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The future impact of information technology in road freight transport

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Abstract

It can be observed that in the past years and in recent years, information technology (IT) trends such as artificial intelligence (AI), internet of things (IoT), cloud computing and big data have been impacting transportation and logistics, in particular road freight transport. However, the future influence of these technologies in road freight transport is not known. Therefore, this thesis aims to investigate the future impact of IT trends in road freight transport. This study was explored through examining the contribution of the chosen IT trends on the selected key performance indicators (KPIs). Data for the research was collected through telematic interviews from six companies and it was interpreted by the use of a mathematical model called Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS). The results showed that AI, IoT and big data are the IT trends that will influence road freight transport in the future, while the other trends will have less and no impact on road freight transport.

Keywords: IT trends, KPIs, Road freight transport, Multi Criteria Decision Making (MCDM), TOPSIS

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List of Abbreviations

IT- Information Technology

AI- Artificial Intelligence

IoT- Internet of Things

KPIs- Key performance indicators

GPS- Global Position System

ICT- Intelligent Transportation Systems

3PLs- third party logistics service providers

SAE- Society of Automotive Engineers

HGVs- Heavy goods vehicles

AR- Augmented Reality

TOPSIS - Technique for Order of Preference by Similarity to Ideal Solution

MCDM- Multi Criteria Decision Making

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1. Introduction

This chapter will provide an overview of the thesis's research topic and brief discussion of the research problem. The aim, research questions and limitations of the study will all be derived from the problem description.

1.1 Background

The road freight industry plays an important role in logistics. When referring to inland freight, road transport accounts for 75.3% of the total freight transported in Europe in 2019 (Statistical Office Of The European Communities. 2020, p.53). As this figure illustrates, when talking about freight transport, road freight plays a crucial role by accounting for the majority of all inland transportation. Determining how much this industry will be impacted by technological advances, is without a doubt a challenging and complex task. When looking at Vehicules manufacturing companies, the integration of IT technologies in future vehicles seems to be a priority. For example, in 2019 Volvo Group announced that it will partner with Nvidia to develop an advanced AI platform for autonomous trucks (Volvo Group partners with NVIDIA to develop an advanced AI platform for autonomous trucks, 2019). Additionally, Jansen Huang, the CEO and founder of Nvidia mentioned the following about this partnership: “ Trucking is the world’s largest network…”, “ The latest breakthroughs in AI and robotics bring a new level of intelligence and automation to address the transportation challenges we face. We are thrilled to partner with Volvo Group to reinvent the future of trucking” (Volvo Group partners with NVIDIA to develop an advanced AI platform for autonomous trucks, 2019). Other companies have also manifested the importance of IT integration on their vehicles. Daimler Truck, the company that produces trucks for prestigious brands like Mercedes-Benz and Freighliner, commented the following about autonomous driving: “ Automated driving has the potential to further reduce the number of accidents. And that has been one of our most important goals for many decades. The technology can also contribute to fundamentally improving our customers' business. That is why we are fully focused on pushing the development of this technology” (Daimler truck., n.d.). It is not only truck manufacturing companies commenting on the future impact of IT technologies, 3Pls (Third Party Logistics Providers) have also made strong statements about this topic. Carol B.Tomé, CEO of UPS, constructed the following statement about digital technology :“ Digital literacy isn’t going to cut it. We're going to have digital fluency as the way we operate and the way we think. The only way we’re going to survive is to become digitally fluent” (US. Chamber of Commerce, 2022). Various relevant actors across multiple industries are highlighting the importance of IT emerging trends in the future of road freight.

Continuing the research and development of road freight transport, requires the understanding of IT technologies as well as how they interact with various aspects of road freight transport. Moreover, it is worth noting that the adoption of these technological trends like: GPS (Global Position System), ICT (Intelligent Transportation Systems) and similar ICT (Information and Communication Technology) have had a vast impact on the industries (Yoshimoto and Nemoto. 2005, p.21). It is crucial to assess whether these new technologies will have a similar substantial impact or perhaps an even greater one. Numerous authors have explained the revolutionary potential of “ Industry 4.0”. Particularly, in the case of logistics. Emphasizing that it can be molded into being more competitive, creating social value and enabling sustainability (Tang and Veelenturf. 2019, p.11).

1.2 Problem Description

There has been a revolution in computing and communications over the last few decades, and all signs are that technological advancement and the usage of information technology will continue at the current rate. The falling cost of communications as a result of both technological breakthroughs and more competition has accompanied and supported the enormous growth of computational power and use of new information technologies (Lee. 2021, p.1). It can be observed that IT has impacted the road freight industry in meaningful ways. For example, ICT systems have enabled companies to: increase the added value of products, optimize routing, enable small scale JIT, facilitate outsourcing of logistics and urban consolidation (Yoshimoto & Nemoto. 2005, p.21). Furthermore, ICT technologies have also contributed in reducing externalities in road freight transport like CO_2 emissions (Wang et al. 2015, p.23). On the other hand, ICT has also contributed in reducing road freight transportation costs (Chatti. 2020, p.130). While cost reduction can be seen as a positive impact, it can also contribute to CO_2 emissions by the simple increase in transportation activities due to the reduced cost. This evidence shows the holistic impact of IT in road freight transportation, nevertheless current literature does not provide a clear idea of how current IT trends will impact the industry in the future. Besides, some authors have expressed the difficulty of assessing only the current impact in road freight transport (Yoshimoto & Nemoto. 2005, p.21). Up to this point, the future impact is not known and therefore uncertain. The aim of this research is to investigate the future impact of IT emerging trends in road freight transport and provide insights about it.

1.3 Purpose and Research Questions

This thesis aims at studying the future impact of IT in the road freight transport industry. The study is set on producers and manufactures from diverse industries, who own or manage their transport network and also third party logistics service providers (3PLs) which provide services such as warehousing, distribution and transportation to the companies that require those services. As IT is continuing to evolve and affects the logistics industry and in particular the road freight transport industry, future effects have to be considered. This thesis will examine how the emerging technologies will impact road freight transportation in the future.

In order to assess the future influence, this investigation will be developed in three stages. The first stage will consist of a comprehensive literature review with two primary outcomes. The adequate selection of the most relevant IT trends present in current literature. Additionally, the collection of relevant KPIs in the road freight transport industry. These performance metrics enable us to evaluate how much potential influence the IT trends have in specific. Quoting Parmenter, author of the book " Key Performance Indicators". "What are KPIs? KPIs represent a set of measures focusing on those aspects of organizational performance that are most critical for the current and future success of the organization" (Parmenter. 2010, p.4). The capability of determining the current and future success of an organization justify the selection of KPIs in this investigation, for assessing the future predictions.

The second stage will consist of gathering the secondary data for the investigation. In order to obtain this information, interviews with questionnaires will be conducted. The interviewees will be employees in organizations from diverse industries, with experience and relevant skills in road freight management. By this careful selection of participants, the investigation gathers relevant information from actors that are familiar with road freight KPIs, as well as the IT technologies and trends used in the industry.

The final stage consists of processing the information applying the TOPSIS methodology. Furthermore, since this investigation aims at predicting, a special matrix will be used previous to TOPSIS. The matrix is three dimensional, providing more information and improving future based predictions when compared with traditional TOPSIS or similar MADM techniques. This revamped matrix is especially useful for future based predictions (Sorooshian, 2021) .

This thesis is expected to provide the reader with insights of the future impacts of IT in road freight transport. To address the research gap, this thesis has been design to answer the following question:

To what degree IT emerging trends will impact KPIs in road freight transport?

1.3.1 Limitations

The research aims to provide a basic understanding of the potential impact of new technologies on road freight transport based on the opinion of available experts working for companies and organizations that rely on this type of transport for their operations. Taking into account the time and resources available, some limitations were established. This study is exclusively focused on road freight transport, it does not discuss the influence of IT trends on freight transport in general or logistics operations. Additionally, the study aims to assess future essenarious. The reader must take into consideration that any assessments of the future can have some inaccuracies in the long run. Additionally, this investigation was conducted with a unique selection of IT trends, not all available trends from industry 4.0 were included due to time constraints and to maintain practicality in secondary data collection.

2. Literature Review

The objective of this chapter is to have a review of past studies in the topic. Logistics are discussed first in the first part. The second segment discusses road freight transportation. Third-party logistics providers (3PLs) and road freight are discussed in the third section. The key performance indicators (KPIs) are the emphasis of the fourth part . The fifth section explains deeper into developing IT trends. The sixth section proposes a multi-criteria decision-making study approach, while the final section summarizes the literature review's findings.

2.1 Logistics

In the last two years, logistics and transportation management has gained notoriety worldwide. This sudden appearance in public opinion has been caused roughly by the disruption of logistics networks worldwide. The disruption has been attributed to the COVID-19 pandemic, plus other factors that were present before this unfortunate event (Xu et al. 2021, p. 1). This situation exemplifies how logistic activities can typically go unnoticed, until they stop working flawlessly and expose their importance in world economies and trade.

Logistics has a wide variety of definitions, the main components are widely agreed by many authors. Nevertheless, it is important to mention that some definitions engage more operations and functions in logistics than others. According to the Council of Supply Chain Management Professionals, logistic management is defined as:

Logistics management is that part of supply chain management that plans, implements, and controls the efficient, effective forward and reverse flow and storage of goods, services and related information between the point of origin and the point of consumption in order to meet customers' requirements (SCM Definitions and Glossary of Terms. 2012 p.15).

According to CSCMP logistics is a function inside supply chain management. Moving forward, Allan Rushton, Phill Croucher and Peter Baker authors of the book: The Handbook of Logistics and Distribution Management. Present the following definition of logistics and its relationship with supply chain management:

One quite widely respected definition also helps to describe one of the key relationships.
This is as follows: Logistics = Materials Management + Distribution.
An extension to this idea helps to illustrate that the supply chain covers an even broader scope of the business area. This includes the supply of raw materials and components as well as the delivery of products to the final customer (Rushton et al. 2014, p. 4).

Similarly, these authors agree on the principle that logistics is a function of supply chain management. Additionally, transportation and storage of goods is again re-established as a key function in logistics. There are abundant definitions of logistics and its specific functions, nevertheless is it worth mentioning that ones employed in this paper are sufficient and do not require additional discussion.

Transportation logistics is the process of getting raw materials, handling resources, and distributing goods using transportation from point of origin to point of consumption. Logistics is a subset of supply chain systems and an important component of them (Hayton, 2021, p. 1). The supply chain is responsible for acquiring and shipping raw materials and subsystems, inbound and outgoing movements inside manufacturing facilities, storage, loading and unloading, and getting products to customers. The processes involved in transferring these products through the supply chain are referred to as logistics. The logistics system includes the transportation and distribution systems (Hayton, 2021, p. 1).

Logistics includes inventory control, warehousing, materials handling, order processing, and related information activities in the flow of products, in addition to transportation. The quantity and quality of transportation required, as well as the form of business interactions between shippers and transportation service providers, are determined by how these activities are handled and structured (Regan et al, 2000, p.4). The demand for longer, more complex, and inherently more expensive worldwide supply chains has developed as a result of commercial globalization. Businesses will look for logistics service providers who can help them achieve their worldwide logistical requirements. This development will fuel the rise of global third-party logistics (3PL) companies that offer a comprehensive range of logistical services, including transportation (REGAN et al, 2000, p. 4).

Moreover, the logistics sector is being transformed by technological breakthroughs such as digitization and automation (Tavasszy, 2019, p. 1) As a result of these developments, supply chains are responding to new opportunities to provide digital services with new business models, and logistics and transportation procedures are being reformed. Product-service systems are being developed from service proposals tied to physical products (Tavasszy, 2019, p. 1).

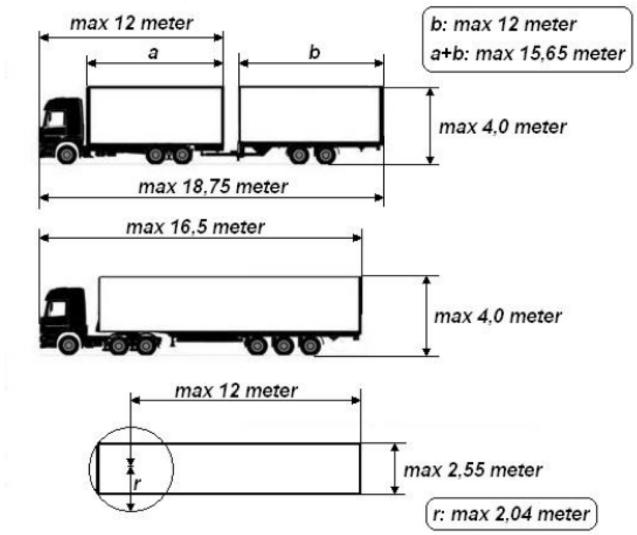
2.2 Road Freight Transportation

According to Eurostat, road transport accounted for 75.3% of the total inland freight transportation in Europe in 2019 (Statistical Office Of The European Communities. 2020, p.53). This figure illustrates the importance of this modal transportation in economic activities and the overall function of society. Road freight is conducted by different types of vehicles, with specific characteristics in capacity, efficiency and regulatory compliance. Vehicle classification can be approached by several methodologies, in this investigation EU regulation will be used. The current guidelines were established in 1996 and were adopted by all EU member states (Council directive 95/53/EC on laying down for certain road vehicles (1984)) .

2.1.1 Motor Vehicles

A motor vehicle is any vehicle that does not exceed 12.00 m in length, with 2, 3 or 4 axles. Additionally there is a weight limit, depending on the number of axles. For 2 axles the limit is 18 tonnes. For 3 axles the limit is 25 or 26 tonnes depending on the number of wheels. Additionally, for 4 axles and two sterling axles vehicles the limit is 32 tonnes (Council directive 95/53/EC on laying down for certain road vehicles (1984)). In figure 1, there is a visualization of motor vehicles used for freight identifiable with the dimension of 12 meters.

