, the Bill of Loading fee, the Customs Clearance, the Customs examination, the ENS and AES (for the tracking system), the export documentation, the ISF (Importer Security Filing), the ATLAS tariff and many other, usually depending on the importer country and the kind of good[13]. As we can see, many of these voices are, in practice, just a documentation's

[13] Hummels D., (2007), *Transportation Costs and International Trade in the Second Era of Globalization*.

drawing and transfer, but currently represent a large cost for companies. The goal of this work is to find a solution to this through the application of block chain technology to the container shipping industry. For this reason, before to move on we will show the importance of containers in this industry.

1.4 The container revolution

During the last ten years, containers, being easily transportable on trains, vessels and trucks, have radically changed international trade. This have been possible also thanks to commercial and political agreements, like the GATT (General Agreement on Tariffs and Trade), which lowering tariffs and barriers on trade, has enabled the globalization process and the current levels of international trade. But it was not enough, in fact, according to many researchers and economists, another factor was accountable for this development: the container[14].

Just seventy years ago, good's shipment features were deeply different. Cargoes were moved from the farm with sacks and cases, carried on the back by animals and workers through a nontrivial process despite the short distances. With technological revolution everything changed. Nowadays goods are shipped all around the world through interlinked efficient transportation system, tracked over long distances and giving the rise to what Ricardo explains in his comparative advantages theory. This process was due to several innovations, especially in transportations and IT technologies which allowed today's industry performances. During this time, shipment industry and international trade have grown simultaneously through the globalization process. Efficiency improvement and scale economies are due particularly to the containerization process and to inter modal shipping. The container itself has nothing of exceptional, it is just an iron box, used for good's transportation, it's not a vehicle, neither packaging. So why this simple case changed so much the world? In Levinson's opinion, what makes the container so special is the way it is exploited. "The Box" writer highlights how container is the gear of the global logistics system, giving the rise to intermodal transports, which moves millions of containers each year[15]. The container was the solution to the high costs of transportation, just carrying all the furniture together in a box. It provided many advantages. First, it allowed a great time saving: before its introduction, in 1965, less than two tons could be charged on a vessel

[14] Frémont A.et Soppé M. (2005), *Container's sea shipment and the globalization.*

[15] Levinson M., (2006), *The Box: How the Shipping Container Made the World Smaller and the World Economy Bigger*. Princeton University Press.

in one hour, after five years, thanks to containers, the tons charged in one hour became thirty. This fact leaded vessels to be bigger and bigger, improving efficiency and reducing costs and time wasting[16]. Now we will see the container's history and evolution, analyzing its impact on international trade.

1.4.1 Container's introduction

Till 1950, goods were carried on vessels unboxed, so that port operations and transportation were slow and inefficient, leading ships to spend more time in ports than on sea. Container was about to change everything. Its first introduction is dated from nineteen century, when British and French national trail were using wooden containers in furniture's transportation. Looking forward, during twenties Union Pacific and New York Central Rail were using a sort of container, charged on trains with forklifts and, almost in the same period, Cincinnati Motor Company developed the first track with attached trailer. Transportation industry was about to be revolutionized with linear and intermodal shipping, but many difficulties had to be still faced. In Europe, the London Midland and Scottish Railway merged in the International Container Bureau (ICB), an organization which mission was to promote container utilization. Fatefully, the project was abandoned because of World War II. Years later, in 1948, the USA army developed the ancestor of modern containers: the 'conex'. It was a small iron container, made to transport troop's personal effects. The first container vessels were developed during fifteens by United Shipping Company in Denmark. In the same period, in Pittsburgh, Dravo Corporation developed another kind of container made of iron, the 'trasportainer', with 2.36 meters in length[17].

As seen, during this period, containers had already been introduced, but despite these isolated and small cases, in early fifteens container shipping was just a small portion of the market because it was too expansive. Goods were still shipped in open top-wooden containers, with small dimensions. One of the complications was the absence of a weight limit and of standard dimensions, but also trade tariffs, which were

[16] Graham M.G. and Hughes D.O., (1985), *Containerisation in the Eighties.*

[17] Frémont A.et Soppé M. (2005), *Container's sea shipment and the globalization*

calculated both on the container and on the goods inside it, increasing costs. Before the container, in fact, every kind of good had its own tariff, established by the Interstate Commerce Commission (ICC). With the introduction of container, tariffs were no more based on the product itself but on its weight and dimensions. In 1931, the ICC declared illegal this system, fighting publicly the container utilization and obstructing its diffusion. After more than fifteen years, in 1954, a research from the USA government calculated that transportation costs were, in average, the 37 percent of the good's transported value and, that time spent for transport was equal to the time spent on port operations. From this point, they started to search a way to carry goods avoiding time and money waste[18].

The solution was pointed by Malcolm Purcell McLean, from North Carolina. At the age of 21, he started its own shipping company, the McLean Trucking Company, with just one truck and himself as single driver. After one year, the drivers were nine and the company was in profit for $230.000. McLean's success was due to a great focus on costs reduction and propensity to innovation. His company was the first to utilize diesel engines on trucks and he stipulated agreements with all gas stations on his routes. In 1954, McLean acquired a Waterman's controlled company, the Pan-Atlantic, and one year later, the Waterman itself, becoming a shipowner. In this way he started to compete with road and trail's transportation systems, providing their same services, but via sea. There was more profit margin because ICC tariffs were lower on sea shipping; here McLean noticed that charging all the truck on the vessel was space-consuming. Container shipping derived exactly from this idea, in 1955. He introduced the first proper container, though out for intermodal shipping and transportation. He realized that using standard boxes easily to transport from the vessel to the truck would have been cheaper and time saver. His idea was to use standardized containers, projected to be easily moveable between trucks, trains and vessels. On April 26th 1965 the Ideal X, an ex oil tanker with nine meters of length, left the port of Newark charged with fifty-eight containers. It costed 0,16 dollars per ton charged, while a standard cargo vessel

[18] Frémont A.et Soppé M. (2005), *Container's sea shipment and the globalization.*

costs per ton were of about 5,83 dollars, representing more than 97 percent in cost saving[19].

Nevertheless, containerization process has been slow. Its diffusion, as for logistics, raised thanks to military industry. It was firstly utilized during World War II by USA in order to transport army furniture to Europe, but the real container's diffusion occurred with the Vietnam War. During sixties Japan was growing fast, so McLean introduced new routes through the West Coast and Vietnam, stopping by Yokohama. Between 1969 and 1973, Japanese industrial production quadruplicated. At the end of sixties, the goods shipped between Japan and California were more than half of the global tonnage and the containerization was spreading through the Pacific Ocean. Between 1966 and 1983 the percentage of countries using containers raised from 1 to 90 percent and McLean was appointed as man of the century for seaborne trade[20].

The1973 was the year of the first container ship from Maersk Line, seventeen years later the Ideal X and five years after the container revolution. The group currently ships millions of tons each year operating on 786 vessels and the containers moved each year has reached 300 millions of units[21]. The amazing growth of international trade, through long distances and on mass scale, shaped the world of today. Malcolm McLean was not the container's inventor; instead he was the first to figure out its potential and to develop a mass scale logistic system focused on containers and inter-modal shipping.

1.4.2 The container's advantages

The containerization is based on container's exploitation in logistic activities. It simplified all shipping industry: being an interchangeable and standardized box, now furniture could be easily moved from the farm to the truck, then to the quay and from here on the vessel. The container shaped many others industrial transportation means, giving the rise to intermodal and multimodal transport. Intermodal shipping is, as said

[19] Frémont A.et Soppé M. (2005), *Container's sea shipment and the globalization.*

[20] Levinson M., (2006), *The Box: How the Shipping Container Made the World Smaller and the World Economy Bigger*. Princeton University Press.

[21] Frémont A.et Soppé M. (2005), *Container's sea shipment and the globalization.*

previously, a method of moving cargo that involves more than one kind of transportation, whether truck, rail, ship or plane. It uses special containers, so goods can be transferred from ship to rail to truck without having to be repacked. In this way, time scheduling is shorter and costs lower, improving all the logistic systems and business's supply chains. In this context, we see that container's standardization has been of big importance. As discussed earlier, wooden containers were already in use during the nineteenth century, but they started to have standardized dimensions only during fifties, and more precisely, during Vietnam War, with the introduction of the 'conex'. Nevertheless, also in this period there was too much differentiation among containers dimensions. The Marine Steel Corporation, a company producing containers in New York, had more than thirty different models[22].

According to many experts, it was because of this high differentiation if containerization process has been so slow. During this times, European containers were not able to be shipped in America because of dimensions mismatch between their trail and truck systems. It was the United Sates Maritime Administration (or Marad) to introduce standardized dimensions for containers in 1958. In the same year, the International Standard Organization (ISO) was established and, its commission, concluded that all businesses and actors, both from Europe and America, involved in logistic activities, had to cooperate on the development of standard dimension for the promotion of intermodal shipping. In September 1961, politicians and managers from eleven different countries had a meeting in New York with the ISO. After five years, in 1966, the members agreed on the container standardization. In this way, container shipping started its real rise[23].

This easy introduction, revolutionized transportation industry and logistic activities, allowing intermodal shipping. From this moment, ports and, shipping schedules in general, have been much more efficient and shorter. Nowadays, container shipping uses standard containers of various sizes to load, transport, and unload goods. These are as below:

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[22] Slack, B. (1998), *Intermodal Transportation*.

[23] Frémont A.et Soppé M. (2005), *Container's sea shipment and the globalization.*

- 20 foot (6,09 m),
- 40 foot (12,18 m),
- 45 foot (13,7 m),
- 48 foot (14,6 m),
- 53 foot (16,15 m).

The standard measure of containers is a twenty-foot equivalent unit or TEU so a twenty-foot container equals one TEU, a forty-foot container equals two TEU and so on[24]. The containers are all built to an international standard, so they are interchangeable between container shipping companies, and with rail and trucking companies. As a result, containers can be moved seamlessly between ships, trucks and trains. The two most important, and most commonly used sizes today, are the 20-foot and 40-foot lengths. The container sizes had to be standardized so that containers can be most efficiently stacked one on top of the other, and so that ships, trains, trucks and cranes at the ports can be specially fitted or built to a single size specification. Proper loading or 'stuffing' of containers is very important to the safety and stability of containers and ships and a number of efforts have been undertaken to improve the safe handling of containers. Standardization now applies across the global industry, thanks to the work of the ISO. Containers are generally constructed of aluminum or steel with each container size and type built according to the same ISO specifications, regardless of where the container is manufactured. Shipping containers are available in a variety of types in addition to the standard dry cargo container, often referred to as "special" equipment. These special containers include open end, open side, open top, half-height, flat rack, refrigerated (known as 'reefer'), liquid bulk (tank), and modular all built to same exterior lengths and widths as the standard dry cargo containers. Containers in the global container fleet equate to more than 34 million TEU. Open tops are used for easy loading of cargo such as logs, machinery and odd sized goods. Flat racks can be used for boats, vehicles, machinery or industrial equipment. Open sides may be used for vegetables such as onions and potatoes. Tank containers transport many types of liquids such as chemicals, wine and vegetable oil. Every container has its own unique

[24] Slack, B. (1998), *Intermodal Transportation*.

unit number, often called a box number that can be used by ship captains, crews, coastguards, dock supervisors, customs officers and warehouse managers to identify who owns the container, who is using the container to ship goods and even track the container anywhere in the world[25].

In addition to the container standardization, another great innovation is accountable for the containerization process: the information and communication technologies (ICT) revolution. In fact, if the container's diffusion allowed transports integration and intermodal shipping, now it was necessary a way to manage and connect this global chain. The ICT revolution succeeded to the container's one, occurring during nineties with the internet diffusion. Now, thanks to e-mails, it was possible to communicate instantaneously and almost without costs and, no less, from 1995, with e-commerce introduction the international trade reached amazing levels. In fact, information systems played a central role in the containerization process. From info exchange to documentations printing, computer systems were an important resource, but before nineties just a few companies were able to bear its cost. With the ICT revolution, shipping companies started to implement computer systems in order to improve their efficiency and reduce the costs[26].

Before the containerization, a cargo ship was able to handle just 10.000 tons of goods, spending about two weeks in port operations. Between 1980 and 2018, the deadweight tonnage of container ships has grown from about 11 million metric tons to around 253 million metric tons[27]. As of July 2016, the global cellular container ship fleet had the capacity to carry some 20 million standard containers. Simultaneously to the vessel capacity, also the quantity of goods carried by containers has risen from around 102 million metric tons in 1980 to about 1,83 billion metric tons in 2017[28]. Liner vessels, primarily in the form of containerships and roll-on/roll-off ships, carry about 60% of

[25] Slack, B. (1998), *Intermodal Transportation*.

[26] Stopford M. (2002), *E-commerce-implications, opportunities and threats for the shipping business*.

[27] ISL: *Shipping statistics and market review*,2014 Logistica Efficiente: www.logisticaefficiente.it

[28] ISL: *Shipping statistics and market review*,2014 Logistica Efficiente: www.logisticaefficiente.it

the world's sea borne trade each year, worth about $12 trillion USD in 2017, with approximately 400 liner services in operation, most sailing weekly[29].

The container revolution provided many changes to vessels, ports and to logistic systems in general. It turned the seaborne shipment into an industrial process, granting efficiency and reliability worldwide. In the container era there are scheduled path for goods, connecting hundreds of ports around the world. In theory, the global fleet could transport more than 260 millions of tons daily, the same quantity moved annually during 1950[30].

Analyzing the difference from container shipping and traditional shipping we found out that container vessels can carry from three to six times more than a normal cargo ship monthly. This is due particularly to the reduction of the port's turn-around timing (the timing for furniture loading and unloading operations). In fact, one of the major effects of the containerization is the reduction of ports schedules. Nowadays, to pick up 1000 TEU we spend in average 20 hours, before the container from 70 to 100 hours were necessary at the port for turn-around operations[31]. This fact was the key for another great innovation in logistics: the just-in-time system.

As we can see, the container provided a great efficiency to all the transportation and logistics industry. Ports were enlarged and good's theft decreased. In addition, being the container more resilient to weather and clashes, the risk of damages was reduced and there wasn't the necessity for storing the goods at destination, reducing substantially the supply chain's cost. In example, compensation claims have been reduced of the 95% from the container's introduction[32].

Anyway, the greater contribution of containers to the shipping industry was, as said earlier, its exploitation in intermodal transportation. These two introductions leveraged each other in an amazing way during the last twenty years. According to the WTO,

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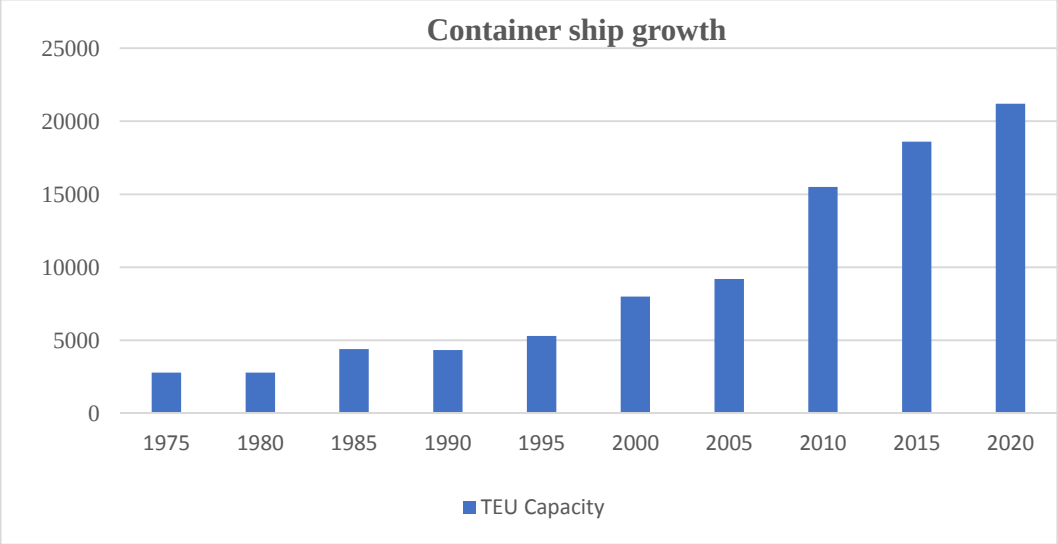
[29] *World Trade Report*, (2017).

[30] *Worldshiping.org*

[31] Levinson M., (2006), *The Box: How the Shipping Container Made the World Smaller and the World Economy Bigger*. Princeton University Press.

