National College of Ireland

The use of Artificial Intelligence in the distribution and transport process to optimise routes, reduce operating costs and provide better customer service at the time of delivery of goods

MSc. International Business

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Project Submission Sheet

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Research Methods

The use of Artificial Intelligence in the distribution and transport process to optimise routes, reduce operating costs and provide better customer service at the time of delivery of goods.

Your Name/Student Number	Course	Date
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AI Acknowledgment

This section acknowledges the AI tools that were utilized in the process of completing this assignment.

Tool Name	Brief Description	Link to tool
DeepL Translator	Translate some sentences	https://www.deepl.com/es/translator

Description of AI Usage

This section provides a more detailed description of how the AI tools were used in the assignment. It includes information about the prompts given to the AI tool, the responses received, and how these responses were utilized or modified in the assignment. **One table should be used for each tool used**.

DeepL Translator	
DeepL Translator is a leading machine translation service that uses artificial neural networks to translate text into 31 different languages in real time.	

Abstract

The purpose of this study was to analyse the relevance of using Artificial Intelligence (AI) in the logistics process of goods distribution and transport, with a special focus on improving route planning to achieve a reduction in operating costs and better organisation and customer service in a timely manner for the recycling company MIRALGAR. This research mentions different theories and mathematical models, such as 'Graph Theory' and the 'Execution and Replanning Surveillance Agent Model,' to enrich and support the topic. It also analyses several applications that artificial intelligence has contributed to evolve and help the world of transport logistics, and how different companies have been implementing them efficiently. Surveys and interviews were used as research tools to evaluate the organisation of route planning within the mentioned company. The results confirmed that the company needs to improve and implement new planning methods, as it has suffered significant losses, delays and high operating costs. Therefore, it was concluded that this research was a success, as the use of surveys and interviews had a positive influence on MIRALGAR, since they reflected on their current situation and showed a high interest in starting to use artificial intelligence to help them improve this process and stand out in the logistics environment.

Keywords: Logistics; Artificial Intelligence (AI); Distribution; Transport; Planning; Routes; Operating Costs; Algorithms; Graphs; Machine Learning (ML); Optimisation; Fleets; Smart Locks

Submission of Thesis and Dissertation

National College of Ireland

Research Students Declaration Form

(Thesis/Author Declaration Form)

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1. Introduction

In this research, I highlight the importance of understanding the usefulness of artificial intelligence for the recycling company MIRALGAR in order to improve the planning of its goods delivery routes, emphasising the importance of using, implementing and training in artificial intelligence programmes.

In this work, I highlight the benefits and the significance of implementing artificial intelligence to achieve efficient route planning.

To carry out this research, I have analysed different specialised sources and theories on the subject of artificial intelligence and other aspects that form part of it.

The objectives proposed in this research have been fully achieved, both general and specific.

The methodology is another important point to discuss, as I have gained a broader understanding of how to develop tools to obtain the required information in the field of study through bibliographic sources.

With this in mind, I present a series of conclusions and recommendations as suggestions for achieving better customer service and delivering goods on time and in the right way.

2. Literature Review

In an increasingly globalised and competitive world, logistics has become a fundamental process for any company, as it is responsible for managing a wide range of important tasks for the transfer of goods, services and related information (Bowersox, 2007). Consequently, logistics is the process that strategically connects people, operations and resources to generate efficiency, reduce costs, satisfy customer needs and operate successfully within the market. Therefore, if it is poorly managed or avoided, it can determine the failure of a company.

In logistics, we find five different processes, which are listed below: Purchasing, Storage, Inventory Management, Transportation, and Customer Service. These processes must be carried out properly to ensure that the final product is received by the buyer on time and in the proper form, without price alterations and free of damage. Effective communication must exist between all parties involved so that operations flow smoothly.

In the business world, companies and leaders expect profitability and a positive net profit from all expenses and operations, so it is extremely important to know how to manage these types of activities and avoid future losses.

2.1 Logistics Process

Purchasing Process

Correctly defining all the materials needed to manufacture the product is essential in the purchasing process, as it directly influences the continuity of operations. This means that the purchasing agent must analyse the correct quantities to be purchased and do so at the right time to avoid operational interruptions in production due to a lack of materials and/or raw materials. No company wants unexpected disruptions in production, which not only cause

delays but can also create a negative perception among the company's customers.

Storage Process

Based on the concept of the storage process, within logistics management, this involves the reception, storage, management and distribution of goods within a warehouse, with the aim of maintaining efficient and secure control of the products at all times until their distribution. Therefore, the storage process is a key factor in guaranteeing the quality of the goods. This is because activities are carried out to protect and preserve the products correctly, which must be classified to ensure better order and avoid losses or confusion between goods. It is advisable for companies to choose the best storage system that suits the needs of their products in order to optimise space and reduce costs.

The storage location must be suitable for the goods to be kept in their natural state, without suffering any alterations, so the appropriate tools must be available for when the goods need to be handled.

Inventory Management Process

The inventory management process is the set of activities that involve planning, organising, monitoring, and controlling the products or materials that a company has in stock, from acquisition to sale or use.

Therefore, the incoming and outgoing goods must be managed in order to carry out inventory control. This will ensure that the necessary quantities of stock are always available to meet customer needs and to know when to purchase more material or increase/decrease production. In proper inventory management, the number of items in stock must be recorded to prevent theft, accumulation of goods or shortages.