Figure 1 - European modular systems classification



(TFK & KTH. 2007 , P.1)

2.1.2 Articulated Vehicles

An articulated vehicle consists of a motor vehicle and semi-trailer cumple to the vehicle, not exceeding 16.5 m in length. The weight restrictions are the following. For two axle motor vehicles with tree axle semi trailers, 40 tonnes. Regarding three axle motor vehicles with two or three axle semi trailers, 40 tonnes. Finally, for three-axle motor vehicles with two or three-axle semi-trailer carrying a 40-foot ISO container, 44 tonnes (Council directive 95/53/EC on laying down for certain road vehicles (1984)). In figure 1.1, there is a representation of articulated vehicles, identified by the 16,5 m length.

2.1.3 Road train

The biggest vehicle in this classification is the road train. It came by the combination of a truck and a short trailer with a maximum length of 18,75 m (TFK & KTH. 2007 , P.17). Two and three axle motor vehicles with two or three axle trailers, have a maximum weight limit of 40 tonnes. Furthermore,when combining two axle motor vehicles with two axle trailers the weight limit is 36 tonnes (Council directive 95/53/EC on laying down for certain road vehicles circulating within the Community the maximum authorized dimensions in national and international traffic and the maximum authorized weights in international traffic' (1984)).In figure 1.1, there is a representation of road train, identified by the 18,75 m length.

2.1.3 Additional parameters & considerations

There are additional parameters in classification that are applicable to all freight transportation vehicles: maximum width of 2.55 m and maximum height of 4.00 m (Council directive 95/53/EC on laying down for certain road vehicles (1984)).

From the three classifications previously established, there are some additional considerations regarding road trains. There are European countries that tolerate additional weight and dimensions, like sweden. Sweden permits road trains with a maximum dimension of 24 m, Finland also permits road trains of 22 m (TFK & KTH. 2007 , p.13). Since these dimensions do not comply with the EU regulation previously mentioned, they are only used for national transport. Furthermore, it is worth noting that there are relevant sub-categories in motor vehicles. Vans and other small vehicles are typically used in last mile delivery, given its flexibility in size and low operational cost (Bergmann et al. 2020 , p.48).

2.1.3 Propulsion Systems

The vehicle's propulsion system is crucial in road freight transportation. Influencing the operational cost, the environmental performance and the customer satisfaction. The main engine type used in the industry is the internal combustion engine. This engines rely on different types of fuel like : diesel, petrol, compressed natural gas (CNG), liquefied natural gas (LNG), Biofuel, Liquefied petroleum gas (LPG), bio-diesel and dimethyl ether (DME) (McKinnon. 2009, p.640). By far the most common fuel used in the industry is diesel, mainly because of its high efficiency, availability, cost and the majority of vehicles only accept this energy source. Nevertheless, diesel has a great set of drawbacks, primarily its environmental impact with the emission of PM10 particles. Which are linked to severe respiratory illnesses (McKinnon. 2009, p.655). The other fuels previously listed have an overall better environmental impact, nevertheless all of them emit CO2 as a result from internal combustion engine approach. The current tendencies, both social, legislative and cooperative, impulses an intense migration to decarbonization. The industry has (Rushton et al. 2014, p. 565).

Electric and hydrogen systems are currently being developed and even implemented at a minor scale in road freight. Battery electric trucks (BET) and fuel cell electric trucks (FCET), have shown great potential in light to medium intensity operations while assessing competitiveness (Noll et al. 2022, p.16). These alternative propulsion systems are the most promising technologies currently in hand to assess the environmental impact of transportation in general and road freight transport as well.

2.1.4 Autonomous Vehicles Technologies

Without a doubt autonomous technologies in freight transport is without a doubt a potential game changer in the industry. The Society of Automotive Engineers (SAE) has produced a useful document classifying and defining the technologies in autonomous vehicles. According to SAE, there are 5 levels in drivers automation systems:

0. *No diver automation.*

1. *Driver assistance*.

2.*Partial driving automation*.

3.*Conditional driving automation.*

4.*High driving automation*.

5.*Full diving automation*.

(The Society of Automotive Engineers. 2021, p.30)

This classification of automation technologies proportionates a better understanding when discussing the potential or actual impact of automation. The classification is conducted by a progressive scale, from no automation to full or complete automation.

2.3 Third Party Logistics Providers (3PLs) & Road Freight

3PLs have enabled companies to give outstanding levels of service, without the need of incurring in fixed costs and managing complex operations. The industry plays a key role in logistics, any study focusing on road freight transportation should acknowledge the relevance of the 3PLs.

3PLs provide a wide range of services, the most common being: transportation, warehousing, inventory management, fulfillment (Rushton et al. 2014, p. 563).

Primary transportation, often referred to as “Trucking” , materializes when there is movement of cargo between two points without a direct link to the customer or final user (Rushton et al. 2014, p. 563). The focus is in cost reduction by maximizing utilization of the vehicles. Since demand is typically asimetric, meaning that for example a company sends cargo from point A to point B but does not require to send cargo from point B to point A. 3PLs compile demand from many actors, achieving high levels of efficiency. This efficiency translates to lower cost, when compared with in-house logistics.

Secondary transportation and delivery refers to the movement of cargo between two points, being the final destination the consumer or end user of the mentioned cargo (Rushton et al. 2014, p. 563). One important difference between primary and secondary transportation is the operational objective. Secondary transportation focuses on customer service rather than in cost reduction. Cost also plays an important goal, since this type of transportation is cost sensitive as well, nonetheless the service to the customer is determinant. Providing adequate service to the customer is challenging and costly from an in-house logistics perspective. Again by aggregating demand, 3Pls can provide a great service at an adequate cost (Rushton et al. 2014, p. 563).

2.4 Key Performance Indicators (KPIs)

Selecting the adequate measurements of performance is a challenging task in road freight transport. The difficulty stands on the ground of what type of performance is intended to be measured and what actor is being affected by that indicator. For example, from a customer point of view the main performance indicator will be service. This service can be interpreted in many ways, on time delivery and price, to give common indicators. On the other hand, from a logistics provider perspective, the performance indicators focus can change. To exemplify, for a 3PL, the most important performance indicators can be efficiency, cost and vehicle utilization (Rushton et al. 2014, p. 563). Since this organization is for profit, their focus is on providing an adequate service at the lowest possible cost for the customers and remaining competitive. Moreover, there are KPIs designed to measure the externalities of road freight transport and the impact on society. This type of transport has a direct effect on important and relevant issues like: CO2 emissions, traffic congestion, noise emissions, etc (Rushton et al. 2014, p.644).

Many organizations select KPIs based on their preferred management framework. For example, The DuPont System, the ZVEI System and the Balance Scorecard influence the selection of KPIs (Prause and Schröder. 2015, p.279). On the other hand, David Parmenter author of the book "Key Performance Indicators", has proposed seven characteristics of effective KPIs:

1. Non-Financial.
2. Measured Frequently.
3. Are acted on by the CEO and senior management team.
4. Clearly indicate what action is required by the staff.
5. Are measures that tie responsibility down to a team.
6. Have significant impact.
7. They encourage appropriate action.

(Parmenter. 2010, p.6)

Parmenter exposes a clear idea of how performance indicators have to be understood and acted on from upper management to regular staff. Moreover, it also measures that they encourage appropriate action, which translates into operational actions that can be taken by the staff. Finally, he comments on the importance of significance of the impact.

2.4.1 Government Perspective KPIs.

Governments around the world have developed different transport policies in order to best fit their interests. Assuming that the government should implement sane policies that benefit society and reduce externalities present in the industry, these indicators are useful to determine relevant KPIs for society in general. In 1997, the UK government launched a road freight benchmarking program (McKinnon. 2009, p.640). The objective of this program was to accurately measure and implement a sustainable distribution strategy. With this goal in mind the following KPIs were established, according to McKinnon in his article " Benchmarking road freight transport-Review of a government-sponsored programme".

1. *Vehicle loading*. Measured by payload weight, pallet numbers and average pallet height.

2. *Empty running*. The distance the vehicle traveled was empty.

3. *Fuel consumption*. For both motive power and any refrigeration equipment.

4. *Vehicle time utilization*. This has been measured at hourly intervals over a 48-hour period for all the vehicles surveyed.

5. *Deviations from schedule*.

(McKinnon. 2009, p.640)

This benchmark is directed to efficiency, utilization and precision. The government interest is that road freight transport in the UK should be conducted with the highest efficiency possible. Additionally, some indicators can be clearly identified as commun in the logistic industry.

Another insightful conclusion is that the government's intention is that the vehicles should operate as little as possible and to have the least amount of vehicles possible.

2.4.2 Customer Perspective KPIs.

Customers might well be the most relevant of the three actors mentioned previously. Customer satisfaction is critical in logistics as a general and in road freight transport. There is a lot of competition in the industry and an unhappy customer can easily change providers. To understand what are the relevant indicators for customers, the book " The Handbook of Logistics and Distribution Management", will be used as reference. The book offers a complete review of logistics performance, nevertheless only the useful element of road freight will be used.

The authors divide the logistics customer service elements into three categories. Pre-transactional elements, transactional elements and post-transaction elements (Rushton et al. 2014, p. 35). From these categories road freight is present on transnational elements, that includes the physical transportation or movement of goods. According to authors, the following KPIs are related to road freight transportation:

1.*Delivery Alternatives*.

2.*Delivery Time*.

3.*Delivery Reliability*.

4. *Condition of Goods*.

(Rushton et al. 2014, p. 35).

The customer perspective is extremely important. The Pareto rule established that the product surround, composed of delivery services and customer support, only accounts for 20% of the cost while representing 80% of the total impact of the product (Rushton et al. 2014, p. 35). Since logistics combined with customer service only account for 20% of the product cost. Road freight which is a component of logistics does not represent a relevant role in the overall cost of products. Cost is not a relevant performance indicator for customers, in what road freight concerns. The relevant indicators are speed, reliability and alternatives.

2.4.3 Logistics Providers Perspective KPIs.

Logistics providers have specific and well defined objectives in managing their vehicles operations. It is logical to assess that the objective of the industry is to offer adequate service with the lowest possible cost, as a general rule or goal. To understand how logistics providers pursue this goal, the book " The Handbook of Logistics and Distribution Management", will be used as reference. The authors claim the following regarding optimization of vehicle usage:

1. *To maximize the time that vehicles are used (ie make sure they are working for as long as possible)*.
2. *To maximize the capacity utilization of vehicles (ie ensure that all vehicles are as fully loaded as possible within legal limits).*
3. *To minimize mileage (ie complete the work by traveling as few miles as possible)*.
4. *To minimize the number of vehicles used (ie keep the capital or fixed costs to a minimum).*
5. *To ensure that customer specific delivery requirements are met (ie timed deliveries or vehicle type restrictions)*.
6. *A combination of (some or, where possible, all) of the above.*

(Rushton et al. 2014, p. 481).

As it was mentioned previously, logistics aim at operational and cost efficiency, by high vehicle utilization in time and capacity, low distance (as low as possible), the smallest fleet possible (the number of vehicles operated by the company) and satisfying customer service (complaining with delivery times).

Furthermore, it is worth mentioning that there are several additional KPIs that logistics providers can incorporate to benchmark their transportation performance. The article " Integrating KPIs for improving efficiency in road transport", published in the journal " International Journal of Physical Distribution & Logistics Management" has insightful contributions. The researchers selected 12 KPIs after reviewing 130 publications regarding transportation performance:

1. *Lead Time.*
2. *Transport cost.*
3. *On-time delivery.*
4. *Vehicle utilization.*
5. *Customer satisfaction.*
6. *Perfect order fulfillment.*
7. *Returned products.*
8. *Processing time for orders.*
9. *Average delay.*
10. *Errors in orders.*
11. *Transport distance.*
12. *Number of complaints.*

(García-Arca, Prado-Prado and Fernández-González. 2018, p.935)

2.5 IT Emerging Trends

Since the start of the industrial revolution, at the end of the 18th century, technological development has been the main precursor of economic growth and social progress (Stearns, 2013). This progress has enabled enormous prosperity and reached important milestones. One of them, the development of the first computer in 1840 (DeFranco. 2022, p.85). Although this computer can be outperformed by any simple calculator nowadays and be several times faster, this achievement 180 years ago has truly transformed the world. Currently, computers are considered a mundane object that can be found in any household. Nevertheless, the powerful computers now available would not be so useful without being interconnected. In the 1960s, funded as a military project, the development of the internet started. Later on, in the 1980s the application was directed to researchers and universities, with the intent of sharing data between them (Greenstein. 2010, p.1526-1528). The network that we know today was shaped in the 1990s, when privatization and further development by key companies like IBM took place (Greenstein. 2010, p.1528). The internet has truly transformed the word by enabling the instant symbiosis of data. Nonetheless, perhaps the biggest contribution of the internet is enabling the development of new industries that rely on its network to function. The two previously mentioned inventions, together subsidize the adoption of IT (Information & Technology). This term gained traction in the 1980s, when historians and academics realized its importance (Cortada. 2015, .p24).

The world is becoming increasingly digital and there is great potential in the future. Companies are undergoing significant changes as a result of the development of Logistics 4.0. Many experts and businesses believe that automation, networking and digitization will play an increasingly vital role in the sector (Oleskow-Szlapka and Lubiński, 2017, p. 1). Technology is one of the important components that makes logistics efficient and with recent technological advancements, this function is growing more important and diverse (Choi and Song, 2018, p. 1). It is widely acknowledged that the proper application of technology may improve the basic function of logistics while also allowing for the creation of new logistics business models (Choi and Song, 2018, p. 1). For example, bar-coding and radio frequency identification (RFID) technologies are widely utilized to track things and collect real-time data across the whole supply chain (Choi and Song, 2018, p. 1). This data can also be employed in conjunction with information systems like point-of-sale and warehouse management systems to help with management and decision-making (Choi and Song, 2018, p. 1).