[32] Hummels D., (2007), *Transportation Costs and International Trade in the Second Era of Globalization*.

global exports have shifted from $2,03 trillion US to $18,26 trillion between 1980 and 2011[33]. From 1950 to 2004, international trade has grown, in average, of the 5.9% annually. The growth in the production sector has been even wider, around the 7.2% annually. This is the result of the combination between containerization process and internet technologies, which together have reduced transportation costs, and, as already pointed, transportation costs are crucial in all major decisions of a company, like where to produce or where to sell the products[34]. This amazing growth has been pushed by the container's standardization process and by ICT revolution.



Graph 1.4: Container ship capacity growth from 1975 to 2020.

Thanks to containers, new products have been introduced and international trade started to rise till the current levels. We can say that, during last fifty years, container has sustained and leveraged international trade much more than all the political and commercial agreement, leading to what we call globalization process. In short, international trade and shipping industry have grown together from the beginning, highlighting a strong connection between seaborne transportation industry and global economy.

[33] *World Trade Report*, (2013).

[34] World Trade Organization, (2017). *World Trade Organization*.

Lund University, in Sweden, analyzed 22 developed countries, founding out that container utilization has increased trade between two countries of about 320% on a period of five years, and of about 790% on a period of twenty years[35].

Nevertheless, container's implications go far away from these. Thanks to it, many regions have been much more accessible, so that raw materials, goods and customers previously distanced by huge transportation costs or by lack of connections, now are all part of the global market. Every object in our ordinary life implies thousands of kilometres, from smartphones to bananas. This has been a real revolution, probably not even perceived by the public.

[35] Bernhofen D. (2013), *Estimating the effects of the container revolution on world trade.*

1.4.3 Industry's technological level

Paper base processes has been one of the reasons shipping has lagged behind other industries in moving to electronic forms. The variety of different languages, laws and organizations involved in moving cargoes made standardization a slow process inside the industry.

With the application of internet and communication technologies to the container and logistics industry in 90s, the market gained a great efficiency and cost saving, reducing schedule times by 40% and errors by 30% on average. The email allowed for faster and cheaper communication from different countries, while the Internet and the Radio-Frequency Identification (RFID) allowed for the tracking of vessels and containers in real time. In this way, the efficiency and security of the industry was growing in an always more complex system, relying on advances in transport technology and cargo handling[36].

Today's technology level is still connected to that old-decades technologies. The majority of containers is not tracked at all or tracked with tags that exploit different technologies. These tags can be active or passive, where the first ones have a battery, while the seconds don't. They exploit foremost RFID's technologies, but some exceptions are made with bar codes, Magcards or smart cards. These technologies are exploited in ports for the identification of containers in transit. Usually RFID's technologies are integrated with Management Information Systems (MIS), for the management of information, and with Electronic Data Interchange (EDI), improving the efficiency of international logistics and intermodal transportation. EDI systems, in particular, have gained always more a central role in international transportation during the last decades. It is a tool for the exchange of information among different partners and actors involved in a supply chain's ecosystem. Despite its importance in the efficiency improvement and costs reduction, this system is still not largely used in the world, where communications associated with good's transportation are slow and replicated many times. In fact, the complexity of this market is associated with the fact

[36] Frémont A.et Soppé M. (2005), *Container's sea shipment and the globalization.*

that each intermediary needs to communicate with many external actors, so ICT technologies are of fundamental importance[37].

Thus, EDI technologies, together with GPS (General Positioning System) technologies and RFID's systems, are of great importance in today's container transportation industry and in logistics, having a central role in the performance of many different businesses. They have allowed these companies to gain profit margin over the last years, but what lacks today is a system that puts all these different technologies together, combining data and information from different sources and companies and monitoring each step inside the supply chain.

With these containers sometimes holding products from different suppliers, and ship cargoes sometimes ending up with thousands of customers in dozens of countries, the transition to a uniform electronic system presents major challenges. Thus, what is essential in the today's industry is something that unifies all these information and data from different systems and operators. Blockchain could be a ground-breaking technology inside the industry and can obviously respond to this necessity thanks to its functions and applications. But in which way and what kind of this technology should be applied to this industry in order to be the most appropriate and functional?

1.4.4 Container's transportation market

Inside the container shipping market there are 67 companies operating worldwide. According to the British Mds Transmodal, more than the 87% of world capacity in the containers transportation industry is in the hands of the first ten companies. This is the result of a merging process occurred during the last years, in fact, just five years ago the same ten leading companies were in charge for less than half of the market. Danish shipping line APM-Maersk, with a total capacity of around four million TEUs, is currently the largest container-shipping company globally, accounting for the 21% of the world capacity, followed by the Swiss Msc owned by Gianluigi Aponte and the French Cma Cgm. Off the podium we can find Hapag-Lloyd

[37] Y.H.V. Lun (2015), *Shipping and logistics management*.

(after the acquisition of the Arabic Uasc), Cosco (China Ocean Shipping Company), Evergreen, Oocl (Orient Overseas Container Line), Mol, Yang Ming and Nyk. The last one is about to merge with the Japanese companies Mol (Mitsui O.S.K. Lines) and K line (Kawasaki Kisen Kaisha) creating the Ocean Network Express (or ONE) which will account for the 8,7% of the global market share in the container market. Also, the Oocl has been acquired by Cosco, giving to the Chinese group the 12% of the global lines. In addition, if we consider the three main alliances between these companies, the market concentration reaches the 99% of the container sea shipment. In fact, there are three big alliances between them: 2M, Ocean Alliance and The Alliance, which together, account for about the 99% of Europe-Asia trade, the 89% of Transpacific one and the 83% of Transatlantic trade[38].

According to Bimco (Baltic and International Maritime Council), during the last two years international seaborne trade have been back to the rise. Expectations for 2018'grown were of about 3,9 percent (compared with 4,5 percent during 2017); not so much, but still enough to soak up the excess capacity in the sector generated by new large carrying capacity vessel. Data from Container Trades Statistics show that during 2017 about 15.8 million of TEU (+3,7%) have been shipped via sea between Asia and Europe, while the largest growth has occurred on the Asia-North America routes with 18.5 million of TEU, representing a rise of 7,3 percent. The largest market is found to be in Asia, where in one year the interregional trade has moved 40.9 million of TEU (+4,3%). Also, Bimco analysis highlight an increase of 1,2 percent in the global cellular container ship fleet capacity during 2017, due to more than 254 thousands of TEU (254.173) represented by all the new vessels in the market during 2016. Between these, the biggest part is represented by small size vessels, where just five new units will carry more than 20 thousands TEU. In this way, the new container ship fleet capacity should be of about 1.05 millions of TEU, with just approximately 191 thousands of TEU of overcapacity represented by 65 vessel. This last data represent a strong improvement

[38] Bloomberg. *www.bloomberg.com*

in the efficiency of the sector, leading to a new future of profitability after years of loss[39].

According to researchers from Drewry, the global aggregate loss during 2016 of the 15 leading companies in container carrier industry was of about $3,5 billion, but in 2017 the Harpex Shipping Index (representing the container seaborne trade levels) was already of 439 points, which means a growth of 40 percent. Even if far away from the pre-crisis levels (-76% from 2005), it seems that the market has reached a new balance, mostly thanks to the rise of Asiatic trade, in particular China, Japan and India. Also, in 2017, the five leading container handling ports worldwide were Asia-based. The port of Shanghai was the busiest container port in the world, handling about 40.2 million TEUs of containerized cargo. This trend is confirmed by data: from the 15 leading companies, the profitable ones during 2016 were all operating in Asia at a regional level: Matson and Hapag Lloyd (both with a profit of $141 millions), Wan Hai ($58 millions) and CMA CGM ($29 millions). On the opposite side, during the same period the worst have been Hyundai Merchant Marine ($716 millions in loss), Yang Ming ($453 millions), Maersk Line ($396 millions) and MOL ($354 millions). The best performances came from small companies like Matson and Wan Hai with a profit margin respectively of 9,2% and 3,3%, while none of the big players have been able to reach the 2% in profit margin during 2016, as highlighted by Drewry. On the long run, there will be more opportunities due to the M&A process of the last years, but this have already been eroded by the entrance of new vessels[40].

As we can see, the issues in this complicated market are several. In the next section we will analyze these complications, so that to understand which of them could be fixed by a block chain technology.

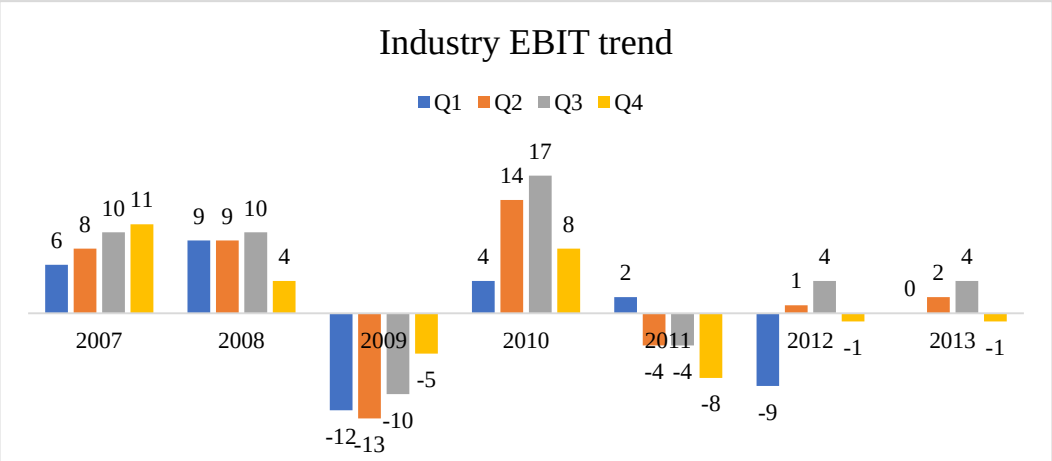
[39] *www.bimco.org*

[40] www.drewry.co.uk

1.5 Today's industry issues

The container transport industry has enjoyed a dramatic and dynamic past, but its future looks no less exciting or demanding. The industry has been highly unprofitable during the last years. Making things worse, earnings have been exceptionally volatile. Several factors are responsible for this evidence.

A big part of the problem is that the industry has added capacity for years, despite the financial crisis. In 2015, the typical vessel handled about 10.000 twenty-foot TEU, five times more than ships built in 1990. Not surprisingly, pressure to fill this capacity and capture the efficiency benefits of larger vessels has led to hasty decisions by carriers. In turn, profits have become exceptionally volatile. Record losses in 2009 were followed by strong profits in 2010, and significant losses again in 2011.



Graph 1.5: Industry Ebit trend including 14 of the largest companies

The supply/demand imbalance, the larger vessels that will only make the imbalance worse, and the volatility of profits are significant problems. However, according to McKinsey experts, these could be symptoms of deeper challenges:

- The market is saturated, and the industry is now in a race for market share leading to a new price war.
- Many shipping companies have ineffective cost-management systems. Also, companies are pricing at their marginal cost. That's not necessarily bad, but for small companies it is irrational, and when everyone does it, the industry suffers.

- The difficulties from small companies to enter this market leads to other problems: innovation in service offerings is sporadic. Most carriers offer the same or similar service to all customers, regardless of need. Carriers are missing opportunities to charge premiums for value-added services (for example, intermodal and guaranteed delivery times) and are unable to monetize innovations. In particular, innovators and innovations are slowed down and, as seen in section 1.4.3, it is not changed a lot from the introduction of the first standard container in 1955.
- There is an opaque procurement process largely perceived by the customers of this market. This evidence is highlighted by the presence of many intermediaries between farms and carriers.

So, as seen in this chapter, the industry is mainly composed by old-decades technologies and based on paper documents. Many fundamental processes are slowed down by these inefficiencies. Currently, up to 20% of all containers in the world are unaccounted for at any time when it comes to precise location, destination and current ownership. Due to a lack of real-time tracking and sharing of container locations, the vessels that carry them have overstocked inventories, which could be reduced by 15%-20% if empty containers are tracked. Real-time location tracking will present numerous solutions to age-old industry problems. In particular, empty container repositioning is a practice that has been massively costly for the shipping industry. In 2016, the Boston Consulting Group claimed that repositioning empty containers cost the shipping industry between $15 and $20 billion USD a year.

These problems are real and significant, and largely beyond the power of any one company to address. But shipping companies cannot afford to throw up their hands and accept their fate. There are several things the container transport industry can do to prepare for the next 25 years: focusing on the end consumer, pursue digitalization and automation with conviction and cultivate a spirit of experimentation and innovation. In fact, in an industry traditionally focused on physical assets, “the digital era presents many new challenges, potentially disrupting business models and creating new value streams,” read the McKinsey report. “Customer expectations of container transport are also being radically re-shaped by e-commerce and innovations in last-mile logistics; as

end-consumers come to expect same-day delivery, the demands on the container transport industry – which is only a couple of steps removed – will only rise".

Companies that will take on a full program of initiatives can boost earnings. To realize that, however, firms must also ready their organizations for change. That's a nontrivial challenge: in fact, very little has changed in container shipping since the first container in 1955. Companies need to find ways to help employees embrace new ways of working and must be prepared to bet on the future. Carriers that embrace change will be better prepared than their rivals to make the best of the current business cycle and to thrive in the next one.[41]

With a block chain technology applied to containers, the industry could boost its profit margin and gain many advantages like greater economies of scale, flexibility, supply chain reliability and predictability, consolidation and integration, automation and productivity, and environmental performance. In practice, the potential benefits of this technology for the container industry are staggering. Before to see this, in the next chapter we are going to describe the functioning of blockchain technologies, so that to deeply understand its advantages and possible applications on this industry.

[41] McKinsey report (2016). www.mckinsey.com-research.

Chapter 2: Blockchain technologies

2.1 The genesis of blockchain: Bitcoin's history

Blockchain, the technology that runs Bitcoin, has developed over the last decade into one of today's biggest ground-breaking technologies, with potential to impact every industry from financial to manufacturing to educational institutions. Yet, we can't discuss the history of blockchain technology without first starting with a discussion about Bitcoin.

Nowadays there are thousands of cryptocurrencies, like Ether, Litecoin, Ripple and Dogecoin (that started off in 2013 as a joke based on an internet meme and now is worth about half a billion dollars in market capitalization), but to understand cryptocurrencies, you have to go back to an earlier form of digital money. Diners Club was the first ever credit card, and it advertised itself as the ticket to a new modern lifestyle. Credit cards were a revelation. By 1979, half of American households had one. They freed us from carrying around cash everywhere, and in the age of Amazon, Google and Uber, there is no need for cash at all. Until there is.

For as long as we have been tinkering with computers, on any mass scale, there has been a dream of digital cash. A cash that would function like cash, in the sense that it is non-traceable, anonymous, instant, free to use and that in the same time would be able to interoperate with computer networks. A way to buy and sell things online without Big Brother watching. That is a lot harder than it sounds. It is a problem that tricked computer scientists for decades. It even had a name: The Byzantine Generals Problem.

A group of generals, each commanding a portion of the Byzantine Army, encircle a city. They must decide whether to attack or retreat. But whatever they decide, the most important thing is that they reach a consensus. But consensus is difficult to reach, because the generals in this army also cannot trust each other, just like we cannot trust each other online. A general might say they plan to attack, when they actually plan to retreat, and just one dishonest general means everyone else dies in battle. The generals

had no choice, they needed to route all of their battle plans through a central authority. That is why a site like Amazon needs to check with our bank to make sure we have the promised money.

Looking for the genesis of cryptocurrency, it was the Cypherpunk movement the discovering of cryptography. These people had talked about the need and the possibility for a digital currency that was anonymous or could be anonymized, using cryptography. They were looking for the beautiful anonymity of cash, but cash that was not printed by governments. Instead it was made by a bit of code, powered by citizens of the internet, and that you could trust it. This movement emerged in early '90s and they were hyper-concerned about privacy and about personal liberty.

Before Bitcoin, in fact, a lot of people had come up with their own systems. Some of them came very close to happening. The one that probably came the closest was DigiCash form David Chaum. He was not a Cypherpunk, instead he inspired the movement. The Cypherpunks in fact came upon David Chaum's tools. They were interested in the ones that could be used to disempower the government and power individuals. That is, the break between him and the Cypherpunks came when Chaum realized he would need existing institutions to help him with his project and started talking governments and banks. He was very close to having this first cryptocurrency happen in the late '90s, but nobody was really prepared for it outside the Cypherpunk movement and the conversation died down. Still, there was not much of an alternative without a solution to the Byzantine Generals Problem. Then, almost twenty years later, someone came along and solved it. Satoshi Nakamoto[42].