Transportation Process

The logistics process of transportation is considered important, as it involves rationalising and optimising the movement of goods from their point of origin to their final destination. The transportation flow encompasses different stages, including the supply of raw materials, production, storage, distribution and delivery. It is the responsibility of companies to analyse the best mode of transport for their goods (air, sea or land) and which routes to choose to speed up product delivery in the best conditions, taking into account packaging and insurance to prevent damage or loss.

In this process, various commercial documents must be completed to regulate the movement of goods in a timely manner, since if a document is missing or incorrect, it will be a problem for the goods to reach their final destination and will therefore affect the estimated delivery time.

Customer Service Process

In the business world, it is extremely important for a company to care about its consumers, providing them with good customer service that makes them feel comfortable and secure in their shopping experiences. 'The customer experience for a company is considered a key factor for success, as it will define the idea that consumers have of the company' (Cárdenes Doctor, 2022).

The service must be secure, easy and quick to respond. Time is money and is one of the factors that customers value most. A customer who is satisfied with their purchase will return and make new purchases. They will also recommend the product or service, which will attract new consumers and increase brand recognition.

Each logistics process has a goal to achieve, which involves a large number of important and complex activities. It is clear that companies depend on the

proper management and development of these processes to be successful. Nowadays, thanks to innovation and technological advances, there are new methods and tools that can help optimise and facilitate each of these processes.

2.2 Distribution and Transport

2.2.1 Introduction to the Distribution and Transport Process

The distribution and transport process is one of the most important stages for companies that manage and depend on this process, since, if carried out and planned properly, companies will successfully achieve their objectives.

At this stage, the main aim is to minimise risks and errors made previously or those that may arise in the future. Therefore, the decision-making process is very important for companies, as it aims to solve a variety of problems (Ścibiorek and Kruszyński, 2024; Walczak, 2012). Risk management is also important, as the timely identification of potential incidents during transport can prevent serious injuries and significant financial losses. Such incidents may include vandalism, vehicle breakdowns, natural hazards and human error.

Optimising transport costs has become one of the greatest desires of companies, as these costs are often very high and reducing them can have a positive impact on a company's profits. If they can be controlled, they can provide significant competitive advantages. Fuel, insurance, freight and shipping costs, salaries and vehicle maintenance are generally taken into account.

For companies, it is essential to have the right staff and equipment to carry out efficient transport planning, as well as to earn the trust of customers through effective punctuality, safety, and quality. This means that managers and executives must focus on key elements such as route optimisation and planning, ensuring that all necessary documents are in place for the transport of

goods, optimising transport costs, anticipating possible unforeseen events during the journey, such as theft, natural hazards, etc., as well as selecting the appropriate vehicle and driver.

In practice, the transport process includes preparing the transport concept, preparing the goods for transport, organising the transport process, physically moving the cargo, managing commercial activities, and analysing and evaluating the completed process (costs, time, quality, complaints). (Kulińska, Masłowski, Wojtynek, 2018). It is clear that the transport process is not just the action of moving goods, but rather a whole process involving many activities and factors to ensure its success.

On the other hand, stakeholders are now pressuring organisations to incorporate environmental considerations into decision-making in order to reduce environmental impact, often linked to greenhouse gas (GHG) emissions (Abbasi and Nilsson, 2012; De Stefano and Montes-Sancho, 2023). As time goes by, concern and responsibility for environmental protection in the business environment are becoming more prominent, so companies must start taking action to create more sustainable models and not lose interest of stakeholders who are becoming increasingly informed and demanding on this issue. Currently, environmental impact is no longer considered an isolated issue and is increasingly important for generating competitiveness and stability in organisations. Companies, including logistics companies, are capable of performing long-term tasks, are in a state of exchange of matter, energy and information with the environment, and strive to maintain a dynamic balance (Ścibiorek & Kruszyński, 2024; Penc, 1998). These are companies that constantly interact with their environment, so it is important and fair that they take care of it. Logistics processes, particularly transport, have a significant impact on the environment. Emissions from the transport sector have increased at an annual average rate of 1.7%, faster than any other end-use sector, and account for around 24% of global CO2e emissions, with freight transport accounting for 40% (International Energy Agency, 2023). As a result, companies are looking to

implement methods that help them reduce their environmental impact and demonstrate that they are operating as green businesses.

2.3 Route Planning

According to Masłowski (2019), in transport logistics, route planning is one of the key factors for proper operational organisation. It is defined as the process of finding the most efficient and cost-effective way for transport to move goods from a point of origin to a point of destination and to be handled in a timely manner.

Route planning is often a complex and time-consuming task, as it must take into account traffic conditions, travel time, distance, costs, and the safety of drivers and vehicles. Good route planning guarantees cost reduction and offers a better customer experience. It is important to select the right vehicle, whether air, sea or land, and ensure that it meets the necessary conditions for transporting and organising the goods, as it is essential to know how to accommodate the correct quantities and make the most of the available space. Some products may be temperature-sensitive, so the place where they are to be transported must be suitable to ensure the quality of the cargo.

Likewise, "When planning the route of a vehicle transporting dangerous goods or merchandise, special attention should be paid to roads with the best possible surface and the least amount of traffic. Due to the potential threat to the environment, as well as to human health and life, roads running close to active leisure centres, sports areas or urbanised areas of the city should be avoided" (Van Heeswijk, Mes, Schutten, 2019). This is why route planning must be properly stipulated, as any error can have serious consequences that affect not only the company and the customer, but also people and environments unrelated to the operation. Errors can lead to permanent losses, mistrust, low professionalism and increased costs.