2.5.1 Artificial Intelligence (AI)

According to Boucher (2020, p. 1), Artificial intelligence (AI) is a term that refers to systems that exhibit intelligent behavior by analyzing their environment and acting autonomously to achieve certain goals. AI is a system that accurately understands external input, learns from certain data, and then uses those insights to fulfill clear objectives and tasks through flexible adaptation (Bartneck, Lütge, Wagner and Welsh, 2021, p. 8). Bartneck et al (2021, p. 8) goes on to postulate that AI is the study of intelligent agents that acquire information from their surroundings and act on it. Manufacturing systems, responsive agents, logical planners, neural networks, and decision-theoretic systems are all examples of features that map sensory perceptions to actions and cover a variety of ways to reflect these operations, including production systems, reactive agents, logical planners, neural networks, and decision-theoretic systems (Bartneck et al, 2021, p. 8).

Freight movement by road frequently necessitates volume forecasting. Such expertise is required to track industry trends and assist large and small trucking companies in making decisions (Mrowczynska, Ciesla, Krol and Sladkowski, 2017, p. 1). AI technologies in transportation fuel and interact with several megatrends currently affecting the industry (European Parliamentary Research Service, 2021, p. 1). The word "megatrend" rather than "trend" emphasizes that these developments will persist longer and have far-reaching consequences outside of the transportation industry, but their growth patterns and effects are more difficult to anticipate (European Parliamentary Research Service, 2021, p. 1).

Artificial intelligence is most connected with autonomous and semi-autonomous mobility in the transportation sector. These new means of transportation are aimed towards reducing traffic congestion, fuel emissions, air pollution, and driving costs (European Parliamentary Research Service, 2021, p. 1). They should also reduce the frequency of road accidents, increase safety, and handle the mobility demands of businesses in adverse weather. Self-driving vehicles, out of all the forms of transportation influenced by AI, are the ones making significant progress (European Parliamentary Research Service, 2021, p. 1). Although major automakers predict 'real self-driving' or 'almost self-driving' vehicles as soon as 2021, academics warn against fast AI deployment in safety-critical environments, such as driving (European Parliamentary Research Service, 2021, p. 7).

Small firms with little assets and minimal funding can use AI-powered technology to tap into existing resources, such as a city's truck drivers or motorbike couriers, to create effective solutions for their clients (Conde and Twinn, 2022, p. 3). This has the potential to upend existing business paradigms and deliver more cost-effective solutions to industries that are ripe for technology advancements. This is already happening in the e-logistics space, and it might be advantageous in emerging nations where starting a business is difficult due to a lack of funding (Conde and Twinn, 2022, p. 3). More so, Trucking is a prominent target for AI interventions, with cargo delivery as a possible early adopter of autonomous vehicles around the world. (Conde and Twinn, 2022, p. 3).

AI solutions are aimed at improving the transportation grid's efficiency in terms of planning, routing, and parking management. As a result, precise traffic flow projections will decrease fuel costs for urban and freight transportation, as well as accidents on the road network (European Parliamentary Research Service, 2021, p. 37). This is due to the efficiencies provided by traffic control utilizing ITS (Information Technology Systems), which forecasts future demand on the road network at different times of the day, reducing congestion, spreading traffic more evenly (with fewer accidents to disrupt traffic flow), and even optimizing signal lights. (European Parliamentary Research Service, 2021, p. 37).

Truck platooning, which involves linking numerous heavy goods vehicles (HGVs) within a short distance of each other and allowing them to automatically and concurrently accelerate or brake, is also achievable thanks to AI (Niestadt, Debyser, Scordamaglia and Pape, 2016, p. 4). While the lead HGV is operated by a person, the drivers in the following vehicles may only be available in the event of complex traffic circumstances (such as roundabouts) or unforeseeable occurrences, rather than actively driving. It is envisaged that the obligations of following HGV drivers will gradually diminish in the future, until they are no longer required (Niestadt et al, 2016, p. 4). Due to their processing, control, and optimization capabilities, artificial intelligence is critical within driverless vehicles. AI will help make autonomous vehicles safer and more widely available (Soffar, 2019, p. 4).

2.5.2 Augmented Reality (AR)

AR (Augmented Reality) is a type of technology that mixes virtual and real-world information. Multimedia, 3D modeling, real-time tracking and registration, intelligent interaction, sensing, and other technical techniques are among the tools it employs (Chen et al., 2019, p. 1). Its basic premise is to apply computer-generated virtual information to the real environment following simulation, such as text, photos, 3D models, music, video, and so on. The two types of information complement each other in this way, resulting in a real-world improvement (Chen et al., 2019, p. 1). The goal of augmented reality is to make the user's life easier by introducing virtual information not just to his immediate surroundings, but also to any indirect view of the real-world environment, such as a live-video feed (Carmigniani and Furht, 2011, p. 3). The user's perception of and interaction with the real environment is improved through augmented reality. While Virtual Realism (VR) technology, also known as the Virtual Environment, totally immerses users in a synthetic environment without allowing them to view the actual world, AR technology enhances the sensation of reality by superimposing virtual objects and cues onto the real world in real time (Carmigniani and Furht, 2011,p. 3).

Even though augmented reality is still in its early stages of adoption in logistics, it has the potential to provide major benefits. AR, for example, can provide logistics suppliers with instant access to predictive data at any time and from any location (Heutger, 2014, p. 13). This is essential for the precise planning and execution of operations like delivery and load optimization, as well as offering greater levels of customer care (Heutger, 2014, p. 13). Logistics companies have substantially enhanced the efficiency, dependability, and security of freight transportation during the previous decade by utilizing new information technologies (Heutger, 2014, p.15). In areas such as completeness inspections, international trade, driver navigation, and freight loading, AR has the potential to improve freight transportation even more (Heutger, 2014, p. 15). For every e-commerce retailer, Last Mile Delivery is the most expensive step. As client bases expand and become more dispersed, shipping products to customers at a reasonable cost has become a priority for many merchants (Miščević, Tijan, Žgaljić and Jardas, 2018, p. 5) According to a DHL Trend Research survey, drivers spend 40-60 percent of their time identifying the suitable boxes for the next delivery within their truck. Many people rely on their memories of how the truck is loaded to complete this operation (Miščević,et al, 2018, p. 5). The AR application might be used to speed up package identification and reduce the time it takes to figure out which package goes where after delivery (Miščević,et al, 2018, p. 5).

2.5.3 Internet of Things (IoT)

Miščević,et al, (2018, p. 4) postulates that, by 2021, the market for industrial Internet of Things (IoT) is expected to reach $123.89 billion. The term "Internet of Things" refers to the concept of connecting goods or products via the Internet (Miščević,et al, 2018, p. 4). The Internet of Things (IoT) is a subset or extension of the Internet of Everything (IoE). It integrates all M2M (Machine-to-Machine) communications, as well as Machine-to-People (M2P) and technology-assisted People-to-People (P2P) interactions, in this way (Miščević,et al, 2018, p. 4). According to Akkaya and Kaya (2019, p. 100), internet of Things enables people to see, hear, think, and communicate with one another through sharing information such as embedded devices, sensor networks, communication protocols, and so on, as well as the transition of basic technologies from a standard to an intelligent system. Physical factors can link to Internet-enabled devices and systems via the IoT technology (Akkaya and Kaya, 2019, p. 100). Fleet and asset management is another important area where IoT can help. Sensors, for example, can track how often a vehicle, container, or ULD is used or idle. They then send this information to be analyzed for optimal utilization (Macaulay, Buckalew and Chung, 2020, p 20). Many logistics vehicles nowadays are already packed with sensors, embedded CPUs, and wireless connectivity, as mentioned before in this section. Sensors that measure each load's capacity can provide additional information about vehicle spare capacity on certain routes (Macaulay,et al, 2020, p 20). IoT may therefore enable a central dashboard for all business units to focus on discovering surplus capacity along established routes. That would also enhance fleet efficiency, fuel economy, and reduce traffic congestion miles, which can account for up to 10% of truck miles (Macaulay, et al, 2020, p 20).

More linkages between items, places like warehouses and storefronts, and businesses have been developed thanks to the Internet of Things. As a result, internet and network connectivity at supply chain hubs like storage and freight transit can offer significant benefits (Akkaya and Kaya, 2019, p. 100). From temperature and humidity sensors that monitor supply chain quality control, to testing using IoT technologies that can detect when a shipment is contaminated. The logistics industry makes use of IoT in a variety of methods. Companies can link their devices to a single cloud platform, share important data, and obtain real-time forward vision in their operations if they have the correct IoT solutions in place (Akkaya and Kaya, 2019, p. 100).

The primary impact of IoT adoption on businesses is the data generated by the technology. Big, open, and linked (BOLD) are three elements of the Internet of Things (Brous, Janssen and Herder, 2020, p. 3). To begin with, IoT generates huge amounts of data that is often of greater quality than data generated through traditional methods, indicating better scope and often improved accuracy, increased variability, coming from a variety of sources, and being more timely than traditional data, often being real-time or near-real-time and having significantly larger volumes (Brous, Janssen and Herder, 2020, p. 3). In the transportation and logistics industry, the Internet of Things offers several possibilities. Various applications or needs of a transportation system are included in these opportunities. Vehicles can be tracked via IoT in terms of their movement, location, whether they are running or stopped, and whether they are in need of maintenance, among other things (Muni Sankar and Booba, 2020, p. 5). All of these factors can be intelligently monitored with IoT solutions. Vehicles are typically employed for logistical purposes or to transport any big loads that are packed within the truck. During these times, it's critical to keep an eye on and control the truck's indoor parameters, such as temperature, humidity, and lighting (Muni Sankar and Booba, 2020, p. 5).

2.5.4 Big Data

Big data is defined as "datasets that are too large for traditional databases or computers to process" (Panigrahi, Suryadevara, Sharma and Singh, 2019, p. 576). Capture, storage, administration, and analysis are the four major components of big data. Scalability, Availability, Data Integrity, Data Transformation, Data Quality, and Privacy are a few of the primary vulnerabilities connected with Big Data. Scalability of data is an issue in Big Data. The ability of a storage device to deal with an increasing amount of data (Panigrahi, et al, 2019, p. 576). One of the most significant challenges with Big Data is the availability of data that specifies the system's on-demand resources by an authorized individual. Then there's data integrity, which is concerned with the alteration of data by an authorized individual solely to prevent data misuse (Panigrahi, et al, 2019, p. 576).

Big data refers to data sets that are too massive for typical data processing methods to examine and handle (Akkaya and Kaya, 2019, p. 101). Big data refers to data that is growing in amount and diversity while moving at a quicker pace than it has ever been (Akkaya and Kaya, 2019, p. 101). Big Data is made up of various components, but the main attributes are variety, velocity, volume and veracity. Big data is a term that refers to data sets that are larger than the storage, administration, and processing capabilities of commonly used software. The huge dimensions of big data, along with the sophistication of the analysis required to reap the benefits, has resulted in the development of new class technologies and tools to manage it (Akkaya and Kaya, 2019, p. 102). Most companies in the logistics industry have recently begun to position themselves to make more effective use of big data. In logistics and transport fields, big data is utilized to improve operational efficiency (Route Optimization, Address Verification, Shift Planning, Real-Time Analysis), risk management, and customer experience (Akkaya and Kaya, 2019, p. 102).

Volume

The amount of data generated, stored, and controlled within the system is referred to as volume. The growth in volume is responsible for the increase in the quantity of data produced and stored, as well as the necessity to exploit it (Riahi and Riahi, 2018, p. 3). The quantity of data collected by a corporation is referred to as volume. This information must be applied in order to get useful knowledge. Enterprises are drowning in ever-growing data of all forms, readily amassingterabytes or petabytes of data (Hadi, Shnain, Hadishaheed and Ahmad, 2015, p. 20). For example, transforming 12 terabytes of Tweets per day into superior product sentiment analysis; or converting 350 billion annual meter readings to better estimate power use (Hadi et al,2015, p. 20).

Velocity

The rate at which data is transferred from sources such as corporate processes, machines, networks, and human interaction with things like social networking sites, mobile devices, and so on is referred to as Big Data Velocity (Sowmya and Sravanthi, 2017, p. 1). The data flow is vast and never-ending. If one can handle the velocity, this real-time data can enable researchers and organizations to make useful judgments that generate strategic competitive advantages and ROI (Sowmya and Sravanthi, 2017, p. 1). Data velocity necessitates advanced solutions capable of storing, processing, managing, and analyzing streams of heterogeneous data, as well as inferring value from motion (Abu-Salih et al., 2021, p. 5). Velocity symbolizes the recurrence during which data is created, captured, and shared. The data emerges by stream and should be monitored in real time (Riahi and Riahi, 2018, p. 3).

Variety

Big diversity or big varied forms of data sources with different structures from whence it came, and the kinds of data accessible to anyone, is what big variety means. At a higher level, big data can be divided into three categories: structured, semi-structured, and unstructured. Relational database systems, such as Oracle, store structured data (Sun, Strang and Li, 2018, p. 4).The data on the internet is unstructured. Unstructured data makes up about 80% of the world's data. Since they consist of a big number of slang phrases and a mix of languages in a multi ethnic, multi-language context, blogs and tweets on social media are not structured data . The info on the Internet is extremely diverse. In the world of We Chat, for example (Sun, et al 2018, p. 4).