The 2008 was the year of financial crisis. The system almost collapsed again, but the central bank came to rescue it, printing trillions of dollars to save bank institutions and creating in people this new desire to have a financial system that existed outside the bands of Wall Street, outside the bands of central banks and that return money back to the people. It is remarkable that this idea of Bitcoin was launched just a few weeks after Lehman Brothers went bankrupt and the whole system nearly collapsed. What the crisis

[42] Marr B and Davies S (2018), *A very brief history of blockchain technology-Technology Reporter* – Forbes.

showed was that the existing system had some major flaws. It was not working, and people were hungry for some sort of alternative. So, all of a sudden, the conversation around cryptocurrency came back to life after the financial crisis, and people went back to those experiments of the 1990s, looking at new ways of putting old ideas together.

At that time there was a small group of people that were working on the idea of a new digital money, that will be entirely private, not connected with the government, global and purely digital. This was the idea underling Bitcoin. Its inventor was Satoshi Nakamoto, whose true identity is still unknown (he could also be a group of people, probably from the Cypherpunk movement).

"I have been working on a new electronic cash system that is fully peer to peer, with no trusted third party. Its name is Bitcoin." (Satoshi Nakamoto)[43].

He released the paper "Bitcoin: A Peer to Peer Electronic Cash System" in 2008 that described a "purely peer-to-peer version of electronic cash" known as Bitcoin, and blockchain technology made its public debut. After Nakamoto's whitepaper was released, Bitcoin was offered up to the open source community in 2009. Blockchain provided the answer to digital trust in financial institutions, because it records important information in a public space and doesn't allow anyone to remove it. It is transparent, time-stamped and distributed. In practice, the problems that cropped up in the crisis were very much a part of the writings of Satoshi Nakamoto. He unleashed a cryptocurrency that you could buy online and then spend as freely and anonymously as if you were using cash.

Any discussion of Satoshi's identity has to go back to the fact that Bitcoin was based on this small number of projects back in the 1990s, that only a handful of people knew about, like Hash Cash, Bit Gold and B-Money. In this way, you end up with a pretty small group of people who would have known about these projects[44].

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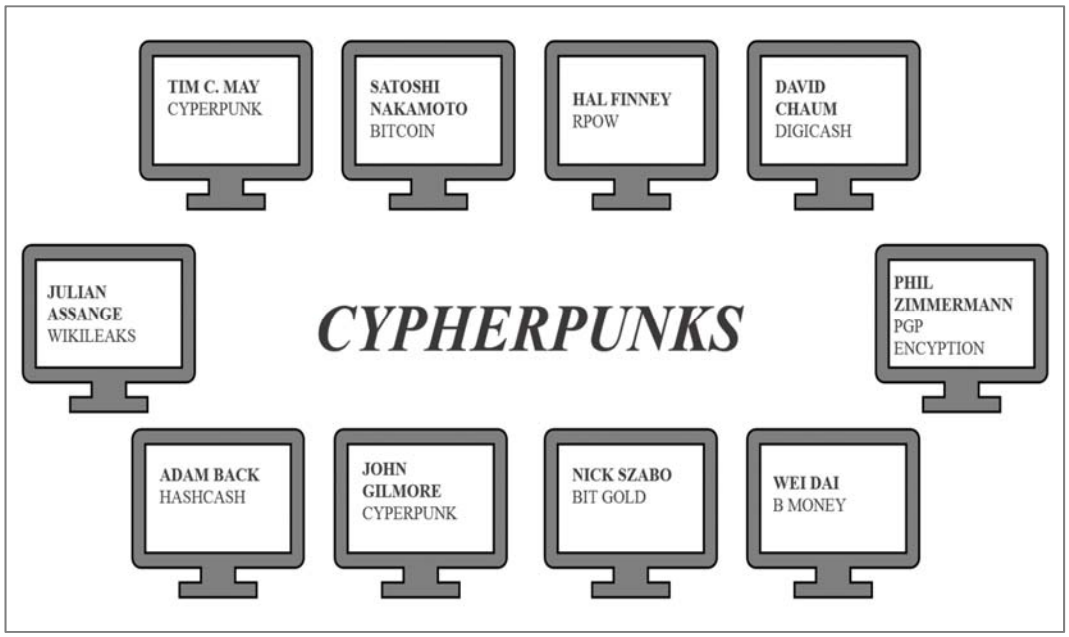
[43]Satoshi Nakamoto (2008), *Bitcoin: a peer to peer electronic cash system.*

[44] Marr B and Davies S (2018), *A very brief history of blockchain technology-Technology Reporter* – Forbes.



Imagine 2.1: Some of Cypherpunk movement's members

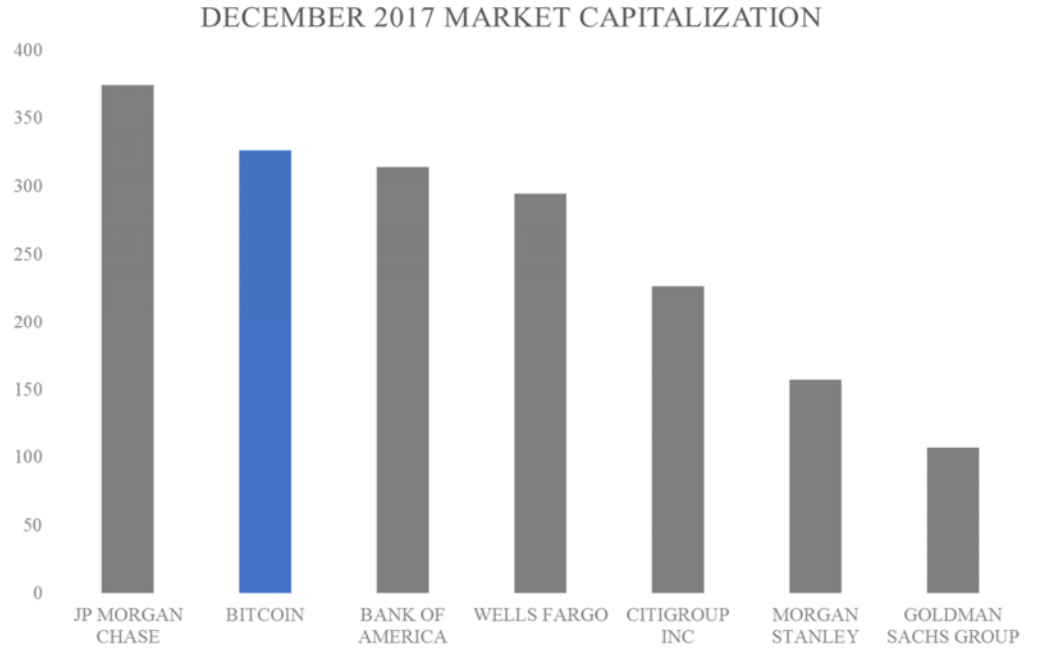
Nick Szabo was the creator of Bit Gold. His interest in this idea he had been working in 90s' was really revived during financial crisis, especially with privacy, contracts and the problems of governments and other trusted third parties. So, in 2008, he brought Bit Gold back into the conversation. In the same days Hal Finney came up with his own system. So did Adam Back, with Hash Cash and Wei Dai with B-Money. In practice, what Satoshi did, in 2008, was took a lot of these ideas and made them work. He created an encryption-based protocol utilizing a ledger called the blockchain, allowing for many kinds of transactions to occur.

For some period, people thought David Chaum was Satoshi. But it is more probable to be Hal Finney. He was the first guy to work with Nakamoto. He was a cryptographer. As soon as Nakamoto released it, he was one of the first people to email back and show interest in the project. In the first weeks of Bitcoin he worked with him setting up the system and Satoshi Nakamoto sent Hal Finney the first ever Bitcoin transaction. However, this is still a mystery and so it will remain.

Going back to Bitcoin, in its early days, the first group showing interest in it was just a bunch of tech-minded coders. Then the libertarians came on board, who saw it through a political lens, so that these two groups worked together and overlapped too. In

addition, the timing was perfect, because the existing system was in utter disrepair. It was like a match to a pile of wood. The whole thing went viral and took off so that there was a network effect: the more people get involved the stronger the network got, and the more it grew, so that it really started growing on itself.

The big bang moment for Bitcoin was with Silk Road. It was an online free market that could sell anything, illegal services like drugs and arms included. A $1.2 billion online criminal market place, exactly. So, virtual currencies posed challenges for law enforcement and authorities also started to get involved in it and, thanks to Silk Road, the press ate it up. Now the interest in Bitcoin became global. It got so popular, that by the end of 2017, it was valuable as the big banks it stood against[45].



Graph 2.1:Bitcoin market capitalization in billions of dollars (2016).

Businesses began creating their own cryptocurrencies and selling the coins as a way to raise money, like shares on a stock market. Also people treated cryptocurrencies like a stock market too, investing in different ones, trying to buy low and sell high. And over the last few years, it has been pretty easy to sell high.

[45] Tapscott D (2016), *Blockchain revolution.*

Looking better at Bitcoin, people suddenly started to understand the potential of blockchain technology. In practice, we can say that "blockchain is to Bitcoin, what the internet is to email. A big electronic system, on top of which you can build applications. Currency is just one"[46].

Even today, there are many who believe Bitcoin and blockchain are one and the same, even though they are not. Those who started to realize, around 2014, that blockchain could be used for more than cryptocurrency, started to invest in and explore how blockchain could alter many different kinds of operations. At its core, blockchain is an open, decentralized and distributed ledger that records transactions between two parties in a permanent way without needing third-party authentication. This creates an extremely efficient process and some people predict will dramatically reduce the cost of transactions.

When entrepreneurs understood the power of blockchain, there was a surge of investment and discovery to see how blockchain could impact supply chains, healthcare, insurance, transportation, voting, contract management and more. Nearly 15% of financial institutions are currently using blockchain technology. On February 2, 2013, the European Commission commissioned the Monitoring Centre and Forum on blockchain, and, some days earlier, also the British Parliament started to study blockchain's possible applications. Lately, on December 2018, also Italian government commissioned the MiSE to study blockchain technologies and distributed ledgers possible applications[47].

Today, Bitcoin is just one of the several hundred applications that use blockchain technology. It has been an impressive decade of transformation for blockchain technology and it will be intriguing to see where the next decade takes us.

In the next section we will explain the way blockchain operates, but in order to better understand it, we will before analyse the functioning of Bitcoin, being this the first application based on it.

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[46] Marr B and Davies S (2018), *A very brief history of blockchain technology-Technology Reporter* – Forbes.

[47] Ansa.it

2.1.1 The Bitcoin revolution

With money we needed somebody who could stand as the central issuer, somebody who was the trusted third party and could guarantee that the money was real. For hundreds of years, we have had governments issuing money. But money is just an accounting system. That is what Bitcoin is. Bitcoin is just an accounting system. It is a way of recording transaction and value, and it does it digitally, so people can send value directly and everything is recorded in an open ledger. Think back to those Byzantine generals. If their orders were recorded on the blockchain, each general would have a copy of every other general's battle plans, always updated and 100% verified.

By monitoring and updating that ledger, in a collective, consensus-based system, you do away with the need for somebody in the middle to be that sort of repository of all the information, and that is what gets away from the fees, the inefficiencies, and ultimately the potential for corruption and risk that come with centralizing information in that way[48].

So, what the blockchain does is to take that trusted third party function and to automate it. In practice puts all information about each single Bitcoin into an online open ledger, which is there for anybody to see, so that every Bitcoin is accounted for and people know that are not getting a counterfeit one.

Before if you wanted to send something of value across the internet, you had to get somebody else involved, like a credit card company, PayPal, or maybe a bank involved into the transaction. The promise of Bitcoin is that you are directly sending this currency to another person and then the Bitcoin network performs the function that normally PayPal or a bank or your credit card company would perform. Bitcoin really puts the control back in the hands of everybody, in fact everybody who is participating in the Bitcoin system is controlling how it works. It does this through a system of consensus building where multiple computers all participate in the management of the blockchain ledger, a kind of digital document that keeps track of all the payments. This way, you can have the money supply controlled by computers. That is all bitcoin is.

[48] Khan I. (2017), *Technology Futurist.*

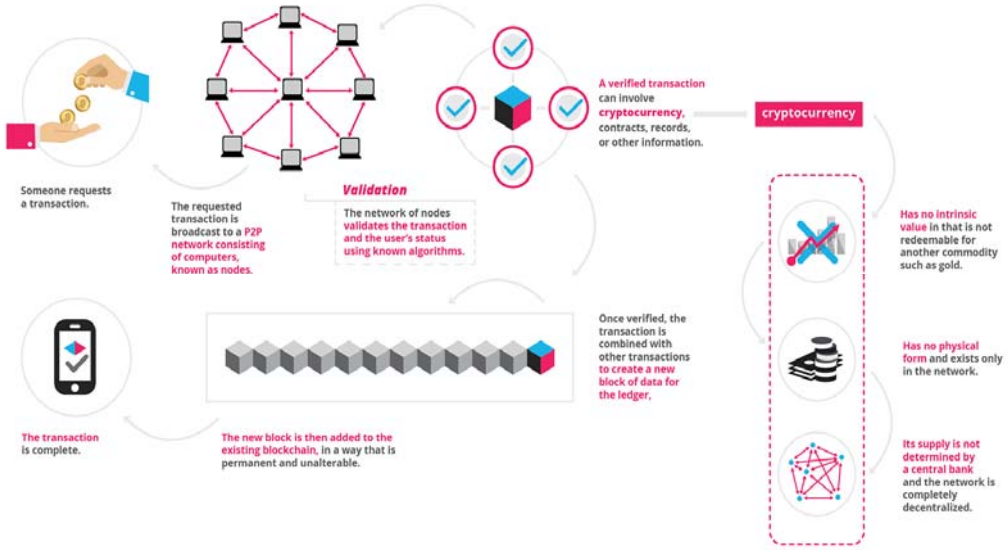

Image 2.2: Bitcoin functioning

The key point here is that this is a distributed ledger. There is not central server. All the other ledger that we have, like the banking and company ones, they all sit and reside inside that company, which means they have one point of attack and can be easily hacked. JP Morgan was hacked by cyber thieves not so long ago. We have had many companies hacked, precisely because there is one central repository of information. The Bitcoin ledger resides on thousands of computers, so that you can't hack it. Every single transaction is recorded, and it is recorded in the blockchain. This simple feature means that it will be permanent. Information in the ledger cannot be altered or changed, so that you can read it and trust it. On the other hand, inside the ledger the identities of people are encrypted. More precisely the wallets are encrypted, so you don't know who is spending the money. Instead, you can know the history of every single Bitcoin out there, you can know where it has been and the different addresses it has gone between. Maintaining this distributed ledger takes a lot of work, but it is no one's job to do it. Instead, the system pays out cryptocurrency to those who volunteer to do it[49].

Thus, the most important actor in the Bitcoin infrastructure are the miners. These are the computers that are tasked with maintaining the ledger of the blockchain to verify the information, to update it and make sure that it is trustworthy. They are incentivized

[49] Mougayar W. (2016), *The business blockchain: promise, practice and application of the next internet technology.*

by being rewarded with bitcoins. In practice, as they are going through the process of confirming transactions, they are simultaneously being subject to a very difficult computing test. The Bitcoin core protocol is forcing them to look for a number. All these miners are ultimately competing to be the one that receives that payout every ten minutes, so that the first one to solve the problem and validate the transaction is rewarded with bitcoins[50].

In practice, Blockchain operates on the Proof-of-Work (PoW) concept, where an expensive computer calculation, or "mining", is done in order to create a block (a new set of trustless transactions). Currently, when you initiate a transaction, it is bundled into a block. Then miners verify the transactions are legitimate within that block by solving a proof-of-work problem, a very difficult mathematical problem that takes an extraordinary amount of computing power to solve. The first miner to solve the problem gets a reward and then the verified transaction is stored on the blockchain[51].

So, what is the most important task is the validation and verification of transactions and the maintaining of the ledger. Bitcoin protocol has been the first to achieve this holy grail of decentralized value exchange that transfers that process of trust to a collective agreement, around a body of independent computers who are compelled, by an incentive system, to maintain that consensus and affirm the information to be correct. For the first time you have a distributed network to come to consensus about what transactions happened on the network. This allows for a trusted ledger, a ledger where there is not a single central party maintaining it, but rather, a network of people maintaining it. That is an incredible powerful concept. Satoshi did not just solve the problem of cash on the internet, he had a solution for the problem of trust on the internet, too[52].