2.4 Artificial Intelligence in the Distribution and Transport Process

2.4.1 Context of Artificial Intelligence in the world of Logistics

Artificial Intelligence (AI) is the ability of computers to perform activities that are regularly carried out by humans. 'In logistics, this evolution encompasses digitisation, networking, automation, intelligence and flexible management, which is referred to as "new logistics"' (Shi, 2022). Other researchers mention that it has had a major influence today thanks to its ability to solve problems flexibly and effectively based on mathematical methods. It is said that one of the most advanced technologies has been developed, as AI has been shown to work more efficiently than humans, since it is designed to work long hours without stopping, as well as to perform and solve multiple tasks (regardless of their degree of difficulty) even faster than humans. AI also has a very low probability of making mistakes when operating, which is why thousands of users turn to it to achieve more accurate results.

Currently, this type of technology has benefited the world in many positive ways in various social, economic, labour, geographical and educational fields, among others. However, as with everything, there must be a balance so as not to generate negative results. 'The potential incremental value of implementing AI in logistics is estimated at 89%' (Szymonik, 2012). It is time for companies to start taking advantage of this new technology, as the logistics environment is becoming increasingly competitive and through the use of AI they can position themselves in the market and, in turn, double their profits and operational effectiveness.

'The integration of AI in logistics offers several advantages, mainly improved efficiency and cost reduction, improved customer service, improved decision-making and data management, and reduced CO2 emissions' (Gonçalves and Domingues, 2025). Artificial intelligence has arrived to facilitate and improve processes and experiences, generating added value that demonstrates how it is

possible to evolve in a positive way, benefiting more than one factor or environment in logistics.

2.5 Integration of AI in transport and distribution logistics management

Artificial intelligence has been taking transport logistics to another level and has had a huge impact on this field, even more so than on the other four logistics processes. These smart innovation techniques are mainly used in optimisation problems. It is claimed that the rapid and immense evolution of AI development has created great opportunities to optimise the performance of companies in different industries, one of the most notable being the transport sector (Nowacki and Wierzbic, 2024).

'Transport logistics using AI creates a whole new dimension in the way goods are transported: innovations in route optimisation ('one of the most complicated but also most decisive parts of the supply chain' (Cárdenes Doctor, 2022)), autonomous vehicles and delivery drones are leading the revolution in freight transport. These advances not only improve the efficiency of transport operations but also help reduce environmental impact and costs' (Abdallah Al-Daradkah, 2024).

2.5.1 Route Optimisation

One of the greatest contributions AI has made in this field has been in route optimisation, which is defined as the process of finding the best route to deliver the finished goods from one point to another. Route optimisation focuses on ensuring that the entire procedure is adept and efficient, taking into account factors such as time, distance and the correct selection of vehicle for each mode of transport. Through the use of AI, it is possible to determine the quantity of goods, their arrangement, and the type or characteristics of the vehicle, ensuring a decrease in costs, as each kilometre or mile reduced proportionally decreases fuel, transport and wage costs, among others.

‘Traditionally, determining the most efficient route for deliveries was an extremely slow process that required a great deal of human judgement and static maps’ (Abdallah Al-Daradkah, 2024). Now, with the use of Artificial Intelligence, this procedure is faster and more accurate. It could be said that VRP is very complex because it uses many mathematical and computer-based techniques to create massive combinations of route possibilities. However, artificial intelligence can be added to this process to find even faster, more accurate and efficient solutions.

That said, AI can use algorithms that help reduce ‘empty trips,’ which means that these algorithms help companies take advantage of the return trip with new cargo to transport and not return with an empty vehicle. This is done with the purpose of avoiding wasting more fuel ‘in vain’ and incurring unnecessary expenses, since drivers continue working without generating any income for the company. It is well known that there are matching platforms where companies post their shipping needs, and carriers are free to accept the load if it is convenient for them. The system then matches the load with the best carrier based on location, price, storage capacity, and other factors. Finally, the shipment is made, and the platform is responsible for tracking it, collecting documentation, and facilitating payment for the service. This new technology helps companies reduce costs and generate more profits, while reducing carbon dioxide emissions and vehicle wear and tear (Figure 1).