Importing datasets from other repositories is also part of the variety. Business firms, for example, undertake analyses using data from daily structural databases as well as social unstructured data received from social media (Abu-Salih et al., 2021, p. 5). Since the data gathered does not fall into a single category or originate from a single source, there are a variety of raw data formats, both structured and unstructured, that can be received from the web, texts, sensors, e-mails, and other sources. Because of this vast number, standard analytical methods fail to manage big data (Taylor-Sakyi, 2016, p. 2).

Veracity

The provenance, accuracy, and correctness of data are all examples of veracity. Objectivity against subjectivity, sincerity against deception, and credibility against implausibility are some examples. Multiple variables were suggested by Demchenko et al. to ensure the integrity of Big data (Abu-Salih et al., 2021, p. 6). Kune, Agarwal and Buyya (2015, p. 9) states that the term "veracity" refers to the data's ambiguity or unreliability. Because the data is frequently erroneous, filtering and selecting the data that is actually required is a time-consuming task. The correctness, truth, and truthfulness of big data are referred to as veracity. IBM researchers coined the term "veracity" to describe the fourth dimension of big data (Sun, Strang and Li, 2018, p. 5). The reality is that big data has a lot of ambiguity, incompleteness, and unpredictability. This could be one of the reasons why ambiguity is listed as one of the top ten big data difficulties. For many types of large data, accuracy and dependability are less controllable (Sun, Strang and Li, 2018, p. 5). For example, Twitter broadcasts a number of tweets containing hash tags, abbreviations, mistakes, and colloquial speech. As a result, large data has a lot of veracity, which is especially true in big data analytics for business decision-making. As a result, companies must employ big data technologies to remove ambiguous, partial, and questionable data in order to achieve high veracity (Sun, Strang and Li, 2018, p. 5).

2.5.5 Cloud Computing

The term "cloud computing" refers to the use of the Internet to access data, information, or software (Miščević,et al, 2018, p. 1).The aim of this type of computing is that the user is no longer reliant on his or her PC (Personal Computer), but may instead enter and receive data regardless of his or her current location or distance from the office or PC (Miščević,et al, 2018, p. 1).The user may access all of the information regardless of the device they are using, as long as they can connect to the Internet (via a laptop, smartphone, tablet, or other device) (Miščević,et al, 2018, p. 1).

Cloud computing is a technology that links billions of sensors, cameras, displays, smartphones, and other smart communications equipment in cloud data centers end-to-end (Akkaya and Kaya, 2019, p. 101). Cost savings, limitless space, backup and recovery, automated software connectivity, quick access to information, faster deployment, easier service expansion, and new services are just a few of the benefits of cloud computing. Companies that employ cloud platforms have immediate access to local logistics IT expertise and can more readily access global markets (Akkaya and Kaya, 2019, p. 101).

Cloud computing implementation is now commonplace (Wang, 2019, p. 8). Cloud computing allows third parties to host ICT systems on behalf of their clients, using a network of distant servers hosted on the internet to store, manage, and process data. Its versatility and ease of use allow not only major enterprises but also SMEs (Small to Medium Enterprises) to use the system, lowering entry barriers for SMEs and enabling technology service providers to develop new business models (Wang, 2019, p. 8). In road freight, for example, the use of telematics and GPS for truck and trailer tracking is widely established. TSPs encourage on-demand models that allow haulage businesses to lease rather than buy tracking equipment, saving money on fixed assets (Wang, 2019, p. 9). Cloud computing, which includes infrastructure as a service (IaaS), software as a service (SaaS), and platform as a service (PaaS), provides adaptable technology for the freight sector, allowing for flexible model scaling-up. With the improved connectivity provided by full fiber and 5G, this is projected to rise (Wang, 2019, p. 9).

2.5.6 Information Technology in Logistics Information Systems

As it can be seen, technological dispersion and dissemination are transforming how businesses function and how they communicate with consumers and suppliers (Prokopovic, Prokopovic and Jelic, 2016, p. 177). Current techniques in charge of managing logistics operations are becoming insufficient in today's dynamic market, forcing managers to reinvent existing methods and modernize logistics activities such as transportation, warehousing, materials management, purchasing, and order processing (Prokopovic,et al, 2016, p. 177). Companies who neglect these developments and fail to fulfill the market's current requirements may lose market share and competitive advantage. As a result, the logistics information system, which is now the thread that connects the logistical activities inside an integrated road logistics system, is given a lot of attention (Prokopovic, et al, 2016, p. 177).

Enterprises can access acquired data through information technologies, which transforms it into useful information. Furthermore, they allow data to be stored and shared across networks from one user to another (Kalkan, 2018, p. 14). Data processing applications were the first applications to use information technologies in businesses in the 1960s. By integrating information technology, new trade and operation ways that are becoming more efficient have emerged (Kalkan, 2018, p. 14). Electronic data interchange (EDI), intranet, extranet, and the internet are examples of these technologies. The most commonly utilized information technology applications in highway transportation operations are vehicle tracking systems and driver tracking systems (Kalkan, 2018, p. 14). A logistics company can follow its cars utilized for highway transportation operations at all times thanks to vehicle tracking systems, and clients can watch them by interacting with their own carrier. Real-time vehicle tracking systems are essential for supply chain management and risk mitigation in logistics operations (Kalkan, 2018, p. 14).

The design of a logistics information system should incorporate all of the information-related components that are required to support the operation's procedures and physical structure (Rushton, Croucher and Baker, 2014, p. 95). In addition to these, business-wide information systems (enterprise resource planning or ERP systems) can have a direct impact on logistics processes and network design (Rushton, Croucher and Baker, 2014, p. 95). Electronic point of sale (EPOS), electronic data interchange (EDI) between organizations, warehouse management systems, truck routing and scheduling, and many more information technologies may be used to support logistical processes and network design (Rushton, Croucher and Baker, 2014, p. 95).

2.5.7 Information Technology in Freight Transport

The circular economy and ecommerce are changing customer behavior. New business models, and automation are just a few of the developments brought on by digitalization in the freight transportation sector (Pernestål, Engholm, Bemler and Gidofalvi, 2020, p. 2). Cooperative Intelligent Transport Systems (C-ITS) can enhance traffic flow, lower fuel costs, and boost transportation efficiency. Digitalization allows for the optimization of existing value chains as well as the rearrangement of the entire value chain. Multimodal transportation can be streamlined and transporter efficiency can be increased with digitization and connectivity (Pernestål, et al, 2020, p. 2).

Truck platooning is predicted to give various benefits at lower degrees of autonomous driving. Long haulage on highways between logistical centers, with human piloted vehicles executing the first and last mile, is projected to be the first large-scale use case for driverless trucks on public roadways (Pernestål, et al, 2020, p. 2). It could lead to a new road freight transport organization that is similar to current multimodal freight transport networks. Long-term effects are expected to include cost reductions for the trucking industry, which will lead to an increase in road transport capacity (Pernestål, et al, 2020, p. 2). In addition, vehicle usage is predicted to rise, resulting in fewer truck fleets. The development of automated trucks is projected to have a substantial impact on the business models and operations of freight transportation companies (Pernestål, et al, 2020, p. 2). Intelligent Transportation Systems (ITS), such as automobile navigation systems and VICS (Vehicle Information and Communication System), which provides drivers with traffic information, have begun to find their way into private vehicles in the transportation business (Yoshimoto and Nemoto, 2005, p. 16). It is now possible to track the location of commercial trucks and freight using GPS, and to use this information to optimize travel routes and freight arrival times. Furthermore, the usage of electronic tags (RFID) and Dedicated Short Range Communication (DSRC) systems, such as the ETC system for collecting highway tolls, shows considerable promise (Yoshimoto and Nemoto, 2005, p. 16). Furthermore, through the development of e-commerce, e-logistics, and e-fleet management, ICT has an impact on road freight transportation (Yoshimoto and Nemoto, 2005, p. 16).

2.6 Multi criteria decision making research methodology

The decision-making technique is a human activity where the decision-maker is inevitably influenced by a variety of factors that, in the end, determine the prevailing decision (Munier, Hontoria and Jiménez-Sáez, 2019, p. 1). Multicriteria Conclusion-Making (MCDM) has emerged as one of the most significant and rapidly increasing subfields of Operations Research and Management Science, with the goal of obtaining the winning decision (Munier, Hontoria and Jiménez-Sáez, 2019, p. 1). It began with Kantorovich's contribution during WWII and continues with today's MCDM, influenced by utility theory in the first instance and multiple objective mathematical programming in the second. Researchers have been perplexed by the fact that different mathematical techniques in solving multi-criteria problems give diverse outcomes since the discovery and execution of methods to solve multi-criteria problems in the 1960s (Munier,et al, 2019, p. 8). It is now widely assumed that this is owing to the fact that decision-making is mostly a subjective process, which explains why, while starting with the identical initial matrix, employing the same mathematical tools, and pursuing the same goal, the outcomes differ (Munier,et al, 2019, p. 8).

All MCDM methods make the options and their contributions to the various criteria apparent, and they all demand judgment. The way they aggregate the data, however, differs (Department for Communities and Local Government, 2009, p. 9). For the different criteria, formal MCDM approaches often include an explicit relative weighting system. The principal purpose is to address the challenges that human decision-makers have in dealing with enormous amounts of complex data in a consistent manner. MCDM approaches can be used to find a single most desired choice, rank options, short-list all number of options for further analysis, or simply separate acceptable from unacceptable possibilities (Department for Communities and Local Government, 2009, p. 9).

2.6.1 Technique for order preference by similarity to an ideal solution

TOPSIS (Technique for order preference by similarity to an ideal solution) is a useful method for resolving multi-criteria decision-making (MCDM) problems (Huang and Jiang, 2017, p. 2). Its goal is to choose the option with the smallest distance from the positive ideal solution (PIS) and the the furthest distance from the negative ideal solution (NIS) (Huang and Jiang, 2017, p. 2). Yoon and Hwang were the first to introduce TOPSIS, a multiple-criteria decision-making process (Rahim et al., 2018, p. 2). TOPSIS determines the relative proximity of an alternative to the optimal solution and uses the Euclidean distance to find the shortest distance from the positive optimum solution and the furthest distance from the negative ideal solution from a geometrical point (Rahim et al., 2018, p. 2). The sum of all the best values that may be attained for each characteristic is interpreted as a significant optimal solution, whereas the total of the very worst values achievable for each feature is described as a negative ideal solution (Rahim et al., 2018, p. 2).

Furthermore, By taking the relative proximity to the positive ideal solution, TOPSIS considers both the range to the positive ideal solution as well as the distance to the negative optimal situation (Rahim et al., 2018, p. 2). Alternate priority orders can be obtained based on a comparison of relative distances. This strategy is commonly used to finish the decision-making process. This is because the concept is straightforward, straightforward to comprehend, efficient to compute, and capable of evaluating the relative performance of alternative decisions (Rahim et al., 2018, p. 2). According to Rahim et al (2018, p. 2), the steps in calculating the TOPSIS method are:

1. Make a decision matrix.

2. Standardized weighted.

3. Defining the ultimate result matrix of positive and negative best solutions .

4. Determining separation.

5. Calculating positive ideal solution.

6. Alternative rank.

2.7 Literature Review Results

2.7.1 Selected Road Freight KPIs

With the purpose of selecting KPIs that offer an holistic benchmarking of road freight transportation, plus taking into account the contribution made by Parmenter on the characteristics of effective KPIs. The following four indicators have been selected:

1. *Vehicle utilization.*
2. *Capacity utilization.*
3. *Successful deliveries.*
4. *Fuel consumption.*

These KPIs were constructed to represent the interests of the three groups previously mentioned: customers, logistics providers and governmental policy. The performance indicators are relevant, measurable and low-biased.

2.7.2 Selected IT Trends

The following are the selected IT trends which have an impact on road freight transportation.

1. *Artificial intelligence (AI)*
2. *Augmented reality (AR)*
3. *Internet of things (IoT)*
4. *Big data & analytics*
5. *Cloud computing*

The 5 mega trends from the literature review are going to be used in this thesis written upon the investigation and their impact on road freight transport. These trends have been chosen as they are the major ones which are being implemented in the logistics and transportation industry. Moreover, It can be noted in the Literature review that, these trends works hand in hand with other aspects of general information technology such as Radio frequency identification (RFID), Electronic data interchange (EDI), Cooperative Intelligent Transport Systems (C-ITS), VICS (Vehicle Information and Communication System), etc within the logistics and transportation sector.

3. Methodology

The methodologies used in our study are presented in this chapter. The research paradigm and strategy are introduced first and then an explanation of the report's design, that comprises key research elements. Following that, the data collecting procedures are provided. Finally, the methodology for assessing the research's quality was detailed.

3.1 Research Approach

When assessing research approaches, quantitative, qualitative, and mixed methods research are the three most popular methodologies. In order to select the most appropriate technique, the researcher foresees the types of data that will be required to answer the research question. Numerical, textural, or both numerical and textural data can be required in order to answer the research question (Juma, 2021, p. 3). Henceforth, researchers usually use the quantitative technique to answer research questions that require numerical data, the qualitative approach to answer questions that require textual data, and the mixed methodologies approach to answer questions that require both numerical and textual data (Juma, 2021, p. 3).

In this investigation, the data was collected by conducting interviews with a questionnaire. Additionally, the purpose of the investigation is to predict the potential influence on selected IT trends on KPIs. To achieve this goal, a questionnaire was developed to understand the actual influence of IT trends on KPIs, as well as the future influence. The information obtained is built on each expert's experience as well as their professional opinion. As it is required by the TOPSIS methodology, their answers have to be numeric to be imputed into the model for obtaining results. The nature of this investigation is purely qualitative, since the information obtained by the questionnaire relies on their experience and professional opinion. Moreover, TOPSIS is well suited for both quantitative and qualitative research (Supraja & Kousalya, 2016, p. 1). Making the selection of this MCDM method a sound decision.