Understanding this, means to understand that the most important thing behind Bitcoin is not the currency. The key factor is the blockchain. It facilitates an entirely different

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[50] Mougayar W. (2016), *The business blockchain: promise, practice and application of the next internet technology.*

[51] Narayanan A. (2016), *Bitcoin and cryptocurrency technologies.*

[52] Crosby M., Sutardja Center for Entrepreneurship & Technology (2015*), Blockchain technology. Beyond Bitcoin.*

perspective, which is that no one is a trusted user. It facilitates a new type of interaction that we have never before seen possible. Bitcoin was just blockchain's first trial run. For this reason, the technical deep features of the Bitcoin functioning will not be the core of this chapter. Instead we will better focalize on the way a blockchain operates.

As already said, Bitcoin has been just the first of the several possible applications using blockchain technology. Before to see them, and in particular at its application on supply chains and containers shipping industry, let's see deeply at the functioning of this ground-breaking technology, outside the Bitcoin context.

2.2 The first blockchain

Satoshi's innovation, that powers Bitcoin and all cryptocurrencies that came after it, is called blockchain. Nevertheless, people think the term blockchain signifies something definite concrete and precise. The fact is that the term blockchain has two meanings. The first one has a strict precise and definite meaning and refers to the blockchain used by Santoshi Nakamoto when he created the Bitcoin protocol (section 2.1.1). Obviously, this is a very specific meaning, it concerns a system of game theory first and foremost rather than technology. In this sense it is disruptive and innovative because enables Bitcoin to exist without a central counterpart and its protocol can change everything from finance and trade to the whole society itself. Then, there is the other meaning of blockchain that is widely used in start-ups and innovation centers. That is a blockchain like anything with a degree of replication and distribution of data on multiple computers, or, something where there is a two-key cryptographic digital signature, for example with certified email and on secure internet connections. In this meanings, blockchain technology can be used for various purposes, but it no longer has a precise, specific significance. In addition, blockchains are also constantly evolving. One of the most recent developments is the creation of smart contracts. As we will see later, these contracts are simple programs that are stored on the blockchain and can be used to automatically exchange coins based on certain conditions. The creation of blockchain technology peaked a lot of people's interest. Soon others realized that the technology could be used for other things like storing medical records, creating a digital notary or even collecting taxes. However, all this different application cases, were made possible thanks to the first real blockchain: the Bitcoin blockchain.

In the Bitcoin case, the blockchain easily operates the transaction of a monetary asset from user A to user B, so that the transaction forms a block of the chain (from here the term blockchain). In practice, again, the chain is just a digital ledger that records all the transaction into the network, while the blocks are the single transactions recorded. Despite what many people thought, the blockchain can record each type of transactions, not only monetary exchange, but also document and, in general, information transactions. Thanks to it, there is no more the necessity for trusted third parties

involved in the transaction. The fundamental promise of blockchain is decentralization. In a normal centralized system, the more people have access to the system, and the more the system could be counterfeit. In fact, the internet was built upon a paradigm, that everyone was a trusted user. Essentially, a government official or a researcher at a university. And this technology was built with that fundamental assumption baked into from the early days of the internet[53].

Now, inside the blockchain, referring to the one that powers Bitcoin, every component of it ensures the reliability of the single transaction. Understanding this means to understand that this technology can be applicated to many different sectors, providing efficiency and better performances to the whole internet applications and more. Before to see where it can be applicated, we will try to explain its general characteristics and technical features.

2.2.1 How the blockchain works

Blockchain technologies are very complex because use cryptographed keys and codes. In this way, it guarantees a high grade of security even being online and public. First of all, as already said, a blockchain is just a public ledger.

Like the name indicates, a blockchain is a chain of blocks that contains information. This technique was originally described in 1991 by a group of researchers and was originally intended to timestamp digital documents so that it is not possible to backdate them or to temper with them. Almost like a notary. However, it was mostly unused until it was adapted by Satoshi Nakamoto in 2008 to create the digital cryptocurrency Bitcoin. Now a blockchain is a distributed ledger that is completely open to anyone. They have an interesting property: once some data has been recorded inside a blockchain, it becomes almost impossible to change it. This because each block contains three main components: the main data, the hash of the block and the hash of the previous block. The data that is stored inside the block depends on the type of blockchain. In the Bitcoin case for example, the blockchain stores the details about

[53] Narayanan A. (2016), *Bitcoin and cryptocurrency technologies.*

transaction in here, such as the sender, receiver and amount of coins. This data are crypted thanks to a classic mechanism of two-key cryptographic digital signature, but of course this is not enough.

A block also has a hash. It is comparable to a fingerprint. It identifies a block and all of its contents and it's always unique, just as a fingerprint. Once a block is created, its hash is being calculated. In practice this mechanism turns each input in a standardized hash.

INPUT	HASH
Hi	639EFCD08ABB273B1619E82E78C29A7DF02C1051B1820E99FC395DCAA3326B8
Welcome	53A53FC9E2A03F9B6E66D84BA701574CD9CF5F01FB498C41731881BCDC68A7C8

Image 2.3: Example of hash

In this way, thanks to the hashing process, changing something inside the block will cause also the hash to change. So, in other words, hashes are very useful when you want to detect changes to blocks. If the fingerprint of a block changes, it no longer is the same block. The third element inside each block is the hash of the previous block. This effectively creates a chain of blocks and it is this technique that makes a blockchain so secure[54].

Let's take an example. Suppose that we have a chain of three blocks. Each block has a hash and the hash of the previous block. So, block number three points to block number two and number two to number one; while the first block is a bit special, it cannot point to previous blocks because it is the first one. It is called the genesis block. Now if someone tries to tamper with the second block, this will cause the hash of the block to change as well. In turn, that will make block number three and all following blocks invalid because they no longer store a valid hash of the previous block. So, changing a single block will make all following blocks invalid.

But also using hashes is not enough to prevent hacking. Computers these days are very fast and can calculate hundreds of thousands of hashes per second. You could

[54] Crosby M., Sutardja Center for Entrepreneurship & Technology (2015*), Blockchain technology. Beyond Bitcoin.*

effectively hack with a block and recalculate all the hashes of other blocks to make the blockchain valid again. To mitigate this, blockchain operates on what is called proof-of-work. It is a mechanism that slows down the creation of new blocks. In Bitcoin case it takes about ten minutes to calculate the required proof-of-work and add a new block to the chain. We will better explain this mechanism later on. However, this mechanism makes it very hard to tamper with the blocks, because if anyone hacks one block, then will need to recalculate the proof-of-work for all the following blocks. In this way, the security of a blockchain comes from its creative use of hashing and the proof-of-work mechanism.[55]

But it does not end here. There is one more way that blockchains secure themselves and that is by being distributed. As already said in this chapter, instead of using a central entity to manage the chain, blockchain use a peer-to-peer (P2P) network where anyone is allowed to join. In practice, when someone joins this network, he gets the full copy of the blockchain. The node, or miner as we called it before, can use this to verify that everything is still in order. The node technically is a computer connected to the blockchain network using a client that performs the task of validating and relaying transactions. Every node is an administrator of the blockchain, and joins the network voluntarily (in this sense, the network is distributed). Each one has an incentive for participating in the network: the chance of winning cryptocurrencies[56].

[55] Rociola A. (2015), *Cosa c'è davvero dentro Blockchain il motore che fa muovere Bitcoin.*

[56] Mougayar W. (2016), *The business blockchain: promise, practice and application of the next internet technology.*

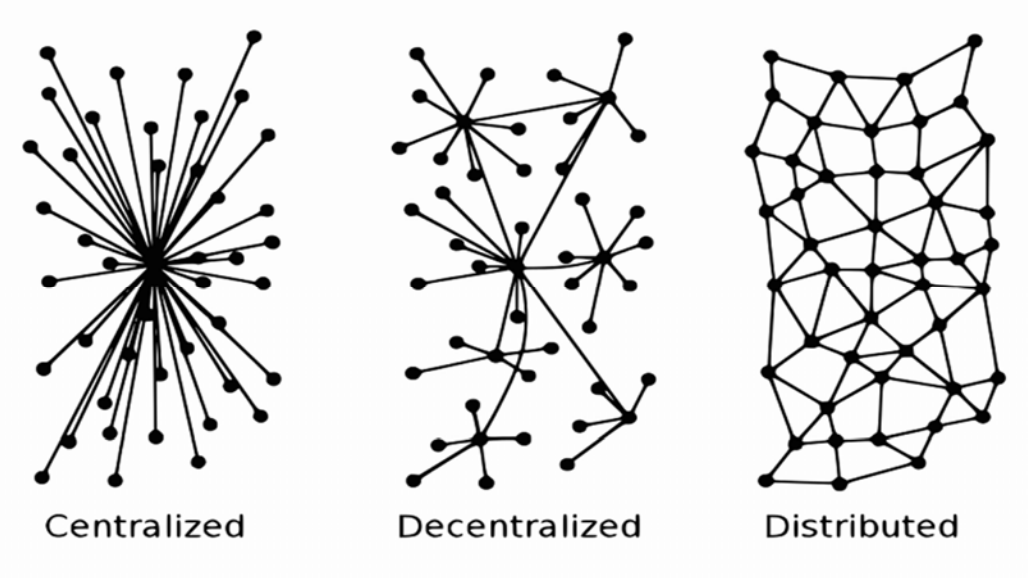

Image 2.4: Types of blockchain's protocols

The trick is to get all miners to agree on the same history of transactions. Every miner in the network is constantly tasked with preparing the next set of transactions for the blockchain. Only one of these blocks will be randomly selected to become the latest block on the chain. Random selection in a distributed network isn't easy, so this is where proof-of-work comes in. In proof-of-work, the next block comes from the first miner that produces a valid one. This is easier said than done, as the Bitcoin protocol makes it very difficult for miners to do so. In fact, the difficulty is regularly adjusted by the protocol to ensure that all miners in the network will only produce one valid block every 10 minutes on average, and all of them have the same chance to do it[57]. Once one of the miners finally manages to produce a valid block, it will inform the rest of the network. Other miners will accept this block once they confirm it adheres to all rules, and then discard whatever block they had been working on themselves. The lucky miner gets rewarded with a fixed amount of coins, along with the transaction fees belonging to the processed transactions in the new block. The cycle then starts again.

The process of producing a valid block is largely based on trial and error, where miners are making numerous attempts every second, trying to find the right value for a block

[57] Mougayar W. (2016), *The business blockchain: promise, practice and application of the next internet technology.*

component called the “nonce”, and hoping the resulting completed block will match the requirements. For this reason, mining is sometimes compared to a lottery where you can pick your own numbers. The number of attempts (hashes) per second is given by your mining equipment’s hash rate. This will typically be expressed in Gigahash per second (1 billion hashes per second)[58]. In this way each nodes is competing with the others in a random process where everyone has the same possibility to record that transaction and be rewarded.

Now let’s see what happens when someone creates a new block. That new block is sent to everyone on the network. Each node then verifies the block to make sure that it hasn’t been hacked. If everything checks out, each node adds this block to their own blockchain. All the nodes in this network create consensus. They agree about what blocks are valid and which are not. Blocks that have been modified will be rejected by other nodes in the network. So, to successfully tamper with blockchain you will need to hack all blocks on the chain, redo the proof-of-work for each block and take control of more than 50% of the peer-to-peer network[59]. Only then your tampered block become accepted by everyone else. This is almost impossible to do!

Thus, summarizing the blockchain mechanism, we have the following steps for the creation of each block:

1. When a transaction is made, its data are received by each node in the blockchain’s network;
2. Each node, represented by one or more miners (mining pools), verify the transaction recording it in a block with the hash of the previous transaction;
3. The miner has to find the proof of work for this new block;
4. Once the proof of work has been found, the miner sends it, together with the new block, to all the other nodes;
5. The other nodes will accept the new block and its proof of work only if it stores a valid transaction that has not yet been recorded in previous blocks;

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[58] Narayanan A. (2016), *Bitcoin and cryptocurrency technologies.*

[59] Crosby M., Sutardja Center for Entrepreneurship & Technology (2015*), Blockchain technology. Beyond Bitcoin.*

6. The block become effectively valid when the proof of work of the next block, containing the hash of the previous transaction, is calculated and verified by all the nodes.
7. Once the block is completely valid, the first miner finding the proof of work, which is the one recording the transaction and creating the new block, receive its fee in Bitcoin.

The groundbreaking innovation of this technology is that by storing data across its network, the blockchain eliminates the risks that come with data being held centrally. Its network lacks centralized points of vulnerability that computer hackers can exploit. The advantages of this system are several. Even if, haw we will see later, this is not the only typology of blockchain, the features of it can be classified as immutability, integrity of the process, transparency, duration, longevity, reliability and availability, exchanges disintermediation, full control of the users.

- Immutability: data inside each block can not be tampered, so they are immutable and have the highest grade of reliability.
- Integrity of the process: thanks to its own nature, the protocol works thanks to its coding, so that it is programmed to operate in the same way every time it receives a given input. In this way there is not the necessity to trust a third party.
- Transparency: the blockchain, being a public and distributed ledger, is completely transparent and everybody can see the information inside the blocks without any permission.
- Duration: the Bitcoin protocol stands on up to five thousand nodes in the world, so that it lacks of vulnerable points and is much more resilient.
- Longevity: devices and applications programmed on a blockchain, have the guarantee that the network is not dependent by any organization and so, that will last for long times.
- Reliability and availability: being distributed on so many nodes, the blockchain has an high level of reliability, because attacking one or more nodes, will not have consequences on the whole network; in addition, being accessible and transparent, it is also available to everybody.

- Exchanges disintermediation: thanks to this trustless system, there is not the necessity of trusted third parties. This is probably one of the main advantage of the blockchain, solving a big issue of the internet.
- Full control of the users: users have the full control on their data and assets on the blockchain, so that they have the guarantee that can not lose it or be tampered[60].

Of course this system has also some cons, due to its inefficiencies. In fact, being this a very young and complex technology, many problems have still to be solved.

2.2.2 Blockchain's inefficiencies

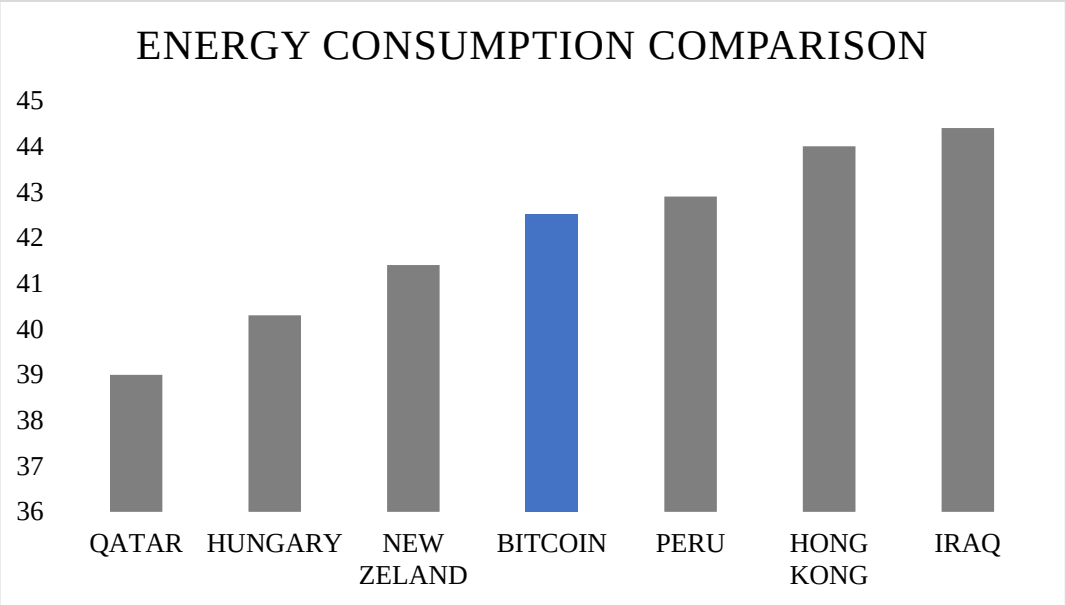
Currently the system just explained is not a so efficient method for information exchanges. It does not envisage a central authority, and this has some advantages, for example the fact that it cannot be censored and therefor prohibited, regulated and, in some cases, spied. But the advantages do not include speed, technical efficiency, or cost savings. Instead, the Bitcoin's blockchain is extremely slow, expensive and inefficient. In practice, it may seem cheaper and faster. For payments to China or India in example, you need to wait weeks for the amount to be credited and will pay a very high percentage in fees, so that a blockchain technology for this kind of economic transactions results more convenient. But that is not for technical reasons. The technologies of this intermediaries are actually very efficient fast and inexpensive. It is the social and economic players and the regulators involved in the transaction that make these operations so expansive and slow. Transactions based on Blockchain are slow inefficient and expensive.