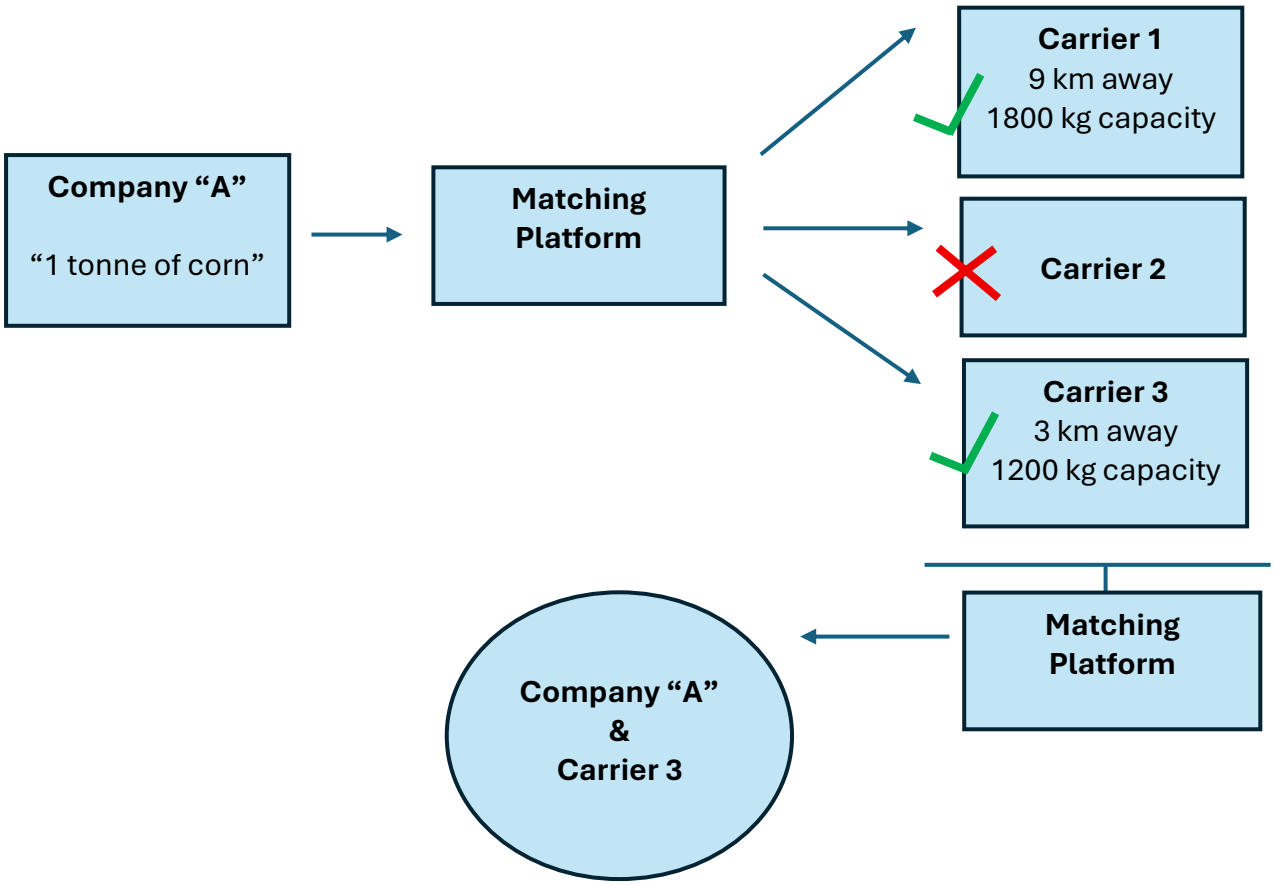


Figure 1

On the other hand, Machine Learning (ML) has also brought innovative changes to transport logistics. This is an area of Artificial Intelligence that allows computer systems to complete specific tasks without requiring explicit programming.

Machine learning learns from the amount of data needed to make decisions automatically and thus efficiently perform the required tasks. According to several computer and logistics researchers, ML enables process automation and optimisation, which results in cost minimisation, detection of factors that may be difficult for humans to perceive, and increased work efficiency. Thanks to machine learning, situations that could affect the transport process have been prevented through the creation of predictive models. An example of this is the company DHL, which decided to use ML to create a system that allows delays in the transport of goods to be predicted weeks in advance. This algorithmic system aims to assist in route planning and delivery processes, as it

has the ability to detect factors that influence delays and take essential measures such as changing routes (Nowacki and Wierzbic, 2024).

Similarly, artificial intelligence algorithms have the ability to predict traffic levels in real time and even detect accidents on the road. They can automatically and continuously generate notifications to inform the driver and transport manager, resulting in new routes being recalculated so that they can continue on the shortest and most efficient route, significantly reducing CO2 emissions and fuel costs. Therefore, this type of technology can also determine and adjust estimated delivery times, as it is based on the driver's speed, remaining distance and fuel level of the transport unit. On the other hand, to control fuel consumption and efficiency, these algorithms have the capability of notifying the exact date and time when a driver refuels, through the use of GPS, as well as the locations where they are authorised to refuel. These are monitored solely by the logistics manager, who receives an alert when this happens, and are implemented in the units by a specialist technician.

In addition, ‘AI and machine learning (ML) integrate data from IoT devices, GPS and vehicle logs to anticipate mechanical problems.’ This helps to extend the useful life of transport vehicles because they focus on maintenance and help to foresee when a part will fail or when repairs will be necessary. This technology is based on the unit's history and its current condition. Its goal is to oversee fleet maintenance before serious and irreparable problems occur.

Thanks to the emergence of AI, tracking systems and devices have been created that work in real time and allow everything that happens with fleets and goods to be monitored. Companies such as Andlauer Transportation Services (ATS) and Fleet Complete have managed to use AI very efficiently, giving them a competitive advantage in the market, as they have vehicles that operate with MGS 200 fleet tracking devices, which are capable of controlling the temperature of goods throughout the shipping process, ensuring product quality and safety. These devices also send real-time alerts in the event of damage to

the unit, speeding by drivers, and even when the rear doors of the unit are opened, which is extremely important to know why, as these should not be opened regularly and without authorisation during the delivery process, and furthermore, this action can affect the temperature of the goods. The devices have the capacity to record and store all information for at least seven years, generating informative reports that guarantee the correct transport and care of the goods (Battal, 2023). This saves time and creates greater reliability and administrative organisation for companies, as well as preventing the loss and wear and tear of documents.

2.5.2 Smart Locks

Carrying out risk management in transport logistics is also essential for companies, as the timely identification of potential incidents during transport can prevent serious injury to human life and significant financial losses. These incidents can include vandalism, technical vehicle breakdowns, natural hazards, and human error.