3.2 Research Design

The techniques for gathering, evaluating, understanding, and publishing data in research investigations are referred to as research designs. It is a comprehensive strategy for linking conceptual research concerns to relevant and feasible empirical research (Boru, 2018, p. 1). To put it another way, the study design establishes the procedure for gathering and analyzing the relevant data, as well as how all of this will be used to answer the research question. According to Akhtar, the phases in research designing consists of specifying the problem or topic to be studied, framing the research design, planning a sample (probability or non-probability or a combination of the two), collecting the data, analyzing the data (editing, coding, processing, tailgating), and preparing the report are the six phases of the research process (Akhtar, 2016 p. 70).

The first step focuses on the creation and development of theories. The research question aids researchers in gaining a deeper grasp of the situation and improving their theories. In addition, the sample size needed to be established. In this scenario, the sample size ranges from four to six organizations. According to current literature, LSDGM (Large Scale Group Decision Making) is appropriate when at least 20 decision makers participate in the process, on the other hand GDM

(Group Decision Making) is appropriate when less than 20 decision makers participate in the process (Tang & Liao, 2021 p.2). Additionally, TOPSIS offers an advantage when compared to other MCDC techniques suited for GDM. TOPSIS offers a rational approach by taking into account actual values and then comparing it to the ideal solution (Wu, Kou & Peng, 2016, p.6). Furthermore, taking into account the number of decision makers, TOPSIS was used to process the data gathered for this investigation.

Finally, structured interviews were conducted, with the use of a questionnaire. The questionnaire was structured in two stages. Stage 1 focused on the current influence of the selected IT on road freight transport and stage 2 focused on the future impact of IT on road freight transport. Stage 2 has additional consideration since it is focused on prediction, specifically the use of 3-dimensional decision matrix. This technique is used for increasing the accuracy for future based decisions, the number of questions is triple in order to obtain a pessimistic, most likely and an optimistic point of view. The results obtained are assigned to the PERT model. This model takes into account the pessimistic, most likely and optimistic results and outputs a single score. The output is then used in the TOPSIS model (Sorooshian, 2021 p.3). Further information about this process can be found later on in this chapter on data collection.

The acquired data was imputed into TOPSIS and compared between the two stages of the research, conclusions were drawn based on the findings. All of these steps were conducted following the eight criteria of quality in qualitative research, as well the methodologies mentioned in the research approach. Further information about the quality of research will be found in this chapter.

3.3 Data Collection

In order to conduct proper research with insightful outcomes, primary and secondary data has been collected and analyzed in this paper. The secondary data was obtained by the elaboration of a literature review, with the intention of gathering all the relevant information available from relevant sources as well as further understanding of key concepts and problems. The main sources used on the review are: peer review articles, books, official enterprise information, non-governmental organizations publications and governmental organizations official documents.The primary data has been generated by the use of interviews. According to Collins & Hussey, interviews and focus groups are an adequate source of primary data collection (Collis and Hussey. 2014, p.130). Furthermore, the individuals selected for the interviews are specialists in the industry with valuable experience.

3.3.1 Literature Review

The literature review was conducted in two stages. The first stage consisted of all the relevant topics identified by the researchers. Starting with road freight transport, continuing with logistics and finalizing with IT emerging trends and technologies. Additionally, while researching the previously mentioned topics, several sub-topics were added when current literature signal their importance. Sub-topics like: 3PLs, automatization, to mention a few. Upon completion of this first stage, an evaluation was conducted by the supervisor. Which suggested further discussion within key subjects: KPIs in road freight transport and IT emerging trends. This observation was valuable since these topics lay the foundation of the problematic inquiry in this paper. Furthermore, the second stage consisted in gathering additional information and discussion in the two topics previously mentioned. By the end of this stage, a comprehensive literature review has been developed. With more than 70 trustworthy references, extracted from multiple databases.

3.3.2 Interviews

Before assessing what type of interview methodology was the most suitable for this investigation, the intention of the interviews must be established. The intention of the interviews is to gather primary data about the future influence and effects of IT trends on road freight transport KPIs. With a clear objective on hand, specific interview methodology can be assessed. According to Cassell, there are four levels of structure for interviews:

1. *Structure*

   Purpose: Gather attitude/opinion data that can be quantified for analysis and theory testing.

2. *Semi structured, thematic format*

   Purpose: Gather information/data about a given topic or theory testing.

3. *Semi structured, distinctive format*

   Purpose: Generate data through understanding how interviewees make sense of different events. As well as, generating data by encouraging participants to project their own views or feelings.

4. *Unstructure.*

Purpose: Gain insights into individuals' lifeworld.

(Cassell. 2015, p.13).

From these structures, a structure interview has been selected. This methodology provides the best structure to gather data from professionals in the industry by the use of a survey. Furthermore, the interview guide should contain a specific set of questions with a numerical output for gathering data (Cassell. 2015, p.13). Additionally, the structure selected provides two types of interviews, information gathering and hypothesis testing. Information gathering interviews are geared towards obtaining data from professionals on a specific topic. On the other hand, hypothesis testing interviews are focused on theting theory through an hypothesis (Cassell. 2015, p.15). Information gathering interview is the most appropriate technique for gathering primary data in this investigation.

3.3.3 Survey

The survey was developed with two stages. The first stage measured the actual contribution of IT trends on the four selected KPIs mentioned on literature review results. Since five IT trends were selected, as well as 4 KPIs for impact measurement, the first stage of the survey has twenty questions in total. The second stage of the survey is more extensive. In this section the questions are directed to see the future impact that each technology can have per KPI. Furthermore, since these questions are focused on prediction, the PERT methodology was selected. This methodology requires to triple the number of questions per criteria of evaluation (Sorooshian, 2021). The interviewee has to answer questions from a pessimistic perspective, most likely perspective and optimistic perspective. In the appendix the questionnaire can be found.

The questions are answered on interval scales. This type of scale offers the following benefits, the same power of nominal and ordinal scales and the incorporation of equality of interval (Cooper and Schindler. 2014, p.276). The scale proposed is from 1 to 10. The interviews can select any of the 10 numbers. The number 1 meaning no or limited contribution and 10 meaning great or meaningful contribution.

3.3.4 Respondents

The selection of the right respondents is crucial for the validity and reliability of the investigation. In order to accomplish these objectives the following criteria was established for participating in the survey:

1. *The respondent has to work for an organization that utilizes road freight transportation in its operations.*
2. *The respondent has one of the following functions on the organization or similar: logistic, purchasing, transport, supply chain, operations. As well as any high level position.*
3. *The respondent has confirmed that IT technologies are relevant and familiar to him/her*.

The respondent that qualifies with the criteria above can provide the information necessary for this investigation. Additionally, the respondent is familiar with the selected KPIs and understands the relevance. Table 1 provides more information about the respondents and the organization they work for, as well as the interview. Additionally, in the appendix all the respondents' answers are displayed.

Table 1 - Respondents & Interviews

Respondent	Position	Company Description	Type of interview	Language
R1	Category Buyer	Multinational Car Production	Telematic (zoom)	English
R2	Transport Material Responsable	Multinational Truck and Heavy Vehicle Production	Telematic (zoom)	English
R3	CEO	Multinational 3PL	Telematic (zoom)	Spanish
R4	Supply Chain Manager & Transport Manager	Multinational Foods Production and Distribution	Telematic (zoom)	Spanish
R5	Logistic Manager	Furniture Production and Distribution	Telematic (zoom)	Spanish
R6	Head of Business Architect	Multinational 3PL	Telematic (zoom)	English

3.4 Research quality

While conducting any type of research, assessing and guarating the quality of the study is essential. By providing sounding evidence that the research was properly conducted, credibility can be gained. When comparing qualitative research with quantitative research, key differences are found. Furthermore, authors have even criticized the "objectivity" and "subjectivity"of qualitative methodologies (House. 2018, p.8). Nevertheless, qualitative research has been established as a scientific method in social sciences with adequate techniques to ensure research quality. To ensure the overall quality of this research, " The eight criteria of quality in qualitative research" has been implemented. This model developed by S.Tracy in 2010, according to the author "...presents eight criteria of qualitative quality, each that may be achieved through a variety of craft skills that are flexible depending on the goals of the study and preferences/skills of the researcher" (Tracy. 2010, p.840) . The eight criterias presented by the author are the following: worthy topic, rich rigor, sincerity, credibility, resonance, significant contributions, ethics and meaningful coherence.

Worthy topic

Numerous collaborations were provided to exemplify the worthiness of the topic. Especifically, in the background and problem description. Furthermore, quotations of important decision makers in the automotive, computer and logistic industry supported the relevance of IT technologies in road freight transport.

Rich rigor

This criteria evaluates the data collection procedure and analysis. Particular attention must be placed on the amount of data that is collected. Quoting the author, “ Did the researcher spend enough time to gather interesting and significant data?” (Tracy. 2010, p.841). Assessing the correct amount of data depends on the methodology. In this particular case, TOPSIS has been selected as the most appropriate methodology. With 4 to 6 interviews, TOPSIS can be developed and results can be obtained. The number of interviewees was previously discussed with the supervisor for approval. Additionally, the methodology in developing and conducting the interview has been properly construed.

Sincerity

This criteria is designed to make the researchers self-reflect about possible biases and their potential influence in the outcome of this investigation (Tracy. 2010, p.842). It's worth noting that the process of self-reflecting can be complex and perhaps not suited for a master thesis. On the other hand, the author mentions that transparency in the process is relevant as well. All the methodology, regarding data collection and analysis has been outlined. Moreover, the transcripts of the interview are available in the appendix of this investigation. Summarizing the efforts made by the authors to create as transparent investigation as possible.

Credibility

As the author points out, the researchers have to accomplish trustworthiness, verisimilitude and plausibility in the results (Tracy. 2010, p.843). To fulfill these expectations the paper must contain a detailed description of the investigation and the use of multiple and credible data sources. The primary and secondary data used in this investigation are solid. The interviews were conducted to experts in the field. Additionally, the sources in the secondary data are academically adequate. Finally, the researchers have reflected on the sources and commented when necessary.

Resonance

The author refers to resonance as the ability of the researchers to transfer information and ideas to the audience (Tracy. 2010, p.845). Beyond holding an adequate format and linguistic coherence, particular emphasis is laying on transferability. Again, that the information and ideas resonate in the audience and provoques further discussion. In efforts to resonate with the audience, this report contains well structured paragraphs with academic language.

Significant contributions

The contributions of any study should aim to be as significant as possible, without overstating or amplifying the results. Two pillars in this step should be taken into consideration, theoretical significance and heuristic significance (Tracy. 2010, p.844). Theoretical significance is the development of new theory, or contributions to existing theory. While, heuristic significance is the encouragement of further research in a particular topic.

This research favors heuristic contributions, by casting light into new technologies and the potential influence in road freight transport. On the other hand, the contributions are limited due to time constraints as well as corresponding to a master level investigation.

Ethics

This research has followed strict ethics guidelines. Starting by complying with the Harvard reference method and avoiding any inadequate appropriation of knowledge. Additionally, the interviews follow a guideline requiring consent for the interviewee to be recorded, completing a transcript. Plus making sure that sensible data is anonymized. The researchers analyzed the results of the investigation and did not find any ethical considerations by making this information public.

Meaningful coherence

This concept refers to the adequate interpretation and connection between theory, the research paradigm and accomplishing the research objective (Tracy. 2010, p.848). Every step of the research process was developed following academic and research guidelines. Additionally, the research objective, in this case answering the research question, was obtained by the development of primary and secondary data as well as TOPSIS as an interpretive technique to generate adequate results.

4. Results of Study

This chapter summarizes the research findings based on the information gathered during the interviews. The interview is the primary source of information, which is supported with library research. The findings will be presented in accordance with the study's research objectives.

The first table corresponds to the weightage assigned at each KPI.The survey was not designed to obtain insights about each KPI relevance according to the interviewees. Furthermore, the literature review did not produce any indication of the differences in relevance between the selected KPIs. Taking into account all this information, all the KPIs where assigned the same weightage, presented in table below.

Table 2 - KPI Weightage

KPI	Weightage	%
Vehicle Utilization	**0.25**	**25.00**
Capacity Utilization	**0.25**	**25.00**
Successful Deliveries	**0.25**	**25.00**
Fuel Consumption	**0.25**	**25.00**

All the results from the questionnaire were compiled and the arithmetic average was calculated, the tables corresponding to these calculations can be found in the appendix. The results corresponding to the weighted normalized matrix are presented in the following tables. Table 2, corresponds to the first stage of the questionnaire, 20 questions in total. In this stage the objective was to obtain measurements of the current state of the selected IT trends in influencing the KPIs. On the other hand, table 3 describes the data collected from the second stage of the interviews. Which corresponds to the future potential of the selected IT trends on affecting the KPIs, 60 questions in total.