The continuous block mining cycle incentivizes people all over the world to mine Bitcoin. As mining can provide a solid stream of revenue, people are very willing to run machines to get a piece of it[61]. Over the years this has caused the total energy consumption of the Bitcoin network to grow to epic proportions, as the price of the

[60] Crosby M., Sutardja Center for Entrepreneurship & Technology (2015*), Blockchain technology. Beyond Bitcoin.*

[61] Narayanan A. (2016), *Bitcoin and cryptocurrency technologies.*

currency reached new highs. The entire Bitcoin network now consumes more energy than many countries. Based on a report published by the International Energy Agency, if Bitcoin was a country, it would rank as shown in the below graph[62].



Graph 2.2: Data in TWh per year (Bitcoin energy consumption index, 2017)

For this reason blockchain is very expensive, in addition right now it is quite slow. Visa's payment network can process 24.000 transactions per second, Bitcoin just seven. Blockchains is not an effective tool to save, protect and store large amount of information because it is very expansive. For the blockchain to work properly, as a decentralized system, there is very little space for information and the cost of that space is very high[63]. The Bitcoin network, as already said, manages to support on the blockchain network about ten transactions per second, which is a very low rate. On networks without blockchains you can manage thousands, millions of transactions per second. So blockchain networks hold very little data and are extremely inefficient and expensive, a problem referred to as the Bitcoin scalability issue. This is largely due to the peer-to-peer and proof-of-work mechanisms. They make sense if the blockchain is applicated strictly to the Bitcoin protocol, but in many other cases, alternative systems

[62] Bitcoin energy consumption index (2017)

[63] Unicredit (2016), *Blockchain technology and applications from a financial perspective.*

could be applicated. In the next section we will explore different types of blockchain technologies, trying to understand the technical differences among them and which problems these differences try to solve.

2.3 Other types of blockchains

The blockchain just seen is the one that powers Bitcoin and, as said, works like a public and distributed ledger, where economic transactions are recorded on blocks from the nodes. This makes it transparent and incorruptible, but also slow and expensive. Effectively, the value of a blockchain is derived by its utility, which is firstly given by four fundamental characteristics: anonymity, transparency, efficiency and immutability. These four features can be seen as the four pillars of a blockchain[64].

- Transparency. Data are recorded in the distributed ledger, a network which is, by definition, public.
- Immutability. It can not be corrupted because, altering any unit of information, would mean using a huge amount of computing power to override the entire network.
- Efficiency. In order to validate and audit data, a huge amount of computing power, and thus of energy, is required.
- Anonymity. The Bitcoin protocol does not require personal information and is completely anonymous; this doesn't mean that it hides information, instead it shares its data with everybody who asks for.

The first type of blockchain, the one that powers Bitcoin, is called "permissioneless", where everybody is allowed to validate the transactions and create blocks, without a particular permission required. On the other hand, companies and organizations have developed other types of blockchain, where the access to the validation process is not public and opened to everybody, so that we can have "permissioned" blockchains where there is a limited number of miners, for which entrance into the network is requested the agreement of the majority of nodes, or, of a single central authority (creating in this last case a classic centralized ledger). Each type of blockchain places a different weight on the four pillars, in a trade-off between efficiency immutability and transparency (the anonymity feature does not lead to particular restrictions, it only

[64] Di Nicola M. (2015), *Bitcoin: una descrizione architetturale.*

challenges regulatory issues). Of course, with less miners and restrictions to their entrance in the validation process, the immutability results to be reduced too, but it will be more efficient. Also the transparency of information can be reduced or abolished with a private blockchain. In the Bitcoin protocol, with a blockchain explorer, everyone can see inside each block even not being part of the network, being it a public blockchain. With a private or consortium blockchain, only the permissioned nodes can see the information inside the blocks. Thus, we can have three types of blockchains:

- Public permissionless blockchain, like the one that powers Bitcoin;
- Consortium / federated permissioned blockchain, where just members of the consortium can run nodes, mining, make transactions and audit blocks (i.e. Energy Web Foundation and R3);
- Private permissioned blockchain, which can be in the form of a completely private blockchain, where all the nodes are controlled by one single entity, or, there is just one central node. This kind of blockchain is largely used by banks and examples of this system are dated before the Bitcoin introduction; for these and other technical reasons, it is controversial if a private permissioned blockchain can be defined a real blockchain or if it is just a normal ledger[65].

	PUBLIC	CONSORTIUM	PRIVATE
SEND	Anyone	Limited	Centralized
APPROVE	Anyone	Few members	Centralized
READ	Anyone	Limited	Limited

Table 2.1: Differences in blockchains

An important difference in terms of efficiency between permissionless and permissioned blockchains concerns the consensus protocol. The Bitcoin's blockchain uses the proof-of-work protocol, an expansive algorithm made to reach the consensus

[65] Di Nicola M. (2015), *Bitcoin: una descrizione architetturale.*

in an open and distributed network[66]. This kind of system, in fact, assumes that there aren't trusted parties in the network, so the process of validation uses competition in order to reach consensus: the miners verifying the transactions are legitimate by solving a very difficult mathematical problem that takes an extraordinary amount of computing power. We have said that the proof-of-work mechanism is the main reason behind the high energy consumption and slow speed of the blockchain. Nevertheless, proof-of-work was only the first consensus algorithm, but it isn't the only one. In particular, with permissioned blockchains, there is not this necessity for a so complicated and competitive way for the election of the node that will crate a new block, because all the nodes are selected and approved, so they are trusted (trusted peer). In this way, permissioned blockchains can use more efficient systems to reach consensus and validate the blocks, but, again, because the consensus is achieved on the whims of the central in charge who can give mining right to everyone or not give at all, it is still debatable if a private chain can be called a blockchain because fundamentally defeats the whole purpose of the Bitcoin protocol[67].

Nevertheless, more energy efficient algorithms have been in development over recent years. The most important case is probably a particular protocol that combines the efficiency of a permissioned blockchain with the advantages of a public one: the proof-of-stake algorithm. With this system coin owners create blocks rather than miners, thus not requiring power hungry machines that produce as many hashes per second as possible[68]. Because of this, the energy consumption of proof-of-stake is negligible compared to proof-of-work. This kind of consensus algorithm would significantly improve sustainability. It is exploited in Ethereum, a public blockchain that reduces inefficiencies and tries to apply this technology outside the cryptocurrencies context. Because of its importance, we will analyse Ethereum in the next section.

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[66] Crosby M., Sutardja Center for Entrepreneurship & Technology (2015*), Blockchain technology. Beyond Bitcoin.*

[67] Rociola A. (2015), *Cosa c'è davvero dentro Blockchain il motore che fa muovere Bitcoin.*

[68] *https://proofofexistence.com/about*

The blockchains that operate with private or consortium permissioned protocols are completely separate and distinct by the Bitcoin's blockchain. These are called alternative blockchains and have been developed in order to find a solution to the inefficiencies of the Bitcoin protocol. By the way, there are also other kinds of blockchain, which operates on and with the Bitcoin blockchain. Each one does something a little different and each one solves different problems to some degree. Thus, a blockchain can be differentiated not only by the grade of decentralization and publicity as just showed, but also on its relationship with the Bitcoin protocol. In this way we can distinguish among three different kinds of blockchains:

- Colored coins is a system that stands on the Bitcoin's blockchain in order to exploit its advantages for other application than virtual currencies. Colored coins is a very particular approach. It uses the Bitcoin blockchain in order to record a transaction, where this transaction is not necessarily a bitcoin exchange. In practice it is a protocol that marks one bitcoin (coloured coin) and assign to it a specific asset that could be a stock or also another currency. In this way there are the Bitcoin protocol advantages applicated to other types of assets and outside the Bitcoin exclusive context.
- Sidechains are a combination of Bitcoin and other chains to reduce inefficiencies. A Sidechain is a blockchain connected to the Bitcoin network, upgrading it and adding other cryptocurrencies to its protocol. In particular this kind of blockchain exploits the Bitcoin's one as an additional security guarantee, but lightening and reducing its disadvantages (slow speed and high costs in particular). Examples of this kind of application are Segregated Witness and Lightning Network.

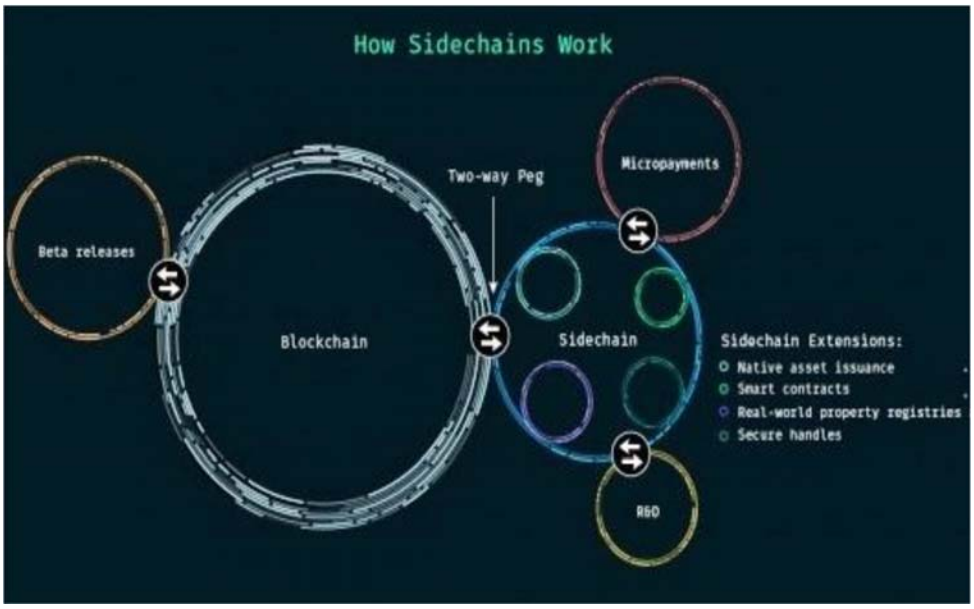

Image 1.5: Sidechain example

- Alternative blockchains, completely independent from the Bitcoin's blockchain. An alternative blockchain tries to exploit the potential of this technology outside the context of cryptocurrencies. Today there are many different cases of this application, which can be public, private or federated, and can use different protocols. For example, Ethereum is used in the development of smart contracts and Ripple for private blockchains[69].

As just seen, the Bitcoin blockchain has been just the first. Today there are many different kind of this technology, each one with different features and issues. Examples of these different types of blockchains are several. Nasdaq is working in partnership with Chain on the development of a permissioned blockchain for the management and regulation of stock transactions. Lightning Network is trying to keep Bitcoin more accessible and efficient. However, when companies use permissioned or private blockchains, the downside is that data inside the blocks will be no more so incorruptible and transparent as in a permissionless blockchain. For this reason Ethereum is gaining so much popularity: exploiting the proof-of-steak mechanism it allows a private blockchain to be as efficient as a private one, but without losing transparency and

[69] Di Nicola M. (2015), *Bitcoin: una descrizione architetturale.*

immutability. In the next section we will better analyse the Ethereum case, a network on which many different applications can be built. Thus, the work on these algorithms and on the different kinds of application offers good hope for the future and sustainability of the technology in general.

2.3.1 Ethereum

Ethereum is a second generation blockchain platform that was developed around 2013 by Vitalik Buterin, a Canadian Russian who was trying to create a platform with the characteristics of Bitcoin, but with additional functionality for building more complex applications. Buterin, the co-founder of Ethereum, was the founder of the Bitcoin magazine and also an initial contributor to the Bitcoin codebase. Around 2013 he was frustrated because of its programming limitations and pushed for a more flexible blockchain. He set out to build the second public blockchain called Ethereum. The largest difference between the two is that Ethereum can record other assets such as loans or contracts, not just currency. Ethereum, launched in 2015, can be used to build “smart contracts”, those that can automatically process based on a set of criteria established in the Ethereum blockchain. Its applications could be anything, from decentralized insurance to new financial instruments, each transaction where actors do not need to trust the issuer regarding the value of the asset exchanged. A particular application case of Ethereum is crowdfunding, usually made through ICOs (initial coin offering), which are developed on Ethereum because of the flexibility that it offers[70].

So Ethereum is a platform and a coding language for the building and implementation of distributed applications, allowing a public decentralization. It is an alternative blockchain and is distinguished for the opportunity to implement on it the so called “smart contracts”, which work on the blockchain without the necessity of servers for the hosting. In this way Ethereum is not merely a blockchain, instead it is a platform that allows to implement these “smart contracts”. They are autonomous contracts that live on the blockchain and allow users to create new kind of applications, without the

[70] Wood G. (2015), *Ethereum: a secure decentralized generalized transaction ledger.*

necessity of intermediaries and with the advantages of the blockchain, but with a flexibility that allows an average developer to interact with the complexity of this technology and to research new use cases. In this way it allows for greater cost and time efficiencies in the creation of new application exploiting blockchain technologies. For this reason this technology has attracted the attention of corporations such as Microsoft, BBVA and UBS who are intrigued by the potential of the smart contract functionality to save time and money.

The largest difference between the two main public blockchains, Bitcoin and Ethereum, is that the first one, currently, operates on the proof of work concept. Ethereum developers are interested in changing to a new consensus system called proof of stake. As already explained, this has the same goal as proof of work (to validate transactions and achieve consensus in the chain) and it uses an algorithm but with a different process. With proof of stake, the creator of a new block is chosen in a deterministic way, depending on its wealth, also defined as a stake (in the PoW protocol the creator of a new block is chosen randomly, with the competition of all the nodes). In a proof of stake system, there is no block reward, but the miners, known as forgers, get the transaction fees. Proponents of this shift, including Ethereum co-founder Buterin, like proof of stake for the energy and cost savings realized to get to a distributed form of consensus[71]. In fact, since in the Bitcoin blockchain every computer in the network processes every transaction, it can be very slow. So the proof of stake can be seen as a blockchain scaling solution, that would determine how many computers are necessary to validate every transaction in a way that doesn't compromise security.

Smart contracts are just a piece of code for our computer and on the blockchain, it merely carries out what it is coded to do. In particular, a smart contract in Ethereum can carry out very simple instructions, for example it releases a service after the receipt of a payment. Also, a smart contract, being just a piece of code, carries out its functions in the same way every time on the blockchain, in a deterministic way. This allows to achieve the same result each time with the same inputs. So, it is clear that a smart contract is easily an autonomous program, executed on the Ethereum blockchain,

[71] Wood G. (2015), *Ethereum: a secure decentralized generalized transaction ledger.*

which for a given input gets always the same result. In example, when a payment is received, a certain service is provided, or if someone makes a certain type of order, then the program releases a certain type of service, and it may be no longer available for others. This system in general can lead us to have a complete independence, autonomy, or automation of some procedures that today require manual inputs or trusted third parties. Examples of possible application of this technology are several, from financial transactions to voting systems[72].

In particular, one application that could be easily built with smart contracts is a decentralized exchange. Usually exchanges are one of the biggest points of centralization, which is creating problems of trust for trading, funds and institutions. Also in the Bitcoin case, just thinking about the Mt. Gox case, which was one of the centralized Bitcoin exchange, we suddenly understand that with a centralized issuer, or institution in general, there is also a central point of attack and vulnerability. These centralized exchanges hold our funds and are trusted, which means that as soon as these institutions, for one reason or another, disappear, also our funds will disappear, and we will lose all of them. So, it is for this that decentralized exchange are so important and have an essential role. These are essentially applications built like smart contracts, on Ethereum, which allow users to have full control over their own funds but at the same time to exchange their assets with other users on the same network[73].

So, to summarize, Ethereum has many features that distinguish it from Bitcoin:

- It is a platform for the implementation of software for the creation of decentralized applications, which are supported by its blockchain;
- Its blockchain is more efficient and faster that the Bitcoin's one, in fact it spends between five and thirty seconds for the recording of a transaction, Bitcoin asks for ten minutes;
- It can support a large network of decentralized applications, not only cryptocurrencies;

[72] Mougayar W. (2015), *The business imperative behind the Ethereum vision.*

[73] Wood G. (2015), *Ethereum: a secure decentralized generalized transaction ledger.*

- Ether, its cryptocurrency, is used for the payment of transaction costs connected with the execution of the applications implemented on the blockchain from the users;
- It reduces the scalability issue of Bitcoin, so that it is more efficient and has much more space for recording data;
- It will use the proof of stake protocol, increasing its efficiency;
- Mining inside the Ethereum network will be more accessible, and easy, because it will not ask for great computing power machines.