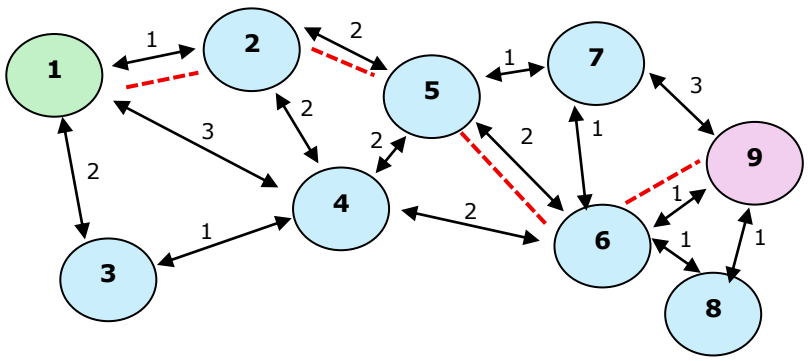
Nowadays, there are smart locks which improve the security of objects and goods, as they are difficult to tamper with and can only be opened using fingerprints, mobile apps or a PIN. Smart locks are designed to prevent unwanted access, and only trusted personnel can gain access. This type of tool works with IoT and AI technology, which is controlled from mobile apps to grant or deny access to delivery personnel and, if opened, is designed to automatically send immediate alerts to the department or person in charge of transport. According to HBOIOT (2025)[1], 'smart locks minimise theft by 42% and inspection times by 70%. They also reduce damage to goods by 18%, saving time and money. This makes them a great support tool for companies that transport goods through dangerous areas, ensuring their safety and financial health. In addition, smart locks with IoT and AI technology have the ability to monitor

[1] HBOIOT: leading manufacturer of telematics hardware and competent and skilled provider of IoV solutions.

shipments and send real-time update notifications, further facilitating planning, optimising routes and reducing delivery delays.

2.6 Graph theory applied to logistics: route planning

Graph theory emerged in Europe in the 18th century. It is a branch of mathematics used to solve complex problems by studying structures formed by graphs (nodes and edges) that represent various relationships and connections between objects. In the world of logistics, graph theory has become an essential tool for optimising routes and traffic flows. Graphs are very useful for forming, understanding and visualising distribution networks, as the nodes represent points of origin, customers or destinations, and the edges symbolise the links that generate possible connections between them, such as routes, also showing the kilometres to be travelled, costs and time. These graphs facilitate route planning, as they can identify all possible routes that may exist in order to choose the most ideal one for the transport and delivery of goods. This theory has served as the mathematical basis for numerous current systems and models that focus on route optimisation, as well as for solving the Vehicle Routing Problem (VRP). Today, with the help of technological advances, artificial intelligence has been implemented to optimise procedures in this field (Bondy and Murty, 1976). (Gross & Yellen, 2006) (Gore et al., 2025).



[1,2,4,5,6,9] = (1,2,2,2,1) =8

[1,4,5,7,9] = (3,2,1,3) = 9

[1,2,5,6,9] = (1,2,2,1) = **6**

[1,3,4,6,8,9] = (2,1,2,1,1,) = 7

Figure 2

In the diagram above (Figure 2), the circles represent nodes and the arrows represent edges. The small numbers accompanying the edges can represent costs, distances, etc. These graphs show the possible routes that can be taken from point 1 to point 9. The red dotted lines represent the ideal route for delivering the goods. Therefore, according to the numerical representation shown, it can be concluded that it is not advisable to take another route, as this would involve more time or money.

We can clearly see from the diagram that graph theory can be very useful for route planning, however, it can have some problems when being used in real life scenarios. This is because the theory uses fixed numbers to calculate the distance, costs and time and does not take into account delays, for example traffic collisions along the planned route or bad weather conditions. Also, if there are many different potential routes to take, it can take a long time to process, especially for the Vehicle Routing Problem. This is because the number of nodes and edges in the graph increases. However, because of advancements in Artificial Intelligence and its integration into logistics, the process is much faster now, even for more complex graphs with many variables. This is because it can help to plan routes that are too difficult or too time consuming for people to do by themselves. When graph theory started in the 18 th century it was only a theory on paper, and it was then only used in Mathematics and science, but eventually, people started to use it in practice for real problems such as planning routes. Once computers came along, it was much easier to calculate bigger graphs, and now, thanks to the help of Artificial Intelligence it is an even faster process.

2.6.1 Vehicle Routing Problem (VRP)

The Vehicle Routing Problem (VRP) is the generic name given to the various problems that arise when numerous deliveries of goods need to be made at the same time (Injac and Drašković, 2024). This model represents an algorithmic challenge, as it uses numerous algorithms to optimise delivery routes. Its main objective is to identify an essential route that allows the use the fewest number of vehicles to make the greatest number of deliveries in order to reduce costs. It is well known that distribution and transport logistics involve very high costs, one of which is the large number of vehicles used. Consider the VRP of a company with five trucks and twenty-seven customers. The VRP is responsible for deciding which route to take, the number of customers each unit should visit, and the order in which they will be visited.

The Vehicle Routing Problem is directly related to Graph Theory, as it is based on the use of nodes and edges to systematically represent a detailed picture of the optimal routes to be taken in order to achieve the objective of optimising costs and distribution networks.

2.7 Theory of Intelligent Agents according to Russell and Norvig (2004)

According to this theory, route planning can be conceptualised as an intelligent agent. This agent, also known as a 'rational agent', is considered a system that has the ability to make decisions by considering all possible options in order to select the one that generates the best results.

The intelligent agent needs perceptions to make decisions, which can be files, signals, numbers, among others, and can receive them at any time. Regardless of the number of perceptions it has received, the intelligent agent has the ability to 'remember' from the first to the most recent, which is called a 'perception sequence.' That said, the intelligent agent is able to make a decision to act

based on everything it has perceived (when the perception sequence is complete).