Table 3 - Weightage Normalized Matrix Stage 1

IT Trend	Vehicle Utilization	Capacity Utilization	Successful Deliveries	Fuel Consumption
Artificial Intelligence (AI)	**0.1122**	**0.1126**	**0.1222**	**0.1192**
Augmented Reality (AR)	**0.0706**	**0.0779**	**0.0872**	**0.0662**
Internet of Things (IoT)	**0.1330**	**0.1169**	**0.1222**	**0.1280**
Big Data & Analytics	**0.1372**	**0.1386**	**0.1222**	**0.1236**
Cloud Computing	**0.0914**	**0.1039**	**0.1003**	**0.1104**

Table 4 - Weightage Normalized Matrix Stage 2

IT Trend	Vehicle Utilization	Capacity Utilization	Successful Deliveries	Fuel Consumption
Artificial Intelligence (AI)	**0.1267**	**0.1269**	**0.1177**	**0.1499**
Augmented Reality (AR)	**0.0763**	**0.0653**	**0.0798**	**0.0681**
Internet of Things (IoT)	**0.1264**	**0.1160**	**0.1206**	**0.1213**
Big Data & Analytics	**0.1284**	**0.1415**	**0.1261**	**0.1139**
Cloud Computing	**0.0900**	**0.0929**	**0.1086**	**0.0875**

Finally, the results of the TOPSIS model are noted on the tables below, table 4 and table 5. Corresponding to the two stages present in this investigation. The tables present the following information: ranking, IT trend, euclidean distance from the ideal best (Si+), euclidean distance from the ideal worst (Si-) and performance score.

Table 5 - TOPSIS stage 1

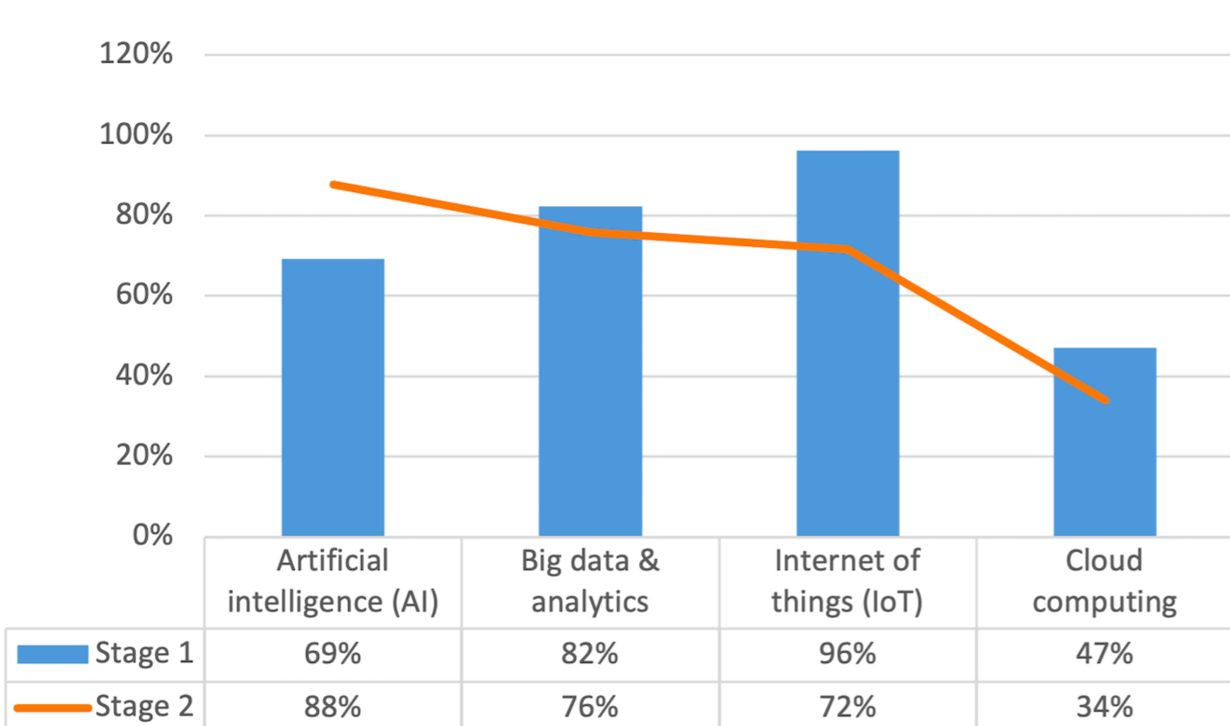
Raking	IT Trend	Si+	Si-	Pi	%
1	Big Data & Analytics	0.0044	0.1123	0.9621	96.21
2	Internet of Things (IoT)	0.0220	0.1022	0.8225	82.25
3	Artificial Intelligence (AI)	0.0371	0.0834	0.6921	69.21
4	Cloud Computing	0.0638	0.0568	0.4707	47.07
5	Augmented Reality (AR)	0.1146	0.0000	0.0000	00.00

Table 6 - TOPSIS with PERT stage 2

Raking	IT Trend	Si+	Si-	Pi	%
1	Artificial Intelligence (AI)	0.0169	0.1202	0.8768	87.68
2	Big Data & Analytics	0.0360	0.1129	0.7580	75.80
3	Internet of Things (IoT)	0.0387	0.0977	0.7161	71.61
4	Cloud Computing	0.0896	0.0464	0.3407	34.07
5	Augmented Reality (AR)	0.1371	0.0000	0.0000	00.00

Additionally, figure 2 offers a comparative view of the differences in results between the two stages. The results are expressed in percentages and Augmented Reality (AR) is excluded from the graph. This is due to the fact that in both stages the performance score was 0 and did not provide any benefit to this comparative analysis figure.

Figure 2 - Statistical comparison stage 1&2



4.1 Artificial Intelligence (AI)

The highest ranking trend in the second stage is Artificial Intelligence, with a performance score of 0.88/1.00. Additionally, this trend ranked third on the first stage with a performance score of 0.69/1.00. The results obtained indicate a solid actual performance, with vast potential in the future.

4.3 Big Data & Analytics

Big data and analytics scored second place on the second stage, as well as on the first stage of the research. Obtaining the following performance scores, 0.76/1.00 on the second stage and 0.82/1.00 on the first stage. Particularly, the observed trend decreases on contribution to the future scenario, with an impressive high performance score on the first stage. Maintaining a similar trend when compared to artificial intelligence.

4.2 Internet of Things (IoT)

The third ranked trend is Internet of Things, with a performance score of 0.72/1.00 on the second stage. Additionally, on the first stage this trend scored in the first place with a score of 0.96/1.00. This technology has a high contribution to road freight transportation, based on the measured KPIs. Furthermore, when future contribution is assessed the potential decreases, although it still holds a high score.

4.4 Cloud Computing

Cloud computing scored fourth place in both the first and second stage exercises. The following performance scores were obtained: 0.34/1.00 and 0.47/1.00 respectively. Interestingly, in this case the decreasing trend continues. Similar to the trend observed in Big Data & Analytics and Internet of Things. Although, it is worth noting that it is quite moderate in proportion.

4.5 Augmented Reality

Lastly, in fifth place in both stages of the investigation is augmented reality. It is worth noting that both performance scores are 0.00, this isolated score is due to the formulas used in the TOPSIS calculations. When calculating the euclidean distance from the ideal worst, the model takes into account the ideal best and ideal worst values. Augmented reality had the worst scores in all four KPIs and in both stages of the process, which generated a value of 0. The last step in the process is calculating the performance score, the model simply adds the best and worst ideal values and divides it by the ideal worst. Since the ideal worst is 0 for augmented reality, the output is 0.

5. Discussion, Conclusion and Future Recommendations

The conclusions drawn from the findings on the future impact of information technology in road freight transport are detailed in this chapter. The study's conclusions were based on the goals of the research, research questions, and findings. The consequences of these findings, as well as the recommendations that follow, will be discussed. Recommendations were made based on the findings and goals of the study.

5.1 Introduction

As mentioned above in chapter 2, five IT megatrends (artificial intelligence (AI), big data and analytics, internet of things (IOT), cloud computing and augmented reality) were used in this study. It can be noted in chapter 1 that IT has already impacted the road freight industry in the past and recent years but the main aim of this study is to figure out the future impact of the selected IT mega trends in road freight transport. The KPIs of road freight transport that were selected are capacity utilization, vehicle utilization, successful deliveries and fuel consumption as mentioned in chapter 2 earlier in this study. This chapter discusses the research's primary findings and, whenever necessary, connects the literature to the findings.

5.2 Discussion

5.2.1 Artificial intelligence (AI)

From the research that was conducted and interpretation of results using TOPSIS in chapter 4, as it stands in the current era (stage 1 in Table 4 above), it is noticeable that AI has 69.21% impact in road freight transport and it happens to be the third highest out of all the IT megatrends that were considered. The results also show that AI is slightly above 50% which might mean that not many companies have implemented AI in their road transportation operations. This could be due to the fact AI can be costly to run and costly to invest in the AI systems.

Furthermore, as shown in Table 5 above, AI resulted in 87.68% which is the highest of all the IT trends in stage 2 for the future impact in road freight transport and there is an increase from the current impact of 69.21%. This increase in the future is most likely from the fact that many companies would be more willing to implement AI than before in their transport and logistics operations. Therefore, improve transportation forecasting, reduction of logistics bottlenecks and delays and enhance effectiveness on route optimization, planning and delivery schedules as mentioned from the The Handbook of Logistics and Distribution Management in chapter 2.

From table 2 and 3 above it can be seen that the increase of impact of AI on vehicle and capacity utilization in stage 2 from stage 1 is more or less the same and this may mean that transport and logistics companies view these 2 in the same way. The shown increase might be due to the fact that many companies would want to implement truck platooning as mentioned earlier in chapter 2, through AI so as to have effective capacity and vehicle utilization. As for AI on successful deliveries it can be noted that, there is a slight decrease in stage 2 from stage 1 which might mean that AI is helping so much in making successful deliveries currently but in the future there might be some road and logistics companies who would opt for other alternatives such as investing more in internet of things or big data that AI. It is also indicated that there is likely to be an increase in the future impact on fuel consumption by AI than recent, this may be because of the same issue of truck platooning as mentioned in the above paragraph, that improves fuel economy. Also the use of autonomous vehicles (AVs) might improve fuel consumption as AVs are expected to be all electric in the future.

5.2.2 Internet of things (IoT)

The IoT is the second most popular trend, with an 82.25 percent first-stage performance score. Furthermore, this trend came in third place with a score of 71.61 percent on the second stage. These results show that generally the IoT is mostly used by many road and logistics companies in the current era and it is most likely that it will decrease slightly in the future but still it will be widely used. That slight reduction may be due to the fact that some companies will shift their focus on IoT in the future and concentrate on other alternatives such as big data and analytics or cloud computing.

Furthermore, as shown in tables 2 and 3 in chapter 4 on the results of current and future impact of IoT on vehicle and capacity utilization, successful deliveries and fuel consumption, it can be noted that the differences are more or less the same. This indicates that the current and future impact of the IoT on these road freight KPIs will most likely be maintained, maybe because of the fact that most companies within road and logistics are and will benefit from IoT in their operations. This may be due to what has been mentioned in chapter 2 earlier that IoT encourages fleet and asset management, the connection between machines and devices and people. Therefore, this may enable truck drivers to use the best routes with less or congestion hence, enables capacity utilization, vehicle utilization, successful deliveries and reduced fuel consumption.

5.2.3 Big data analytics

Big data and analytics were ranked second in the second stage of the research and first in the first stage. 75.80 percent on the second stage and 96.21 percent on the first stage were the performance scores. This results shows that big data analytics is impacting road freight transportation now more than it is most likely to do in the future although the impact will still be way above 50%. It is mostly like that some companies may find it difficult and costly to invest in big data hence, can search for cheaper alternatives.

In addition, as indicated in table 2 and 3 above in chapter 4, there are slight differences of the impact of big data on the road freight KPIs for now and in the future except for fuel consumption which is showing a bigger difference. Therefore, this may mean that road freight companies will continue to invest in big data analytics to have the benefits from the volume, velocity, veracity and variety of data. This will enhance the effectiveness on capacity utilization, vehicle utilization fast deliveries in the future and partly on fuel consumption.

5.2.4 Cloud computing

As shown from the results in chapter 4, In both the first and second stages, cloud computing came in fourth position. The performance ratings were 47.07% and 34.07% respectively. The results show that the impact of cloud computing in road freight transport both in the future and current era is less than 50%. Most likely this means that many companies are not utilizing cloud computing so much but rather making more use of the AI, IoT and big data as they are the ones with the current and future impact above 50%. The reasons behind this might be that cloud computing is costly to implement and to maintain and this is likely to be the case in the future.

5.2.5 Augmented Reality (AR)

As explained above in chapter 4.5 augmented reality has the fifth position with a score of 0 in both stages 1 and 2 and those null scores are due to the method of TOPSIS used for interpretation of the data. It can be noted that the impact of AR in road freight transport is way less than 50% which shows that most companies are not using AR in their road freight transport operations as they are other better options. This is most likely to be the same issue in the future.

5.3 Conclusion

Technological and technical advance has proven to be the main enable of improvement in efficiency in many industries, road freight transportation has not been the exception. Improvements in engines as well as in other areas has constantly improved the capacity, reliability and speed in which road vehicles like trucks can move cargo in a wide range of conditions and situations. Moving forward, technological advances have started to take a more intangible contribution to the naked eye. New improvements focused more on the integration and incorporation of new systems and technologies, rather than a bigger engine or increased cargo capacity. This information and technology trends have proven to have a measurable impact on the industry, our literature review indicated that the impact on the industry was real and the secondary data gathered from experts on the industry confirm it. On the other hand, this investigation was not focused on assessing this information, since it was already well researched by many universities and institutions. The research objective was understanding the future impact of this technology on the industry, by the use of selected KPIs.

5.3.1 Responding research question

To what degree IT emerging trends will impact KPIs in road freight transport?