One particularly interesting trend of smart contract's application, outside cryptocurrencies context, are non-fungible tokens. Essentially when there is an ICO or a crowdfunding event, it is often made by distributing these tokens, a kind of assets which live on smart contracts, almost always on Ethereum, and which allow the community to access various services on the blockchain. Non-fungible tokens are a similar concept, they are assets on a blockchain, but unlike fungible tokens, which we get with an ICO, non-fungible tokens are each different from the other. This means that each token is unique, so that represent unique pieces on the blockchain. It could be anything that is demonstrably scarce, like an artwork or a sticker. In this way we have only one token of that type, which means that the sale or exchange of this token will have different dynamics. It is not traded on an exchange, but more likely on a platform where we can list our unique token for sale[74]. So, thanks to the guarantee of the blockchain and to the flexibility of the smart contract instrument, we can easily possess a certain shared token. In example, we could have a shared token that represents an art work, or even a container, which is owned by ten different parties, and even sell it or trade it on an exchange in a completely secure way, without needing to disturb the other nine owners.

[74] Mougayar W. (2015), *The business imperative behind the Ethereum vision.*

2.4 Blockchain’s applications

Bitcoin and cryptocurrencies were just the first applications of blockchain, but since people has understood its true potential, new horizons have been explored, finding other ways to exploit this technology. Ethereum was built specifically to realize this possibility. Still, in its early stages, Ethereum has the potential to leverage the usefulness of blockchains on a truly world-changing scale.

At the technology’s current level of development, smart contracts can be programmed to perform simple functions. Nevertheless, its possible applications could be several, and even if we are in the early stages of this technology, already there are many successful application cases in different businesses.

- Exchanges

The most common and logical application for a blockchain is the digital value exchange. In this context we can find it in two main different business: the first one is the exchange of a digital currency, like Bitcoin; then, the second one, concerns the use of blockchains for the exchanges of many other digital assets, like stocks and credits. In fact, over the digital currency exchange, the last one seems to be one of the most interesting application for a blockchain, which should provide many advantages to the exchanges of this and other digital assets, bypassing third parties and drastically improving the performance and efficiency in terms of time and cost. The exchange process requires for the duplication and distribution of data to the parties involved in the transaction, from a trusted third party that protects the actors of the transaction. The blockchain, solving the trustless problem, can take the role of many intermediaries, leading to high cost and time savings. Examples of this blockchain application can be found not only in the exchange of stocks and other financial assets, but in almost each type of digital transactions, like with the art, music, and many other goods exchanged online.

- Smart contracts

We have already explained that a smart contract is essentially a software, operating almost always on Ethereum, which is able to make simple operations when specific

conditions occur (For example the release of a service after a payment). However, a smart contract can work in many ways, in particular, the verification that the necessary conditions for the release of the service have been occurred can be made with different protocols, but all of them (prevision markets, oracles, multi-sign transactions) use the blockchain network in order to verify transactions. In this way a smart contract can be used for many different cases. The E-commerce and finance are perfect examples, but also in gambling or Internet of Things the smart contracts could be revolutionary.

- Cybersecurity

As the Bitcoin's transactions are audited by the blockchain network before to be confirmed, in the same way, a blockchain can audits other kind of data and systems. Its protocol is largely able to detect all kind of data tampering inside the network and in real time. In fact, blockchain technology owns perfectly the CIA model (confidentiality, integrity, availability) for data security[75]. This model verifies data through a comparison with their previous condition recorded on the blockchain and already verified. Guardtime is the leader in applying blockchain technology to cybersecurity and works in partnership with many other companies.

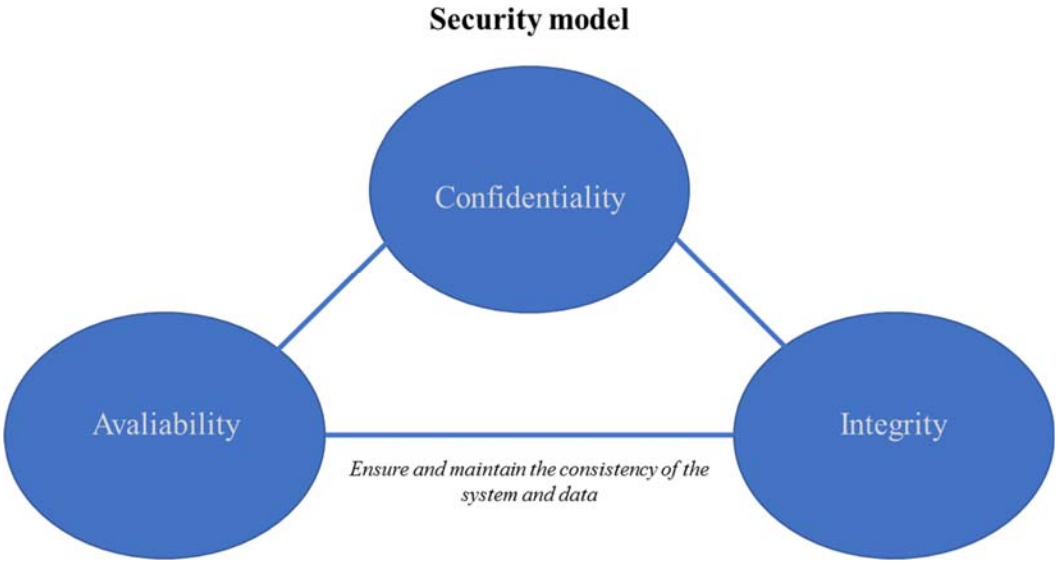

Image 2.6: CIA security model.

[75] Wright A (2015), *Decentralized blockchain technology and the rise of lex cryptographia.*

- Internet of Things (IoT)

Internet of Things refers to network-controlled management of certain types of electronic devices, for instance, the monitoring of air temperature in a storage facility. Smart contracts make the automation of remote systems management possible. A combination of software, sensors, and the network facilitates an exchange of data between objects and mechanisms. The result increases system efficiency and improves cost monitoring. The biggest players in manufacturing, tech and telecommunications, like Samsung, IBM and AT&T, are all betting on IoT dominance. IoT applications will run many businesses, from predictive maintenance of mechanical parts to data analytics, and mass-scale automated systems management[76]. With all these systems connected to the internet, the blockchain protocol could solve many issues connected to security, privacy, interconnection, integrity and also longevity. In fact, with distributed or decentralized systems, the reliability of data could be easily verified, guarantying in the same time anonymity. Examples of this application can already be found in military systems, like the one developed from Guardtime for its partner Lockheed Martin. For what concerns longevity, thanks to blockchains, a smart product could be independent from the life of the company manufacturing the product itself, so that consumers will be sure that its functions are guaranteed in the long run.

- Sharing economy

With the rising of companies like Uber and AirBnB, the sharing economy is already a proven success. Currently, however, users who want to use a sharing service have to rely on an intermediary like Uber. By enabling peer-to-peer payments, the blockchain opens the door to direct interaction between parties, that is, a truly decentralized sharing economy results[77]. In example, OpenBazaar uses the blockchain to create a peer-to-peer eBay. Thanks to it, users can transact with vendors without paying transaction fees, just downloading the app. It operates with a “no rules” ethos which means that personal reputation will be even more important to business interactions.

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[76] *Blockchain technology applications and implications on the shipping industry. https://seanews.co.uk/technology.*

[77] *What is blockchain technology. https://blockgeeks.com/guides.*

- Crowdfunding

Crowdfunding initiatives like Kickstarter and Gofundme are doing the advance work for the emerging peer-to-peer economy. The popularity of these sites suggests people want to have a direct say in product development. Blockchains take this interest to the next level, potentially creating crowd-sourced venture capital funds. Currently there are many examples of this application, almost always connected to some cryptocurrency. One is the crowdfunding made through an ICO (initial coin offering). As already mentioned, it is essentially an IPO, but instead of offering a company stocks, with an ICO the company offers digital coins (cryptocurrency) associated with the value of the company or of the company project to be financed. Already in 2016, the Ethereum-based DAO (Decentralized Autonomous Organization), raised up to $200 million USD in just over two months[78].

- Governance

By making the results fully transparent and publicly accessible, distributed database technology could bring full transparency to elections or any other kind of poll taking. Ethereum-based smart contracts help to automate the process[79]. The app, Boardroom, enables organizational decision-making to happen on the blockchain. In practice, this means company governance becomes fully transparent and verifiable when managing digital assets, equity or information. Also, Earth and Follow my vote are two start-ups aiming to disrupt democracy, creating online blockchain based voting systems for governments

- File storage

Decentralizing file storage on the internet brings clear benefits. Distributing data throughout the network protects files from getting hacked or lost. Inter Planetary File System (IPFS) is an example of this application case. It makes it easy to conceptualize how a distributed web might operate. Similar to the way a bit-torrent moves data around the internet, IPFS gets rid of the need for centralized client-server relationships (i.e.,

[78] Institute of International Finance (2015), *Banking on the blockchain. Reeingineering the Financial Architecture.*

[79] *What is blockchain technology. https://blockgeeks.com/guides.*

the current web). An internet made up of completely decentralized websites has the potential to speed up file transfer and streaming times. Such an improvement is not only convenient. It could be the next upgrade to the web's currently overloaded content-delivery systems[80].

- Prediction markets

The crowdsourcing of predictions on event probability is proven to have a high degree of accuracy. Averaging opinions cancels out the unexamined biases that distort judgment. Prediction markets that pay-out according to event outcomes are already active. The prediction market application Augur makes share offerings on the outcome of real-world events. Participants can earn money by buying into the correct prediction. The more shares purchased in the correct outcome, the higher the payout will be. With a small commitment of funds (less than a dollar), anyone can ask a question, create a market based on a predicted outcome, and collect half of all transaction fees the market generates[81].

- Protection of intellectual property

As is well known, digital information can be infinitely reproduced and distributed widely thanks to the internet. This has given web users globally a goldmine of free content. However, copyright holders have not been so lucky, losing control over their intellectual property and suffering financially as a consequence. Smart contracts can protect copyright and automate the sale of creative works online, eliminating the risk of file copying and redistribution. Mycelia uses the blockchain to create a peer-to-peer music distribution system. Founded by the UK singer-songwriter Imogen Heap, Mycelia enables musicians to sell songs directly to audiences, as well as license samples to producers, giving royalties to songwriters and musicians; all of these functions being automated by smart contracts. The capacity of blockchains to issue

[80] *What is blockchain technology. https://blockgeeks.com/guides.*

[81] Karp N. (2015), *Blockchain technology: the ultimate disruption in the financial system.*

payments in fractional cryptocurrency amounts (micropayments) suggests this use case for the blockchain has a strong chance of success[82].

- Neighbourhood microgrids

Blockchain technology enables the buying and selling of the renewable energy generated by neighbourhood microgrids. When solar panels make excess energy, Ethereum-based smart contracts automatically redistribute it. Similar types of smart contract automation will have many other applications as the IoT becomes a reality. Located in Brooklyn, Consensys is one of the foremost companies globally that is developing a range of applications for Ethereum. One project they are partnering on is Transactive Grid, working with the distributed energy outfit, LO3. A prototype project currently up and running uses Ethereum smart contracts to automate the monitoring and redistribution of microgrid energy. This so-called "intelligent grid" is an early example of IoT functionality[83].

- Identity management

Haw already seen, there is a definite need for better identity management on the web. The ability to verify your identity and financial status is the core of transactions that happen online. Distributed ledgers offer enhanced methods for proving who you are, along with the possibility to digitize personal documents. Having a secure identity will also be important for online interactions, for instance, in the sharing economy. A good reputation, after all, is the most important condition for conducting transactions online. Developing digital identity standards is proving to be a highly complex process. Technical challenges aside, a universal online identity solution requires cooperation between private entities and government. Add to that the need to navigate legal systems in different countries and the problem becomes exponentially difficult. E-Commerce on the internet currently relies on the SSL certificate (the little green lock) for secure

[82] *What is blockchain technology. https://blockgeeks.com/guides.*

[83] *What is blockchain technology. https://blockgeeks.com/guides.*

transactions on the web. Netki is a startup that aspires to create an SSL standard for the blockchain.[84]

- Anti-money laundering and Know you customer

Anti-money laundering (AML) and know your customer (KYC) practices have a strong potential for being adapted to the blockchain. Currently, financial institutions must perform a labour intensive multi-step process for each new customer. KYC costs could be reduced through cross-institution client verification, and at the same time increase monitoring and analysis effectiveness. Start-up Polycoin has an AML/KYC solution that involves analysing transactions. Those transactions identified as being suspicious are forwarded on to compliance officers. Another start-up, Tradle, is developing an application called Trust in Motion (TiM). Described as an "Instagram for KYC", TiM allows customers to take a snapshot of key documents (passport, utility bill, etc.). Once verified by the bank, this data is cryptographically stored on the blockchain[85].

- Data management

Today, in exchange for their personal data people can use social media platforms like Facebook for free. In future, users will have the ability to manage and sell the data their online activity generates. Because it can be easily distributed in small fractional amounts, Bitcoin, or something like it, will most likely be the currency that gets used for this type of transaction. The MIT project Enigma understands that user privacy is the key precondition for creating of a personal data marketplace. Enigma uses cryptographic techniques to allow individual data sets to be split between nodes, and at the same time run bulk computations over the data group as a whole. Fragmenting the data also makes Enigma scalable (unlike those blockchain solutions where data gets replicated on every node)[86].

- Land title registration

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[84] *What is blockchain technology. https://blockgeeks.com/guides.*

[85] Karp N. (2015), *Blockchain technology: the ultimate disruption in the financial system.*

[86] *What is blockchain technology. https://blockgeeks.com/guides.*

As publicly-accessible ledgers, blockchains can make all kinds of record-keeping more efficient. Property titles are a case in point. They tend to be susceptible to fraud, as well as costly and labour intensive to administer[87]. A number of countries are undertaking blockchain-based land registry projects. Honduras was the first government to announce such an initiative in 2015. The Republic of Georgia cemented a deal with the Bitfury Group to develop a blockchain system for property titles. Most recently, Sweden announced it was experimenting with a blockchain application for property titles.

- Stock trading

When executed peer-to-peer, trade confirmations become almost instantaneous (as opposed to taking three days for clearance). Potentially, this means intermediaries, such as the clearing house, auditors and custodians, get removed from the process. Numerous stock and commodities exchanges are prototyping blockchain applications for the services they offer, including the ASX (Australian Securities Exchange), the Deutsche Börse (Frankfurt's stock exchange) and the JPX (Japan Exchange Group)[88]. Probably, the most important is the Nasdaq's Linq, a platform for private market trading (typically between pre-IPO startups and investors). In partnership with the blockchain tech company Chain, Linq announced the completion of it its first share trade in 2015. More recently, Nasdaq announced the development of a trial blockchain project for proxy voting on the Estonian Stock Market.

- Insurance

The global insurance market is based on trust management. Blockchain is a new way of managing trust and can be used to verify many types of data in insurance contracts, like the insured person identity. Also, so called oracles can be used to integrate real world data with blockchain smart contracts, this technology is very useful for any types of insurance that relies on real world data. Aeternity is a blockchain project that is building tools useful in the insurance industry. Also Accenture is building blockchain

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[87] *What is blockchain technology. https://blockgeeks.com/guides.*

[88] Institute of International Finance (2015), *Banking on the blockchain. Reeingineering the Financial Architecture.*

solutions for its insurance clients with the goal to boost efficiency and productivity within this industry. They translate key insurance industry processes into blockchain-ready procedures that embed trust into the system. Ultimately, when this tools will be fully deployed, will help law enforcement, insured and insurers to verify insurance coverage in real time and accelerate claims processing[89].

- Charity

Common complains in charity include inefficiency and corruption, which prevent money from reaching those who are meant to have it. Using blockchain technologies to track donations can let donators to be sure that money is going to end up in the right hands. Bitcoin base charity like BitGive foundation use blockchain secure and transparent distributed ledger to let donators to see that intended party has received the funds[90].

- Healthcare

Healthcare is an industry that relies on many different legacy systems. One of the challenges hospitals face is the lack of a secure platform to store and share data. They are also often victims of hacking. Blockchain technology can allow hospitals to safely store medical records and share them with authorized doctors or patients. This will improve data security and can even improve accuracy and speed of diagnosis. Gem and Tierion are two start-ups that are working on disrupting the current healthcare database[91]

- Supply chain auditing

Consumers increasingly want to know that the ethical claims companies made about their products are real. Distributed ledgers provide an easy way to certify that the backstories of the things we buy are genuine. Transparency comes with blockchain-based timestamping of a date and location (on ethical diamonds, for instance) that corresponds to a product number. The UK-based Provenance offers supply chain

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[89] Krestel N. (2015), *Will the blockchain model change insurance?* http://www.riskheads.org

[90] *What is blockchain technology. https://blockgeeks.com/guides.*

[91] *What is blockchain technology. https://blockgeeks.com/guides.*

auditing for a range of consumer goods. Making use of the Ethereum blockchain, a Provenance pilot project ensures that fish sold in Sushi restaurants in Japan has been sustainably harvested by its suppliers in Indonesia[92].