It is essential that performance measures are established to determine whether the agent is acting successfully. These are rules created by the agent programmer, which must be clear, precise and objective in order to achieve the expected goals. Otherwise, the agent may interpret them subjectively, leading to unexpected or undesirable results.

This helps to better understand how a rational agent works, acting on its own based on automatic commands with a specific task. This can be understood a little better by observing at how living beings (human agents) work: the brain receives information through the senses (sight, hearing, touch, among others) to know what is happening around it (the environment), then processes the information (interprets it and decides what to do in a millisecond) and finally sends a command to the body. Having a perception of what is right or wrong, rational or irrational, varies depending on the established objectives to be achieved.

Maximising performance is possible, as long as the sequence of perceptions of the rational agent is monitored correctly. Achieving objectives will always be the goal, but the agent needs to have stored knowledge so that it can act immediately and autonomously, i.e. the agent must be able to evaluate different scenarios and be capable of making their own decisions within a work environment, which is referred to by the acronym REAS (Performance, Environment, Actuators, Sensors). These are the problems the agent will be faced in a particular situation. The rational agent will then be the solution to these problems and, as a final step, will be able to choose the best one to meet the indicators and obtain the appropriate result.

Just like the Graph Theory, Intelligent Agents are very useful for planning routes, but they too come with their own disadvantages. This is because they can only

use the information and rules that they are given, as a result, if the data or information given to them is wrong, they can make an incorrect decision or calculation. This is why Artificial Intelligence is so important in route planning, because it can help the Agents to adapt faster to the situation and find a solution more quickly. This saves time and reduces costs, because without AI, people would have to check the Intelligent Agents very regularly to make sure they are correct.

2.7.1 Execution and Replanning Surveillance Agent Model

Murphy's Law states that even the best human plans and conditional planning agents can fail, as unforeseen factors or circumstances may arise that prevent agents from executing their actions correctly, and if there is a failure or error, the problem is indeterminate and unlimited. Therefore, execution monitoring and replanning agents are extremely important in route planning.

The execution monitoring agent is responsible for anticipating all possible perceptions and ensuring that everything is going well. There are two types: simple and complex. The first type is called action monitoring, which is responsible for reviewing the environment and conditions and ensuring that the next action is carried out correctly. The second type, called plan monitoring, is responsible for reviewing that the plan is being followed in a comprehensive and structured manner.

As with everything, if something goes wrong, that's when the replanning agent comes into play. It knows all the possible alternatives to take when an unexpected event occurs, and thus execute a new, previously anticipated plan (avoids spending excessive time planning) and achieve the main objective without excuses. For example, a cargo unit has to get to point A and the goal is to deliver the goods on time, but there's a traffic problem on the planned route (the fastest one), as such, the rescheduling agent has to act right away, reorganising the route before the unit gets stuck in traffic, making it impossible to take an

alternative route to get to point A. Together, execution monitoring and replanning form an comprehensive strategy.

```
function REPLANING-AGENT (perception) returns an action
static: KB, knowledge base (includes descriptions of actions)
        plan, a plan, initially ( )
        complete_plan, a plan, initially ( )
        objective, an objective

TO SAY (KB, GENERATE-PERCEPTION-JUDGEMENT (perception, t))
actual ← DESCRIPTION-STATUS (KB,t)
yes plan = ( ) so
    complete_plan ← plan ← PLANNER (actual, objective, KB)
yes PRECONDITIONS (FIRST (plan)) not currently true in KB so
    candidates ← ORDER (entire-plan, sorted by distance to actual)
    find a status s in candidates so that
    error ≠ reparation ← PLANNER (actual, s, KB)
    continuation ← put in the queue complete_plan from s
    complete_plan ← plan ← ATTACH (reparation, continuation)
returns Pop(plan)
```

Figure 3 (Russell and Norvig, 2004)

In this diagram (Figure 3), we can see how the planning agent starts with an objective and develops a plan to achieve it by implementing a series of orderly actions. On the other hand, the replanning agent tracks the unexecuted plan as part of the original and in its entirety. It is then that the agent uses action monitoring (as mentioned in the previous example of the cargo unit) to analyse all viable options to see if any of the plan's preconditions have not been met before continuing with the next action in the strategy. If so, the agent will reevaluate a plan that will take it back to nearest possible point in the original plan. All of the above boils down to verifying that everything is going accordingly, evaluating and examining possible unforeseen events that prevent an objective from being achieved, and, if there is an undetermined situation, devising a plan B to continue as efficiently as possible. Plan monitoring will help achieve success through proper tracking and evaluation of all possible preconditions.

2.8 Relationship between Graph Theory and Intelligent Agent Theory

When it comes to route planning, Graph Theory and Intelligent Agents are both very important, however, they both function very differently. This is because

Graph Theory uses mathematics and networks in order to find the solution using cost and distance to find the most efficient route using an algorithm. It can be said that this method is very precise but sometimes it is slow if there are too many changes in the network or if there are many nodes and edges. Contrastingly, Intelligent Agents can act more quickly and by themselves using previous information and data. However, they can only be successful in determining the solution if all of the information and instructions given to them are correct. As such, it can be concluded that the best solution when it comes to route planning is to combine the two theories as Graph Theory shows the best route to take, while Intelligent Agents help to make decisions faster using the information it receives in real time. This is much easier to do now as a result of Artificial Intelligence because it can update the agents with information and help them to predict changes, which makes the route planning more efficient.

3. Research Question

'How does the use of Artificial Intelligence influence the distribution and transport process in order to optimise routes, reduce operating costs and offer better customer service in the delivery of goods for the MIRALGAR recycling plant?'