The model used in this study, TOPSIS, offers a direct answer to the research question. From the selected IT trends, Artificial Intelligence (AI), Internet of things (IoT) and Big Data & Analytics will have a relevant impact on road freight KPIs. All of the previous mentioned IT trends scored well above 50%, Artificial Intelligence (AI) 88%, Big Data & Analytics 76% and Internet of things (IoT) 72% . It is important to acknowledge that predictive capabilities of PERT used in conjunction with TOPSIS can have inaccuracies, as with any type of predictive assessment tool or methodology. Take this into account, the ranking could be affected in the future since these three trends have near scores. Particularly, Internet of things (IoT) and Big Data and Analytics. Preceding with Cloud Computing, this IT trend will not have a relevant impact on road freight transport provided the low score obtained of 39%. Finally, no conclusions can be drawn with the last IT trend, Augmented Reality (AR). As it was discussed on chapter four and five, the TOPSIS model could not offer any analysis on this case since Augmented Reality (AR) scores the worst scores on every category, which resulted in a performance score of 0. It is evident that the secondary data did not support the future relevance of this technology. Nevertheless, obtaining the lowest performance score possible does not seem logical in any sense, which points to a potential weakness on the TOPSIS model. Giving this information, no conclusion can be drawn on Augmented Reality (AR).

5.4 Future Recommendations

The study conducted for this thesis has identified a number of subjects that would benefit from additional investigation. In chapter one it can be identified that in several areas information is inadequate. While the research in this thesis tackled some of them, others remained. In particular, there is a need for further research on how IT trends will influence other modes of transport individually in the future other than the road which are sea, air and rail transport. In addition, this further research can also be done investigating the future influence of IT trends on transport from a general perspective or in all logistics operations if time permits.

It can be noted that in this research only five IT trends were chosen by the researchers to be investigated due to the limited time but actually there are many of them. On the same note, only six interviews were conducted in this research due to the same issue of limited time. However, there is need for further research taking into account all other IT trends which were not considered in this research and researching about their future impact on transport on a general view. Maybe instead of gathering primary data by conducting interviews, there will be a need to have questionnaire surveys which can reach a large sample and can produce different results.

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2022].

Appendix

Appendix A - Interview questionnaire Stage 1

Artificial Intelligence (AI)

1. How much contribution has Artificial intelligence (AI) on Vehicle Utilization? (on a scale from 1 to 10).

2. How much contribution has Artificial intelligence (AI) on Capacity Utilization? (on a scale from 1 to 10).

3. How much contribution has Artificial intelligence (AI) on Successful Deliveries? (on a scale from 1 to 10).

4. How much contribution has Artificial intelligence (AI) on Fuel consumption? (on a scale from 1 to 10).

Augmented Reality (AR)

5. How much contribution has Augmented Reality (AR) on Vehicle utilization? (on a scale from 1 to 10).

6. How much contribution has Augmented Reality (AR) on Capacity utilization? (on a scale from 1 to 10).

7. How much contribution has Augmented Reality (AR) on Successful deliveries? (on a scale from 1 to 10).

8. How much contribution has Augmented Reality (AR) on Fuel consumption? (on a scale from 1 to 10).

Internet of Things (IoT)

9. How much contribution has the Internet of Things (IOT) on Vehicle Utilization? (on a scale from 1 to 10).

10. How much contribution has the Internet of things (IOT) on Capacity Utilization? (on a scale from 1 to 10).

11. How much contribution has the Internet of things (IOT) on Successful deliveries? (on a scale from 1 to 10).

12. How much contribution has the Internet of things (IOT) on Fuel consumption? (on a scale from 1 to 10).

Big Data & Analytics

13. How much contribution has Big Data & Analytics on Vehicle Utilization? (on a scale from 1 to 10).

14. How much contribution has Big Data & Analytics1 on Capacity Utilization? (on a scale from 1 to 10).

15. How much contribution has Big Data & Analytics have on Successful deliveries? (on a scale from 1 to 10).

16. How much contribution has Big Data & Analytics on Fuel consumption? (on a scale from 1 to 10).

Cloud Computing

17. How much contribution has Cloud Computing on Vehicle Utilization? (on a scale from 1 to 10).

18. How much contribution has Cloud Computing on Capacity Utilization? (on a scale from 1 to 10).

19. How much contribution has Cloud Computing on Successful deliveries? (on a scale from 1 to 10).

20. How much contribution has Cloud Computing on Fuel consumption? (on a scale from 1 to 10) .

Appendix B - Interview questionnaire Stage 2

Artificial Intelligence (AI) ranked on Vehicle Utilization

1. Pessimistically, how much contribution can Artificial intelligence (AI) have on Vehicle Utilization? (on a scale from 1 to 10).

2. Most likely, how much contribution can Artificial intelligence (AI) have on Vehicle Utilization? (on a scale from 1 to 10).

3. Optimistically, how much contribution can Artificial intelligence (AI) have on Vehicle Utilization? (on a scale from 1 to 10).

Artificial Intelligence (AI) ranked on Capacity Utilization

4. Pessimistically, how much contribution can Artificial intelligence (AI) have on Capacity Utilization? (on a scale from 1 to 10).

5. Most likely, how much contribution can Artificial intelligence (AI) have on Capacity Utilization? (on a scale from 1 to 10).

6. Optimistically, how much contribution can Artificial intelligence (AI) have on Capacity Utilization? (on a scale from 1 to 10)

Artificial Intelligence (AI) ranked on Successful Deliveries

7. Pessimistically, how much contribution can Artificial intelligence (AI) have on Successful Deliveries? (on a scale from 1 to 10).

8. Most likely, how much contribution can Artificial intelligence (AI) have on Successful Deliveries? (on a scale from 1 to 10).

9. Optimistically, how much contribution can Artificial intelligence (AI) have on Successful Deliveries? (on a scale from 1 to 10).

Artificial Intelligence (AI) ranked on Fuel consumption

10. Pessimistically, how much contribution can Artificial intelligence (AI) have on Fuel Consumption? (on a scale from 1 to 10).

11. Most likely, how much contribution can Artificial intelligence (AI) have on Fuel Consumption? (on a scale from 1 to 10).

12. Optimistically, how much contribution can Artificial intelligence (AI) have on Fuel Consumption? (on a scale from 1 to 10).

Augmented Reality (AR) ranked on Vehicle Utilization

13. Pessimistically, how much contribution can Augmented Reality (AR) have on Vehicle Utilization? (on a scale from 1 to 10).

14. Most likely, how much contribution can Augmented Reality (AR) have on Vehicle Utilization? (on a scale from 1 to 10.

15. Optimistically, how much contribution can Augmented Reality (AR) have on Vehicle Utilization? (on a scale from 1 to 10).

Augmented Reality (AR) ranked on Capacity Utilization

16. Pessimistically, how much contribution can Augmented Reality (AR) have on Capacity Utilization? (on a scale from 1 to 10).

17. Most likely, how much contribution can Augmented Reality (AR) have on Capacity Utilization? (on a scale from 1 to 10).

18. Optimistically, how much contribution can Augmented Reality (AR) have on Capacity Utilization? (on a scale from 1 to 10).

Augmented Reality (AR) ranked on Successful Deliveries

19. Pessimistically, how much contribution can Augmented Reality (AR) have on Successful Deliveries? (on a scale from 1 to 10).

20. Most likely, how much contribution can Augmented Reality (AR)have on Successful Deliveries? (on a scale from 1 to 10).

21. Optimistically, how much contribution can Augmented Reality (AR) have on Successful Deliveries? (on a scale from 1 to 10).

Augmented Reality (AR) ranked on Fuel Consumption

22. Pessimistically, how much contribution can Augmented Reality (AR) have on Fuel Consumption? (on a scale from 1 to 10).

23. Most likely, how much contribution can Augmented Reality (AR) have on Fuel Consumption? (on a scale from 1 to 10).

24. Optimistically, how much contribution can Augmented Reality (AR) have on Fuel Consumption? (on a scale from 1 to 10).

Internet of Things (IoT) ranked on Vehicle Utilization

25. Pessimistically, how much contribution can Internet of Things (IoT) have on Vehicle Utilization? (on a scale from 1 to 10).

26. Most likely, how much contribution can Internet of Things (IoT)have on Vehicle Utilization? (on a scale from 1 to 10).

27. Optimistically, how much contribution can Internet of Things (IoT) have on Vehicle Utilization? (on a scale from 1 to 10).

Internet of Things (IoT) ranked on Capacity Utilization

28. Pessimistically, how much contribution can Internet of Things (IoT) have on Capacity Utilization? (on a scale from 1 to 10).

29. Most likely, how much contribution can Internet of Things (IoT) have on Capacity Utilization? (on a scale from 1 to 10)

30. Optimistically, how much contribution can Internet of Things (IoT) have on Capacity Utilization? (on a scale from 1 to 10).

Internet of Things (IoT) ranked on Successful Deliveries

31. Pessimistically, how much contribution can Internet of Things (IoT) have on Successful Deliveries? (on a scale from 1 to 10

32. Most likely, how much contribution can Internet of Things (IoT) have on Successful Deliveries? (on a scale from 1 to 10).

33. Optimistically, how much contribution can Internet of Things (IoT) have on Successful Deliveries? (on a scale from 1 to 10).

Internet of Things (IoT) ranked on Fuel Consumption

34. Pessimistically, how much contribution can Augmented Reality (AR) have on Fuel Consumption? (on a scale from 1 to 10).

35. Most likely, how much contribution can Augmented Reality (AR) have on Fuel Consumption? (on a scale from 1 to 10).

36. Optimistically, how much contribution can Augmented Reality (AR) have on Fuel

Consumption? (on a scale from 1 to 10).

Big Data & Analytics ranked on Vehicle Utilization

37. Pessimistically, how much contribution can Big Data & Analytics have on Vehicle Utilization? (on a scale from 1 to 10).

38. Most likely, how much contribution can Big Data & Analytics have on Vehicle Utilization? (on a scale from 1 to 10)

39. Optimistically, how much contribution can Big Data & Analytics have on Vehicle Utilization? (on a scale from 1 to 10).

Big Data & Analytics ranked on Capacity Utilization

40. Pessimistically, how much contribution can Big Data & Analytics have on Capacity Utilization? (on a scale from 1 to 10).

41. Most likely, how much contribution can Big Data & Analytics have on Capacity Utilization? (on a scale from 1 to 10).

42. Optimistically, how much contribution can Big Data & Analytics have on Capacity Utilization? (on a scale from 1 to 10).

Big Data & Analytics ranked on Successful Deliveries

43. Pessimistically, how much contribution can Big Data & Analytics have on Successful Deliveries? (on a scale from 1 to 10).

44. Most likely, how much contribution can Big Data & Analytics have on Successful Deliveries? (on a scale from 1 to 10).

45. Optimistically, how much contribution can Big Data & Analytics have on Successful Deliveries? (on a scale from 1 to 10).