- Supply chain and logistics

With blockchain technology transactions can be documented in a permanent decentralized record and monitored securely and transparently. This can greatly reduce time delays and human mistakes it can also be used to monitor costs labour and even waste in emissions at every point in the supply chain. This has serious implications for understanding and controlling the real environmental of products. The blockchain can also be used to verify the authenticity or their trade status of products by tracking them from their origin. Some blockchain start-ups working in this sector are Provenance, Fluent, SKU chain and Blockverify[93].

Exchanges	Blockchain technology provides many advantages to the exchange of digital assets, bypassing third parties and drastically improving the performance and efficiency in terms of time and cost
Smart contracts	Distributed ledgers enable the coding of simple contracts that will execute when specified conditions are met.
Cybersecurity	A blockchain can audits many kind of data and systems. Its protocol is largely able to detect all kind of data tampering inside the network and in real time.
Internet of Things	Smart contracts make the automation of remote systems management possible, facilitating an exchange of data between objects and machines.
Sharing economy	By enabling peer-to-peer payments, the blockchain opens the door to direct interaction between parties, so that a truly decentralized sharing economy results.

[92] *Blockchain technology applications and implications on the shipping industry. https://seanews.co.uk/technology.*

[93] *What is blockchain technology. https://blockgeeks.com/guides.*

Crowdfunding	Blockchains potentially creates crowd sourced venture capital funds.
Governance	By making the results fully transparent and publicly accessible, distributed database could bring full transparency to elections and other kind of poll taking.
File storage	Decentralizing file storage on the internet brings clear benefits: distributing data throughout the network protects files from getting hacked or lost.
Prediction markets	Prediction markets pay out according to event oucomes.
Protection of intellectual property	Smart contracts can protect copyright and automate the sale of creative works online, eliminating the risk of file copying.
Nneighborhood microgrids	Blockchain technology enables the buying and selling of the renewable energy generated by neighborhood microgrids.
Identity management	Distributed ledgers offer secure methods for providing who you are, along with the possibility to digitalize personal documents.
Anti-money laundering and Know your customer	AML and KYC practices have a strong potential for being adapted to the blockchain, having this the possibility to reduce costs and increase monitoring effectiveness.
Data management	With a blockchain users have the possibility to manage and sell the data their online activity generates.
Land-title registration	As a publicly accessible ledger, blockchain can make all kind of record keeping more efficient. Property titles are a case in point.
Stock trading	When executed peer-to-peer, trade confirmations become almost instantaneous. This means intermediaries get removed from this process.

Insurance	Blockchains can be used to verify many types of data in insurance contracts and to integrate real world information.
Charity	Using blockchain technologies to track donations can let donators to be sure that money is going to end up in the right hands.
Healthcare	Blockchain technology can allow hospitals to safely store medical records and share them with authorized doctors or patients.
Supply chain auditing	Distributed ledgers provide easy way to certificate that the backstories of the things we buy are genuine. Transparency comes with blockchain-based timestamping of a date and location that corresponds to a product number.
Supply chain and logistics	With blockchain technology transactions can be documented in a permanent decentralized record and monitored securely and transparently. The blockchain can also be used to verify the authenticity or their trade status of products by tracking them from their origin.

Table 2.2: Blockchain applications.

As just seen, there are many different possible applications for blockchain technologies and several businesses to be disrupted and reinvented. Many companies and start-ups have already developed interesting projects in different business, but still many steps have to be made and difficulties to be faced before to see a global spread of it. Being so innovative and disruptive, blockchain technology is challenging also the regulators, but the attempts of many governments are giving good hope for the future of it. By the way, being still in the early stage of this technology, it is probable that we will wait other five or ten years before to see its impact on the global economy. In the next chapter, we will see how this technology could innovate the container transportation industry and, through it, all the global logistics and supply chain.

Chapter 3: Applications of blockchain technologies to logistics and container's transportation industry

3.1 Problems in the global supply chain

In global trade isn't changed much since the introduction of the shipping container in 1956. Manual paper-base processes are still common and information about the status of goods is locked away in organizational silos. In a world where the 90% of goods in global trade are carried by the shipping industry in containers, the supply chain slowed down by the complexity of point to point communications across land transportation providers, freight forwarders, custom brokers, governments, ports and ocean carriers.

Each leg and phase of the transportation process involves a number of participants who need to exchange data and documents. Often, in order to increase efficiency, these participants have attempted to exchange data and transact among themselves using a centralized database or a centralized ledger. This is a model which has some drawbacks. Namely, putting all the power in the hands of whoever owns that central ledger. While many industries have been moving in the direction of centralized ledgers, blockchain would shift that trend. With it companies could eliminate centralized transaction ledgers using instead a distributed model. This means every participant can have access to data inside it, while it is also extremely resistant to tampers. So it can solve problems of trust and of how companies and organizations share data.

Today, as soon as people think to blockchain, they associate it to banking and financial services, but probably the biggest industry for blockchain and the most immediate real-world use case should be supply chain management. In fact, blockchain technologies can affect the supply chain market in many ways. In a survey where was asked to professionals what aspect of digitalization would drive the most value in the future, most of them (59%) said supply chain visibility. The reason is that, as seen in chapter one, there are so many problems with the global supply chain right now that blockchain could help to fix some.

The global supply chain is sub-optimal first of all because of ocean freights. As said, they account for the 90% of goods traded globally, this means that 90 percent of all the goods traded in the world enter an ocean freight at some point[94]. The problem with ocean freight is shipping information, which usually travels around through numerous companies and contractors. This cause delays, and delays anywhere in the supply chain not just cost time, they cost real money. In practice, all these intermediaries are continually trying to predict what day certain goods will be carried, or inspected, or at what point of the blockchain they are, in general. So, there are a lot of problems when companies try to plan and forecast their activities and assets management in terms of procurement, manufacturing or financial.

Currently there is a lot to keep track of in each company, but the problem in the supply chain is that there is not just one company involved, but many intermediaries interconnected and who need to share information data and documents. Now if all this data are stored in a database on a website, for example, any of the intermediaries could easily modify the data in order to fit in their best interest, which will probably be different and divergent from the interests of the multiple other companies in the supply chain network. Being multiple competing interests, there is not trusted part inside the chain. This a problem that actually slows down the entire supply chain in any business and manufacture in the world and, by solving it, a much greater efficiency could be gained[95].

Another problem is about small companies. Usually manufactures only want to deal with big companies. Again, this is a question of trust. Big companies have some reputation because they have been ripped off many times and have a large history of clientele. In this way, it is difficult for small companies to enter in the market because they don't have that reputation. This is a vicious circle that is squeezing out innovators and innovation from all the logistics business. This is the reason for the sporadic innovation of the industry discussed in section 1.5.

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[94] Mougayar W. (2016), *The business blockchain: promise, practice and application of the next internet technology.*

[95] *Blockchain technology applications and implications on the shipping industry. https://seanews.co.uk/technology.*

Also, there is an opaque procurement process. Current manufacturing lacks accessibility to the procurement process. Many customers said finding the right service provider is a standard issue in the production and transportation processes. Big companies like car manufacturers can gain competitive rates because of their contractual power, also the ones producing goods with an high value to weight ratio are easily able to afford high transportation costs. But all the other small companies, on the other hand, are excluded from the international markets because cannot afford exporting costs.

Another big problem is that the global supply chain is largely based on outdated technology, usually decades old systems. This is a problem that cause of many delays and inefficiencies in the sector and, again, delays in the supply chain are money lost for companies and all the economy. In first chapter we have analyzed some technologies utilized from freight forwarders into container transportation, but the problem that there is a non-uniformly replication of them among companies and organizations, increasing costs and complexity.

Also property protection and tracking is an issue in supply chains: it is important to know who owns what, when something has been created and where. These are data that should be immutable and time stamped, while right now are totally mutable and modifiable. This aspect involves many different markets where to guarantee to customers the reliability of information, companies have to spend many resources.

Finally, as showed in section 1.5, empty container repositioning is a practice that has been massively costly for the shipping industry. In 2016, the Boston Consulting Group claimed that repositioning empty containers cost the shipping industry between $15 and $20 billion per year. With a shared pools of containers on a single public ledger, companies could benefits from a network effect[96].

To summarize, we have the following general problems in the global supply chains, shared from both manufacturers and service providers, that could be solved with the application of a blockchain:

[96] *https://www.blockshipping.io*

- Difficult for small businesses,
- Opaque procurement process,
- Outdated technology,
- Little to no property protection and tracking technologies,
- Empty container repositioning.

The solution to this could be blockchain: this is a huge opportunity for the global supply chains in order to gain efficiency and make sustainable businesses. Within the supply chain industry there are different sub-applications, like digital ownership, proof of origin, trusted maintenance, tracking and everywhere there are issues regarding trust that all these intermediaries have to deal with. However, according to many companies, the revolution inside the global supply chain should start by applying this technology to the container businesses. As said, at some point, all the goods traded enter in an ocean freight. Thus, applying blockchain to the container transportation industry should be the starting point to revolutionize the entire global supply chain. Creating a network for container's management could solve some problems and, by doing it through blockchain, should stimulate many actors to join it, creating the desired network effect of a blockchain protocol.

In the next paragraphs we will firstly see this technology in the general context of supply chain and then we will focalize on the container transportation industry.

3.2 Blockchain applied to supply chain and logistics

Supply chain is a massive use case for blockchain that can really revolutionize the way we ship goods from point to point. It has many sub-applications in supply chain management, being a perfect tool for information exchanges and assets tracking it can solve many issues of the industry previously analyzed. When blockchain is applied to a simplified supply chain, thus, the potential improvements are obvious. In theory, every participants of the supply chain can access one linked encrypted and validated information set, providing everyone involved with elevated efficiencies and guaranteed data integrity. Blockchain for supply chains allows transparency with a shared record of ownership and location of parts and products in real time.

As any new technology there are high expectations right now, but there are also many unanswered questions. Risks and benefits are at the hearts of any new technology. Blockchain is not exception, as it continues to emerge, expeditors will continue to research and engage in strategic pilots, keeping strategical position to take advantage of blockchain as the technology matures.

The result of this process could be great if there will be one big network cooperating on a blockchain, with every customer, service provider and government agency allowed to use it. In this way instead of having many single databases, we could have one shared database source of truth that is immutable and trusted by each intermediary or customer involved in the process and interested in a product tracking. Actually, tracking the containers is one of the main technological and practical challenge. A number of companies have implemented smart tracking technologies, but currently it is a niche realty and many technical issues have still to be faced.

Also, thanks to a blockchain, there could be a solution to the opaque procurement process issue. A direct connection between buyers and sellers eliminates many intermediaries like brokers involved in these processes. With a blockchain this is possible because there are no more trust and reputation problems. This would make save money to both companies and customers with a win-win situation, improving the efficiency of the sector at a global level.

Blockchain has applications also in data security. In particular the immutability of data is important in supply chain. The problem is that all these logistics intermediaries do not communicate at a machine to machine level, they communicate mostly by email. So, there are interruptions and replications in communications, this is actually a problem in logistics. Taking all these information on the blockchain and giving the access to all the parts involved, could really reduce the effort to move goods around the world.

Blockchain and smart contracts architecture is perfect for these kinds of applications. Looking at a purchase order, it has many different features, from ID to payment terms. Shifting the focus to all the other legs and different steps involved in the supply chain, we can get the complexity and size of information and data exchange between all the parties involved in the transaction and transportation of one single product[97].

That is, blockchain opportunities across the supply chain ecosystem are many:

- Planning and forecasting of stocking
- On-demand procurement and manufacturing
- Supply chain financial forecasting
- Visibility and transparency
- Asset management
- Supply chain execution and operations

Increasing the complexity of this picture, we need to figure out that inside these many sub-applications there are many other internal divisions for each different business. For example, we can find a blockchain for the transparency and tracking inside the pharma industry and another one for the food industry. In particular, the businesses where the blockchain benefits could improve the efficiency of the sector are several. From all the kinds of manufacturing companies, to really specific markets.

The reality of this blockchain replication is actual and tangible. As said, many experiments and pilots have been taken and today there is a situation where many big

[97] *Blockchain technology applications and implications on the shipping industry. https://seanews.co.uk/technology.*

companies and organizations are traying to develop their own blockchain. These are just some of the most interesting projects and initiatives that show us today's reality.

- OriginTrail, already in use in the food industry, is a platform that lets consumers know where their purchases came from and how they were produced.
- IBM Blockchain is a permissioned platform for the tracking and transparency of supply chains inside manufactures. IBM is coworking with different multinational companies to help them approaching this technology
- Blockverify focuses on anti-counterfeit solutions using blockchain to verify counterfeit products, diverted goods, stolen merchandise and fraudulent transactions.
- De Beers, a company which mines, trades and markets more than 30% of the world's supply of diamonds, is planning to use a blockchain ledger for tracing diamonds from the mine to the customer purchase. This transparency will help the industry and anybody who wishes to verify and confirm diamonds are free from conflict (ethical diamonds).
- Fura Gems also plans to use blockchain in its supply process of emeralds, rubies and other precious stones.
- Provenance uses blockchain to provide transparency and certification of supply chains. Customers are increasingly demanding transparency regarding the products they purchase and consume to ensure the sourcing of materials and production of products adheres to their individual values[98].

This kind of situation has some benefits, but also some disadvantages. In fact, in order to really improve efficiency in supply chain at a global level, there should be a unified and transparent blockchain for all these different supply chain.

The advantages in having one single blockchain for the global logistics and transportation industry would be in its standardization. That is, in order to be acceptable from different customers and organization, there is the necessity for standardized systems and protocols of this technology. Just like the real containerization process has

[98] *Blockchain technology applications and implications on the shipping industry. https://seanews.co.uk/technology.*

occurred after its standardization, in the same way, the blockchain revolution in the global supply chain would occur only after its global standardization, with the application of a global framework and shared norms.

This is exactly the role of the Blockchain in Transport Alliance (BiTA), a network of up to 500 companies and organization from 25 countries, with the scope of facilitating the adoption of blockchain technologies in transportation industry, creating a standardized framework, shared among all the actors involved in the industry. At its core there is the development and exploitation of blockchain technologies inside this industry, without the creation of barriers for other companies. The BiTA is a member-driven association and, one of the most interesting projects from it, is the development of solutions that connect blockchain technologies with the Internet of Things and Big Data's world[99].

That is, what should be created is an ecosystem where all the players want to participate because it reduces the cost of everybody. In this way, instead of every logistic company implementing its own database, we could have an ecosystem of these companies with a unique centralized database on the blockchain, implementing all the work that normally is done individually and, through this, reducing the cost significantly. With this system, instead of spending dollars per shipment to amortize costs over years, companies would spend only a few cents to move track and guarantee their goods across the whole supply chain.

But in which way this could be made? According to many, there is one way in which all these different supply chains could converge into one global network. It is the container. Effectively, what many different businesses and products have in common is to be transported inside containers. Again, about the 90% of the global products are carried inside containers. So, it is clear that in order to create a great blockchain for the global supply chain, you need to go through the container industry, the convergence point of almost all the logistic companies and freight forwarders.

[99] *https://www.bita.studio*

3.3 Blockchain applied to container's transportation industry

Globalization has brought the most advanced trading networks the world has seen, with the biggest, fastest vessels, robot-operated ports and vast computer databases tracking cargoes. The container shipping industry accounts for roughly 60% of the world's seaborne trade and transports more than $4 trillion USD worth of goods every year[100]. Nevertheless, a number of factors, including overcapacity, low freight rates, security problems, and stringent environmental regulations, are placing increasing pressure on shippers to optimise their processes and maximise their earning potential. It all still relies on millions and millions of paper documents. Blockchain-based solution could help turn the tide for the industry, and boost efficiency in a way never seen before.

The result could be a revolution in world trade on a scale not seen since the move to standard containers in the 1960s, a change that, as seen in the first chapter, took the world in the age of globalization. Obviously, this large growth has increased the technical and operational complexity of the sector. To make it work, dozens of shipping lines and thousands of related businesses around the world, including manufacturers, banks, insurers, brokers and port authorities have to work and cooperate. A protocol that can integrate all the new systems onto one vast platform should provide the solution to this complexity without the necessity of trusted third parties[101].

If this project will take ground, documentation that takes days will eventually be done in minutes, much of it without the need for human input. The cost of moving goods across continents could drop dramatically, adding fresh resources to companies and new alternatives to relocate manufacturing or source materials and goods from overseas.

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[100] *World Trade Report*, (2017).