3.1 Objectives

General Objective

Raise awareness of the advantages of using artificial intelligence to improve the distribution and transport process in order to optimise routes, reduce operating costs and offer better customer service.

Specific Objective

- To spark interest in the use of artificial intelligence for the distribution and transport of goods at MIRALGAR.
- To learn how the company plans its goods transport routes.

3.2 Justification

Nowadays, in a globalised world where technology is a fundamental part of everyday life, companies cannot ignore this aspect, as it is synonymous, for the most part, with quality and effectiveness over time. Keeping- abreast of new technological developments is seen to open up new opportunities for companies and to enable them to have a high level of preparedness to face the challenges of the current and future market.

This research aims to determine the magnitude of the problem and raise interest in the use of artificial intelligence, on the understanding that it will be of great help in preventing economic losses, making the most of destinations, in the sense that transport returns with goods and not empty, preventing theft of vehicles and goods, among other things, so that the company will be recognised for the quality of its service in delivering goods on time and in the right way.

All of the above will not only benefit the company, but also some customers, who will benefit from route optimisation and, if they are provided with a service to collect their goods, this will be at a lower cost. Furthermore, this new system benefits society as a whole, as it avoids routes where lorries or trailers pollute the environment, as deliveries are made in a single trip.

3.3 Hypothesis

'If the recycling company implements the use of Artificial Intelligence, it will improve its distribution processes and reduce costs.'

3.4 Variables

V - dependent Artificial intelligence

V - independent Training programmes on the use of Artificial Intelligence

4. Methodology

4.1 Type of Research

This research uses a quantitative methodology. This methodology was chosen because the process is sequential and probative, with each stage preceding the next and no steps that can be skipped or bypassed. Although some phases can be redefined, the quantitative methodology allows me to use the multiple data collection process technique. The research approach is specific and defined from the outset of the study, using logic or deductive reasoning; there is no need to test the hypothesis. Among the quantitative characteristics of the approach to the problem, it is oriented towards description, prediction and explanation, and is directed towards measurable or observable data. In the data collection, I used predetermined instruments and numerical data, which allow me to clearly see the state of the recycling company in this case. In the data analysis, the trend and relationship between variables were described, allowing me to compare the results with predictions and previous studies in the future. By looking at the results of the research in the results report, the objective can be presented without trends.

As for the definition of qualitative research, since I understand it as a method that focuses on understanding social phenomena, experiences, and human behaviour, it focuses on the quality of the data. Therefore, it would be necessary for me to engage in the social context in order to observe and participate in the activities of the participants, a situation that is not possible due to the distance

between countries. For the reasons mentioned above, I considered it unfeasible to carry out my research.

Hernández Sampierí (2014:78) ‘Contains the classification of types of study: exploratory, descriptive, correlational, and explanatory.’

Regarding this classification, it will be considered important, the design of the research and other elements of the process will be considered important, due to the type of study that is subject to the strategy used. Any study may have elements of more than one of these four types of research.

As mentioned above, it is important to specify the type of study, which in this case is descriptive. (Sampieri, 2014:80) ‘Descriptive studies seek to specify the properties, characteristics and profiles of people, groups, communities, processes, objects or any other phenomenon that is subject to analysis.’ In other words, they only aim to measure or collect information independently or jointly about concepts.

This work will be carried out under the quantitative paradigm, also known as hypothetical-deductive, rationalist-quantitative or positivist. It is based on the positivist theory of knowledge and is characterised by its quantitative nature in order to ensure the accuracy and rigour required by science.

Positivist knowledge is based on observable phenomena that are subject to measurement, mathematical analysis and experimental control.

The foundations of quantitative methodology have their roots in positivism, which emerged in the first third of the 19th century as a reaction to empiricism, which was dedicated to collecting data without taking knowledge beyond observation.
Later, neo-positivism or logical positivism emerged in the 20th century, making one of the most important contributions to probabilistic induction. The key to

this development is to test hypotheses probabilistically and, if they are accepted and proven under different circumstances, to be able to develop general theories. It should be remembered that the research in question is descriptive.

4.2 Research Design

The research design will be flexible in terms of its plan, structure and general strategy. This provides guidance and direction during the research in order to respond to the problem posed (Arias, 2012; Ñaupas, 2014).

It was considered ideal to use a field design for the research, which consists of collecting data directly from the subjects under investigation or from the reality where the events occur (primary data), without manipulating or controlling any variables (Arias, 2012; Martins & Palella, 2012). The researcher obtains the information, but does not alter the existing conditions, through direct observation, interviews or other techniques (Arias, 2012; Martins & Palella, 2012; Rojas-Soriano, 2013). Therefore, only the data obtained will be described, without manipulating the information.

According to Hernández (2014), 'The term design refers to the plan or strategy devised to obtain the desired information.' Design includes procedures and activities aimed at finding the answer to the research question.