Big Data & Analytics ranked on Fuel Consumption

46. Pessimistically, how much contribution can Big Data & Analytics have on Fuel Consumption? (on a scale from 1 to 10).

47. Most likely, how much contribution can Big Data & Analytics have on Fuel Consumption? (on a scale from 1 to 10).

48. Optimistically, how much contribution can Big Data & Analytics have on Fuel Consumption? (on a scale from 1 to 10).

Cloud Computing ranked on Vehicle Utilization

49. Pessimistically, how much contribution can Cloud Computing have on Vehicle Utilization? (on a scale from 1 to 10).

50. Most likely, how much contribution can Cloud Computing have on Vehicle Utilization? (on a scale from 1 to 10).

51. Optimistically, how much contribution can Cloud Computing have on Vehicle Utilization? (on a scale from 1 to 10).

Cloud Computing ranked on Capacity Utilization

52. Pessimistically, how much contribution can Cloud Computing have on Capacity Utilization? (on a scale from 1 to 10).

53. Most likely, how much contribution can Cloud Computing have on Capacity Utilization? (on a scale from 1 to 10).

54. Optimistically, how much contribution can Cloud Computing have on Capacity Utilization? (on a scale from 1 to 10).

Cloud Computing ranked on Successful Deliveries

55. Pessimistically, how much contribution can Cloud Computing have on Successful Deliveries? (on a scale from 1 to 10).

56. Most likely, how much contribution can Cloud Computing have on Successful Deliveries? (on a scale from 1 to 10).

57. Optimistically, how much contribution can Cloud Computing have on Successful Deliveries? (on a scale from 1 to 10).

Cloud Computing ranked on Fuel Consumption

58. Pessimistically, how much contribution can Cloud Computing have on Fuel Consumption? (*on a scale from 1 to 10*).

59. Most likely, how much contribution can Cloud Computing have on Fuel Consumption? (on a scale from 1 to 10).

60. Optimistically, how much contribution can Cloud Computing have on Fuel Consumption? (on a scale from 1 to 10).

Appendix C - Answers questionnaire Stage 1

R1		R2		R3		R4		R5		R6	
Q.1.1.1	7	Q.1.1.1	7	Q.1.1.1	7	Q.1.1.1	6	Q.1.1.1	X	Q.1.1.1	X
Q.1.1.2	7	Q.1.1.2	7	Q.1.1.2	7	Q.1.1.2	5	Q.1.1.2	X	Q.1.1.2	X
Q.1.1.3	6	Q.1.1.3	6	Q.1.1.3	8	Q.1.1.3	8	Q.1.1.3	X	Q.1.1.3	X
Q.1.1.4	7	Q.1.1.4	6	Q.1.1.4	8	Q.1.1.4	6	Q.1.1.4	X	Q.1.1.4	X
Q.1.2.1	2	Q.1.2.1	8	Q.1.2.1	4	Q.1.2.1	3	Q.1.2.1	X	Q.1.2.1	X
Q.1.2.2	4	Q.1.2.2	7	Q.1.2.2	5	Q.1.2.2	2	Q.1.2.2	X	Q.1.2.2	X
Q.1.2.3	4	Q.1.2.3	9	Q.1.2.3	5	Q.1.2.3	2	Q.1.2.3	X	Q.1.2.3	X
Q.1.2.4	2	Q.1.2.4	7	Q.1.2.4	3	Q.1.2.4	3	Q.1.2.4	X	Q.1.2.4	X
Q.1.3.1	10	Q.1.3.1	9	Q.1.3.1	8	Q.1.3.1	5	Q.1.3.1	X	Q.1.3.1	X
Q.1.3.2	10	Q.1.3.2	9	Q.1.3.2	6	Q.1.3.2	2	Q.1.3.2	X	Q.1.3.2	X
Q.1.3.3	10	Q.1.3.3	8	Q.1.3.3	6	Q.1.3.3	4	Q.1.3.3	X	Q.1.3.3	X
Q.1.3.4	9	Q.1.3.4	7	Q.1.3.4	6	Q.1.3.4	7	Q.1.3.4	X	Q.1.3.4	X
Q.1.4.1	9	Q.1.4.1	9	Q.1.4.1	8	Q.1.4.1	7	Q.1.4.1	X	Q.1.4.1	X
Q.1.4.2	8	Q.1.4.2	9	Q.1.4.2	8	Q.1.4.2	7	Q.1.4.2	X	Q.1.4.2	X
Q.1.4.3	9	Q.1.4.3	9	Q.1.4.3	7	Q.1.4.3	3	Q.1.4.3	X	Q.1.4.3	X
Q.1.4.4	9	Q.1.4.4	9	Q.1.4.4	6	Q.1.4.4	4	Q.1.4.4	X	Q.1.4.4	X
Q.1.5.1	8	Q.1.5.1	5	Q.1.5.1	6	Q.1.5.1	3	Q.1.5.1	X	Q.1.5.1	X
Q.1.5.2	8	Q.1.5.2	5	Q.1.5.2	8	Q.1.5.2	3	Q.1.5.2	X	Q.1.5.2	X
Q.1.5.3	6	Q.1.5.3	5	Q.1.5.3	6	Q.1.5.3	4	Q.1.5.3	X	Q.1.5.3	X
Q.1.5.4	8	Q.1.5.4	6	Q.1.5.4	8	Q.1.5.4	4	Q.1.5.4	X	Q.1.5.4	X

Appendix D - Answers questionnaire Stage 2

R1		R2		R3		R4		R5		R6	
Q.2.1.1.1	3	Q.2.1.1.1	2	Q.2.1.1.1	3	Q.2.1.1.1	6	Q.2.1.1.1	8	Q.2.1.1.1	2
Q.2.1.1.2	7	Q.2.1.1.2	6	Q.2.1.1.2	7	Q.2.1.1.2	8	Q.2.1.1.2	9	Q.2.1.1.2	3
Q.2.1.1.3	10	Q.2.1.1.3	9	Q.2.1.1.3	10	Q.2.1.1.3	10	Q.2.1.1.3	10	Q.2.1.1.3	8
Q.2.1.2.1	4	Q.2.1.2.1	2	Q.2.1.2.1	4	Q.2.1.2.1	4	Q.2.1.2.1	8	Q.2.1.2.1	2
Q.2.1.2.2	7	Q.2.1.2.2	6	Q.2.1.2.2	8	Q.2.1.2.2	6	Q.2.1.2.2	9	Q.2.1.2.2	3
Q.2.1.2.3	10	Q.2.1.2.3	9	Q.2.1.2.3	10	Q.2.1.2.3	8	Q.2.1.2.3	10	Q.2.1.2.3	8
Q.2.1.3.1	1	Q.2.1.3.1	2	Q.2.1.3.1	5	Q.2.1.3.1	2	Q.2.1.3.1	7	Q.2.1.3.1	4
Q.2.1.3.2	3	Q.2.1.3.2	6	Q.2.1.3.2	8	Q.2.1.3.2	4	Q.2.1.3.2	8	Q.2.1.3.2	6
Q.2.1.3.3	6	Q.2.1.3.3	9	Q.2.1.3.3	10	Q.2.1.3.3	6	Q.2.1.3.3	9	Q.2.1.3.3	7
Q.2.1.4.1	3	Q.2.1.4.1	5	Q.2.1.4.1	5	Q.2.1.4.1	6	Q.2.1.4.1	7	Q.2.1.4.1	7
Q.2.1.4.2	5	Q.2.1.4.2	7	Q.2.1.4.2	8	Q.2.1.4.2	8	Q.2.1.4.2	8	Q.2.1.4.2	8
Q.2.1.4.3	7	Q.2.1.4.3	8	Q.2.1.4.3	10	Q.2.1.4.3	10	Q.2.1.4.3	9	Q.2.1.4.3	9
Q.2.2.1.1	3	Q.2.2.1.1	3	Q.2.2.1.1	2	Q.2.2.1.1	1	Q.2.2.1.1	4	Q.2.2.1.1	1
Q.2.2.1.2	5	Q.2.2.1.2	6	Q.2.2.1.2	4	Q.2.2.1.2	2	Q.2.2.1.2	5	Q.2.2.1.2	2
Q.2.2.1.3	7	Q.2.2.1.3	8	Q.2.2.1.3	8	Q.2.2.1.3	3	Q.2.2.1.3	6	Q.2.2.1.3	3
Q.2.2.2.1	1	Q.2.2.2.1	3	Q.2.2.2.1	2	Q.2.2.2.1	1	Q.2.2.2.1	1	Q.2.2.2.1	2
Q.2.2.2.2	2	Q.2.2.2.2	6	Q.2.2.2.2	4	Q.2.2.2.2	2	Q.2.2.2.2	3	Q.2.2.2.2	3
Q.2.2.2.3	4	Q.2.2.2.3	8	Q.2.2.2.3	7	Q.2.2.2.3	3	Q.2.2.2.3	4	Q.2.2.2.3	5
Q.2.2.3.1	1	Q.2.2.3.1	4	Q.2.2.3.1	3	Q.2.2.3.1	1	Q.2.2.3.1	3	Q.2.2.3.1	1
Q.2.2.3.2	2	Q.2.2.3.2	7	Q.2.2.3.2	5	Q.2.2.3.2	2	Q.2.2.3.2	5	Q.2.2.3.2	2
Q.2.2.3.3	4	Q.2.2.3.3	10	Q.2.2.3.3	10	Q.2.2.3.3	3	Q.2.2.3.3	6	Q.2.2.3.3	3
Q.2.2.4.1	1	Q.2.2.4.1	2	Q.2.2.4.1	2	Q.2.2.4.1	1	Q.2.2.4.1	4	Q.2.2.4.1	1
Q.2.2.4.2	2	Q.2.2.4.2	5	Q.2.2.4.2	3	Q.2.2.4.2	2	Q.2.2.4.2	5	Q.2.2.4.2	2
Q.2.2.4.3	4	Q.2.2.4.3	7	Q.2.2.4.3	7	Q.2.2.4.3	3	Q.2.2.4.3	6	Q.2.2.4.3	5
Q.2.3.1.1	6	Q.2.3.1.1	5	Q.2.3.1.1	5	Q.2.3.1.1	4	Q.2.3.1.1	7	Q.2.3.1.1	2
Q.2.3.1.2	8	Q.2.3.1.2	6	Q.2.3.1.2	8	Q.2.3.1.2	6	Q.2.3.1.2	8	Q.2.3.1.2	3
Q.2.3.1.3	10	Q.2.3.1.3	8	Q.2.3.1.3	10	Q.2.3.1.3	8	Q.2.3.1.3	9	Q.2.3.1.3	10
Q.2.3.2.1	6	Q.2.3.2.1	5	Q.2.3.2.1	4	Q.2.3.2.1	2	Q.2.3.2.1	5	Q.2.3.2.1	2
Q.2.3.2.2	8	Q.2.3.2.2	6	Q.2.3.2.2	8	Q.2.3.2.2	3	Q.2.3.2.2	7	Q.2.3.2.2	3
Q.2.3.2.3	10	Q.2.3.2.3	8	Q.2.3.2.3	10	Q.2.3.2.3	4	Q.2.3.2.3	9	Q.2.3.2.3	10

R1		R2		R3		R4		R5		R6	
Q.2.3.3.1	6	Q.2.3.3.1	3	Q.2.3.3.1	3	Q.2.3.3.1	2	Q.2.3.3.1	6	Q.2.3.3.1	3
Q.2.3.3.2	8	Q.2.3.3.2	6	Q.2.3.3.2	6	Q.2.3.3.2	3	Q.2.3.3.2	8	Q.2.3.3.2	5
Q.2.3.3.3	10	Q.2.3.3.3	7	Q.2.3.3.3	9	Q.2.3.3.3	4	Q.2.3.3.3	9	Q.2.3.3.3	7
Q.2.3.4.1	6	Q.2.3.4.1	2	Q.2.3.4.1	3	Q.2.3.4.1	6	Q.2.3.4.1	7	Q.2.3.4.1	1
Q.2.3.4.2	8	Q.2.3.4.2	4	Q.2.3.4.2	6	Q.2.3.4.2	7	Q.2.3.4.2	8	Q.2.3.4.2	2
Q.2.3.4.3	10	Q.2.3.4.3	7	Q.2.3.4.3	9	Q.2.3.4.3	8	Q.2.3.4.3	9	Q.2.3.4.3	4
Q.2.4.1.1	5	Q.2.4.1.1	5	Q.2.4.1.1	4	Q.2.4.1.1	6	Q.2.4.1.1	7	Q.2.4.1.1	3
Q.2.4.1.2	7	Q.2.4.1.2	7	Q.2.4.1.2	8	Q.2.4.1.2	8	Q.2.4.1.2	9	Q.2.4.1.2	5
Q.2.4.1.3	9	Q.2.4.1.3	10	Q.2.4.1.3	10	Q.2.4.1.3	10	Q.2.4.1.3	10	Q.2.4.1.3	7
Q.2.4.2.1	5	Q.2.4.2.1	5	Q.2.4.2.1	4	Q.2.4.2.1	6	Q.2.4.2.1	7	Q.2.4.2.1	3
Q.2.4.2.2	7	Q.2.4.2.2	7	Q.2.4.2.2	8	Q.2.4.2.2	8	Q.2.4.2.2	9	Q.2.4.2.2	5
Q.2.4.2.3	9	Q.2.4.2.3	10	Q.2.4.2.3	10	Q.2.4.2.3	10	Q.2.4.2.3	10	Q.2.4.2.3	7
Q.2.4.3.1	2	Q.2.4.3.1	4	Q.2.4.3.1	3	Q.2.4.3.1	4	Q.2.4.3.1	6	Q.2.4.3.1	2
Q.2.4.3.2	5	Q.2.4.3.2	7	Q.2.4.3.2	6	Q.2.4.3.2	6	Q.2.4.3.2	8	Q.2.4.3.2	6
Q.2.4.3.3	7	Q.2.4.3.3	9	Q.2.4.3.3	9	Q.2.4.3.3	8	Q.2.4.3.3	9	Q.2.4.3.3	8
Q.2.4.4.1	2	Q.2.4.4.1	4	Q.2.4.4.1	3	Q.2.4.4.1	1	Q.2.4.4.1	5	Q.2.4.4.1	3
Q.2.4.4.2	5	Q.2.4.4.2	6	Q.2.4.4.2	6	Q.2.4.4.2	3	Q.2.4.4.2	8	Q.2.4.4.2	6
Q.2.4.4.3	7	Q.2.4.4.3	8	Q.2.4.4.3	9	Q.2.4.4.3	4	Q.2.4.4.3	9	Q.2.4.4.3	8
Q.2.5.1.1	2	Q.2.5.1.1	3	Q.2.5.1.1	3	Q.2.5.1.1	2	Q.2.5.1.1	5	Q.2.5.1.1	1
Q.2.5.1.2	4	Q.2.5.1.2	5	Q.2.5.1.2	6	Q.2.5.1.2	4	Q.2.5.1.2	8	Q.2.5.1.2	2
Q.2.5.1.3	6	Q.2.5.1.3	7	Q.2.5.1.3	8	Q.2.5.1.3	6	Q.2.5.1.3	9	Q.2.5.1.3	3
Q.2.5.2.1	1	Q.2.5.2.1	3	Q.2.5.2.1	4	Q.2.5.2.1	2	Q.2.5.2.1	7	Q.2.5.2.1	1
Q.2.5.2.2	3	Q.2.5.2.2	5	Q.2.5.2.2	8	Q.2.5.2.2	3	Q.2.5.2.2	8	Q.2.5.2.2	2
Q.2.5.2.3	5	Q.2.5.2.3	7	Q.2.5.2.3	10	Q.2.5.2.3	4	Q.2.5.2.3	9	Q.2.5.2.3	3
Q.2.5.3.1	1	Q.2.5.3.1	2	Q.2.5.3.1	5	Q.2.5.3.1	2	Q.2.5.3.1	7	Q.2.5.3.1	1
Q.2.5.3.2	2	Q.2.5.3.2	4	Q.2.5.3.2	8	Q.2.5.3.2	4	Q.2.5.3.2	8	Q.2.5.3.2	2
Q.2.5.3.3	4	Q.2.5.3.3	8	Q.2.5.3.3	10	Q.2.5.3.3	6	Q.2.5.3.3	9	Q.2.5.3.3	3
Q.2.5.4.1	1	Q.2.5.4.1	3	Q.2.5.4.1	3	Q.2.5.4.1	2	Q.2.5.4.1	7	Q.2.5.4.1	1
Q.2.5.4.2	2	Q.2.5.4.2	4	Q.2.5.4.2	6	Q.2.5.4.2	3	Q.2.5.4.2	8	Q.2.5.4.2	2
Q.2.5.4.3	4	Q.2.5.4.3	7	Q.2.5.4.3	9	Q.2.5.4.3	4	Q.2.5.4.3	9	Q.2.5.4.3	3