[101] *Blockchain technology applications and implications on the shipping industry. https://seanews.co.uk/technology.*

With a blockchain platform that unifies the container industry the benefits wouldn't be confined to shipping. Improving communications and border administration using blockchain could generate an additional $1 trillion in global trade, according to the World Economic Forum[102]. In Rahul Kapoor's opinion, an analyst at Bloomberg Intelligence in Singapore, "this would be the biggest innovation in the industry since the containerization", it would basically bring more transparency and efficiency to many different businesses and markets[103].

To make an idea of the benefits of such a solution, in 2014, Maersk followed a refrigerated container filled with roses and avocados from Kenya to the Netherlands. The company found that almost 30 people and organizations were involved in processing the box on its journey to Europe. The shipment took about 34 days to get from the farm to the retailers, including 10 days waiting for documents to be processed. Also, one of the critical documents went missing, only to be found later, hidden in a pile of paper. Shipping that single container of flowers from Kenya to the port of Rotterdam, resulted in a stack of nearly 200 communications. Using this example, we can examine how blockchain could be implemented to create trust and security in the digitalized document workflow and improve the efficiency of global supply chains[104].

As already seen, goods transportation evolves many phases and actors. A single shipping requires signatures from dozens of agencies approving the export and even more documents that describe the origin, chemical treatments, quality of the product and customs duties.

In the Maersk example, using a PC or a mobile device, the Kenyan farm could submit a packing list that becomes visible to all participants involved. With this simple action a smart contract enforces an export approval workflow between the agencies and other participants. As each agency signs, the status is updated for all to see. Simultaneously, information about the inspection of the flowers, the status of the refrigerated container, the pick up by the trucker and all other information are communicated to the ports of

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[102] World Trade Organization, (2017). *World Trade Organization*.

[103] Bloomberg. *www.bloomberg.com*

[104] *IBM.com/Blockchain*

Mombasa allowing them to prepare for the container. All actions relating to the documents and physical goods are captured and shared: which documents were submitted when and by whom, where the flowers are and who is in possession of them and the next steps in their journey. In practice, a solution to the paper base document workflow and information exchange is achieved.

The shipping paper trail begins when a cargo owner books space on a ship to move goods. Documents need to be filled in and approved before cargo can enter or leave a port. A single shipment can require hundreds of pages that need to be physically delivered to dozens of different agencies, banks, customs bureaus and other entities. Blockchain provides secure data exchange and a tamper proof repository for these documents and shipping events. This system could significantly reduce delays and fraud, saving billions of dollars annually and according to the WTO reducing barriers within the international supply chain could increase worldwide GDP by almost 5% and total trade volume by 15%[105].

Thanks to blockchain and smart contracts, it would be very simple the exchange of important document and data. Also, connecting the blockchain with IoT sensors, there could be the creation of time-stamped blocks with information regarding the product characteristics like its provenance, expiring date and so on.

Over to the information centralized exchange, this technology could solve many other problems in the industry. The planning and forecasting for companies and ports would be much more efficient, in fact, it is possible to create an inventory management blockchain for ports and companies. This system could also help captains and crews to report their vessel's fuel consumption in compliance with international regulations.

Also, the visibility and transparency of processes could gain, with benefits for many businesses supply chains and their consumers. One perfect example of the importance of supply chain transparency is the food industry. The food industry's complex network, from farmers to dealers, makes tracking down foods challenging. Blockchain

[105] World Trade Organization, (2017). *World Trade Organization*.

can improve the transparency and efficiency of finding out where the food come from and when it has been produced.

Another issue solved by this technology could be the procurement process. As said, because lacks in trust and reputation, small companies are usually squeezed out; a process that slows down innovation in the whole market. With blockchain there are no more trust and reputation issues, so that also small companies would be able to enter the market.

Blockchain in the procurement process allows for another application of this technology: the possibility of smart contracts to be paid in cryptocurrencies. In the containers market there are companies from all over the world, with many different currencies, so currently banks and intermediaries are necessary, but this takes away money and time. Considering the rent of a container for one week going from Europe to India, transportation costs ask for more than three weeks to be paid and up to 5% in fees. Within cryptocurrencies, just a few minutes will be taken and a few cents in fees. This also offsets the risk of fluctuations and brings grater cost efficiency[106].

These are all possible applications of a blockchain in the container transportation industry. By the way, what is fundamental in this process, again, is the development of standardized practices and unified blockchains in order to exploit scale economies and, even more important, don't create barriers between companies involved and customers interested in transportation processes and information.

[106] *https://www.blockshipping.io*

3.4 Types of blockchains for the container's industry

Once understand the benefits and advantages of blockchain in the supply chain and container transportation industry, we need to figure out which kind of this technology should be the most appropriate.

As discussed there are several types of blockchain, which can be distinguished among its technical features. In particular, apart from its protocol and validation process, a blockchain can be public, permissioned (consortium) or private. A public platform should allow for a greater interoperability and interaction among different actors, a key factor in logistics. Unfortunately, the question of whether freight forwarder companies will join one big blockchain solution largely has been answered with a shared no from the industry

Thus, the real question is if a private or permissioned blockchain could provide to the industry the real benefits of this technology. According to many business experts, like the APL's senior manager Sai Wing Cheng, "blockchain has value when you have multiple users". So it is not much about public versus private as it is about the number of users and the value grows the more parties are involved, as in a network-based value.

Opponents to that theory states blockchain needs to be public to fulfill its true potential. The CEO of Ship Chain John Monarch is one of them. "We firmly believe that public blockchains are the true game-changing technology. There really isn't much to gain for an enterprise by using private or permissioned blockchain systems, due to the lack of inherent trust in them. They could just as well use a centralized database, as it would behave the same. A public blockchain, with its incentive mechanisms such as tokens, truly fosters the trust of the ecosystem without having to trust all of the players involved"[107].

Looking around, that seems to be a shared vision, also from who has not conflicted interests in said so. Effectively, if any company in the game come out with its own solution, it will not move forward and there will not be benefits at all from this

[107] *https://www.joc.com*

technology. If the advantages of blockchain come from the interconnection and the network effect achieved with it, an individual private blockchain affects the perceived neutrality of these solutions.

Interoperability is the key word. “Defining how that interoperability works will be very important. That’s why we want to have more carriers involved. The more the network grows, the more chance it will have to attract other carriers. It would be detrimental for the shipping industry if the different factions and initiatives compete head-on trying to make their specific blockchain technology choice the de-facto standard for the industry,” said Peter Ludvigsen, CEO and founder of Blockshipping[108].

In practice, what should be done is to create standardized system, so that it will be easy for customers and small companies to operate and run on blockchain from different organizations in the supply chain system. In this way, whatever public or permissioned, the blockchain will guarantee that grade of interoperability and interconnection that is so important to achieve in the logistics industry.

Over these arguments, we have seen that a completely private blockchain pones many issues about its immutability and visibility. In a theoretical world, a public blockchain with thousands of participants (nodes) would provide the greatest trust. But this would also shake an entire industry that is not ready to lose its market control. This might end up being a dead end for blockchain: a technology that is optimally used in a public, trustless environment, into an industry that pathologically seeks trust. For this reason, the right trade off should be the adoption of permissioned blockchains, with the willingness to guarantee the access to all the parties involved and the creation of accepted standards in order to facilitate customers, small companies and organizations involved in the industry.

The adoption of blockchain in logistics and container industry might well depend on whether solutions are private permissioned or public. The promise of blockchain in logistics should be leveraging the number of people involved in a shipment and take them as an advantage, rather than an impediment. However, the first projects from the

[108] *https://www.blockshipping.io*

industry seem to go in another direction. As we are going to see, many start-ups and organizations are teaming on the development of blockchains in logistics and, in particular, in container industry. Even if none of them is using a public blockchain, it seems to be a great willingness to create a large network for the cooperation and interconnection of different actors. Probably the first reason behind these projects is the cost reduction and efficiency improvement more than the interconnection and networking, but the adoption of blockchain technologies from big organizations and market leaders is the sign that the industry has understand that the first one has to go through the second.

3.5 Current projects of blockchain application in the shipping industry

Companies managing hundreds of containers need to be super-efficient so a lot of them are leveraging blockchain technology and bringing around its benefits. Probably the most interesting project is the one developed by the market leader Maersk. It is addressing the industry problems trying to exploit blockchain technologies in partnership with IBM.

They are developing a distributed permissioned blockchain accessible by the supply chain ecosystem designed to exchange data and document. In practice Maersk and IBM are employing blockchain technology to create a global tamper proof system for digitalize trade workflow and tracking shipments end to end, eliminating frictions and costly point to point communications. Trade Lens, this is the name of the platform born from their collaboration, will be launched with the potential ability to track millions of containers journeys per years and integrate with customs authorities and other related companies. In fact, To its development are currently partnering other 94 organizations like ports and competitors (CEVA, Damco). This platform aims to act like a multiple window. This means that, even being a permissioned blockchain (so it will not be completely transparent and freely accessible), Maersk and IBM will sell it as a service for everyone will ask for.

Trade Lens will have a great impact on international shipping, not only because of the cost and time saving, but foremost because it will disrupt and eliminate many businesses actually connected to the shipping industry. According to Maersk, the implementing of this platform will reduce the total transit time of about 40%. The necessary steps answering the question “where is my container?” will be reduced from ten to one and people involved in this process will be reduce from five to one[109].

Another great project of blockchain application in the container industry is the Danish start-up Blockshipping. It is developing the world’s first freight container registry,

[109] *IBM.com/Blockchain*

called the Global Shared Container Platform (GSCP). The system is blockchain-based and will provide a real-time registry of 27 million containers that could save billions every year.

Blockshipping is made up of a number of industry experts. Its Global Shared Container Platform aims to provide a complete registry of every shipping container in the world, while also introducing a new system for secure, smart contract-based transactions between industry players, such as carriers, ports, terminals and hauliers.

Blockshipping estimates that a global registry could save the sector a minimum of $5.7 billion USD. Increased efficiency is also set to have a massive environmental impact by reducing CO2 emissions by 4.6 million tonnes annually.

The primary goal of the platform is to let shippers know where containers are in real-time. Blockshipping is banking on the fact that smart sensors will eventually be applied to all containers, but until then, the GCSP will rely on data points generated when containers enter or leave ports or are loaded onto or off container ships. Again, up to 20% of all containers in the world are currently unaccounted for at any time. One of the fundamental components of the GSCP is its Empty Container Repositioning (ECR) engine, which continually calculates the position of empty containers and available trucks, and passes this information onto shipping lines, automating many procedures.

The GSCP will therefore provide an increased opportunity for a ‘grey-box’ concept, the idea of offering shippers a shared pool of containers that aren’t linked with a specific company. Henrik Hvid Jensen, Blockshipping’s advisor on blockchain design, says that thanks to GSCP “the repositioning of empty containers can be based on all containers in the world and not just the ones owned by shipping companies. The chance of them having the right container at the right time is increased when we have a pool of containers, instead of from a specific company.” Thus, by opening up an entire market of containers and tracking empty ones, shipping lines could save on the huge fuel costs and emissions accrued by the movement of empty containers, which currently make up 40% of those being shipped worldwide.

Besides being a global registry for containers, the GSCP will also act as a trading platform for a wide range of services that today are being exchanged through other

channels, some of which are inefficient and costly. The GSCP will operate on a private/confidential blockchain, which provides a shared digital ledger through which participating companies can view container information and engage in direct transactions. Interactions will be authorised by autonomous intelligent software agents (AISAs) that are instructed by parties to automatically negotiate container rental transactions on their behalf, thus eliminating the need for a third party and the additional admin costs that result. Agreements established between AISAs (in example one from a shipping line and one from a container owner) are formulated into smart contracts, which automatically regulate the terms of the deal. In this way the platform aims to build trust between shipping companies and incite them not only to share container information with each other, but also to be host of other services.

Blockshipping anticipates it will launch the first version of the platform at the start of January 2019, but that the product will not 'break even' until up to 18 months after this date. The project is being funded by private investors and an initial coin offering launched by the company this summer. Blockshipping aims to be tracking 16 million container units in the next three to four years. The company recently announced it was developing a new app, known as BoxSpotter, which allows people all over the world to scan shipping containers as they pass by[110].

The real issue is inducing industry players to join the platform. Many shipping companies already have leasing agreements in place and may not like the idea of sharing their containers with others, or don't yet believe in the potential of blockchain. It can be seen with an analogy with fax machines: there isn't much value if only your company uses it, but as more acquire them the value increases exponentially with the number of connections to the network.

In a white paper outlining the GCSP project, Blockshipping says it is it is negotiating with several large carriers, and that it is intending to pursue alliances with those who are already engaged in vessel sharing agreements. It is also in discussion with an undisclosed Asian container company about using the platform to support real-time

[110] *https://www.blockshipping.io*

container tracking. Regardless of the difficulties, the ambition on display here is palpable. If the GSCP delivers on its potential, the future of blockchain in this industry could be very bright. Despite to its result, however, the GSCP could potentially be a flagship example of the power of blockchain to effect change in the maritime industry[111].

Over to these main projects, other solutions have been implemented related to blockchain in freight forwarder industry. Accenture is working with the shipping line APL for the development of a blockchain implemented in bill of loading processes. Cargo Smart, instead, in partnership with Oracle, is trying to use blockchain for documentation shipping, bookings execution and shipments tracking. Also Cargo X aims to use blockchain for the securement and exchange of documents like bills of loading. Smart Containers is putting containers on the blockchain to facilitate the management and payment process for these assets[112].

All these cases give us good hope for the future of this technology. Probably we will need to wait some more year to see the effects of that process, but the advantages of a blockchain technology into the supply chain and container transportation industry are undeniable.

[111] *https://www.blockshipping.io*

[112] *Blockchain technology applications and implications on the shipping industry. https://seanews.co.uk/technology.*

Conclusions

The twin objectives of logistics should be to manage the firm's global supply chain at the lowest possible cost and in a way that best serves customer needs. This has leaded transportation industry to be stacked for many years and to operate with very low marginal rates in order to be competitive. Even if in more recent years the global trade, and thus the transportation industry and logistics, has been back on the rise, the uncertainty of these days suggests that shipping companies need to ready their organizations for change.

The Trump's protectionism, the slowdown of the Chinese economy, the trade war between USA and China, but also the Brexit, are all flags that the global economy needs to find a new balance. In this scenario blockchain technologies seem to be the next great disruptive technology as much as the internet in 90s' and the container, for international trade, during the last thirty years.

In this thesis we have seen that the possible advantages of this technology are countless. Not only in logistics and supply chain, but from financial institution to the Internet of Things, it seems that this technology could provide a greater efficiency to the global economy in general.

In particular, as the focus of this elaborate, we have seen that the starting point for blockchain to revolutionize logistics should be the container. It is the pivot of the global chain: the 90% of all the goods traded in the world are carried into a container at some point and the container shipping industry accounts for roughly 60% of the world's seaborne trade and transports more than $4 trillion USD worth of goods every year. Thus, only through this market blockchain could attract and persuade all the actors involved in the global logistics.

In fact, as pointed in chapter three, the greater benefits from a blockchain technology for the container's transportation industry and the global supply chain there would be only with many participants involved, in a network-based value. As stated by the Former US Secretary of the Treasury Larry Summers, "Blockchain has the same

character a fax machine had. A single fax machine is a doorstop. The world where everyone has a fax machine is an immensely valuable thing."

Thus, a unique great public blockchain for the whole sector should provide the greatest efficiency and advantages. By the way, it seems that the big actors of the container industry are developing multiple blockchain solutions. That is, at least for the next future, the hopes for one single public platform for the tracking and monitoring of almost all the goods has disappeared.

Everyone understanding the potential of this technology is developing its own blockchain in order to gain a sort of first mover advantage. However, these individual solutions mean that someone has understood the potential and benefits of this technology.

But can individual solutions build enough critical mass to take advantage of blockchain technology? Again, the key word is interoperability. Being the value of a blockchain platform based on a network effect, in order to be valuable and provide benefits to the global economy, there is the necessity to standardize these solutions, so that organizations, small companies and even customers will be able to exploit and run all these different platforms. As much as the real containerization has occurred after its standardization, in the same way now there is the necessity for standardization and interoperability among these different blockchain solutions.

Of course, many steps have still to be made and issues to be faced. An important question is if companies and organizations will have the in-house expertise and willingness to participate in multiple blockchains. Also, the regulatory aspects are controversial and, as for every new technology, there is divergence and uncertainty in different countries. These and other issues suggest that it will be a long process and probably its benefits will not occur before the next five or ten years. By the way, the efforts of companies like Maersk and organizations like Blockshipping mean that something in this industry is changing and its actors are trying to do something that has been stucked for too long: innovate.

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