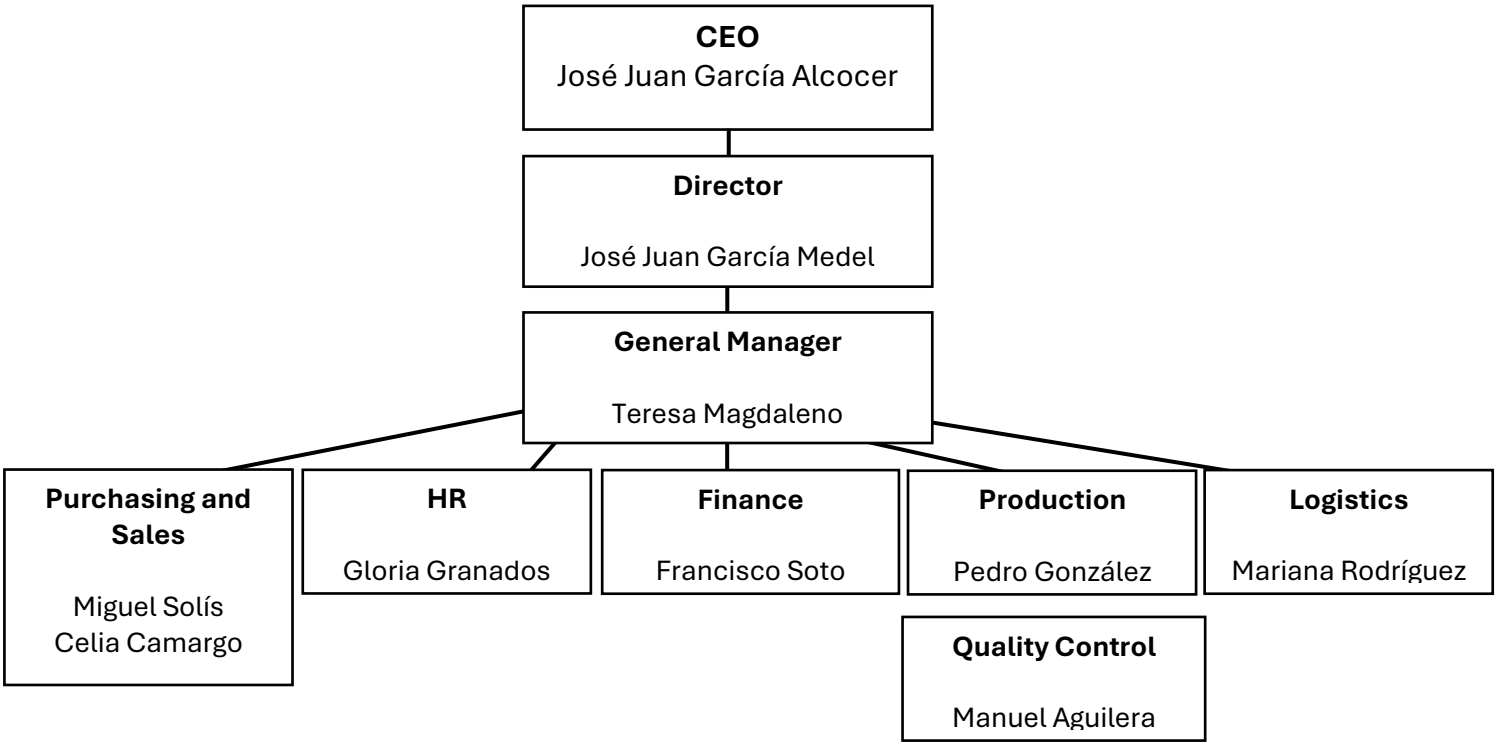
The strategy adopted to obtain the necessary information from the research subjects was to interview the heads of the different departments: the CEO, the director and the general manager. It should be noted that they were given freedom to choose the topic in order to understand the situation affecting the company as a whole. Subsequently, a questionnaire was developed to find out about the logistics of the route planning area.

4.3 Study Population

This research was conducted at the recycling company MIRALGAR S.A de C.V located in the community of Aldama Jaripitio, municipality of Irapuato, Guanajuato, Mexico. MIRALGAR is a company with more than 25 years of experience in the industrial and recycling sector. It also manufactures and sells 100% recycled polyethylene bags, among other products.

4.4 Research Subjects

The recycling plant is organised as follows:



MIRALGAR is a company that has grown significantly over time. As a result, it has implemented additional services, such as supporting other companies by collecting recyclable materials, which are then converted into raw materials for the manufacture of bottles, bags, plastic sawdust, buckets, and other materials.

The exponential growth of the company has also brought several problems, which have been prioritised, with the following being given the highest priority or urgent attention: the company has been experiencing delays in delivering

orders; there is no organisation in place for managing delivery routes, as the company only knows one specific route for each destination; and there does not appear to be good communication between drivers and managers when they encounter unexpected situations such as getting stuck in heavy traffic. It is worth mentioning that they are also affected by a lack of route planning when collecting materials from another company.

On the other hand, MIRALGAR delivers its orders as soon as they are ready to go out, but it does not have a 'plan B' in case of any disruptions. The company has also had to pay a lot of overtime to drivers as a result of incorrect estimates of delivery times, which has led MIRALGAR to consume high levels of fuel due to taking routes in poor conditions, increasing delivery times. Consequently, there are occasions when drivers do not respect speed limits because they are already behind schedule.

Unfortunately, MIRALGAR has suffered due to the theft of significant quantities of products on numerous occasions, which has had a substantial impact on the company's profits. This occurs mainly when drivers stop to refuel, as there are robbers who open the rear doors of the vehicles and take goods from inside. In addition to the theft of goods, the company has detected fuel theft from vehicles by drivers themselves and outsiders, as a result of poor social conditions in the locality. It has also been observed that some vehicles are not in the best condition, as they have mechanical faults and continuous tyre wear, which also causes delays in the delivery of goods.

4.5 Information Gathering

It was considered important for the research to gather first-hand information about the conditions under which the recycling plant operates and to listen to the problems faced by the company through interviews, in order to analyse which of those is currently causing significant economic losses. Without a

doubt, the most significant problem is the process of distribution and transport of goods.

Therefore, after analysing the best methods that would be useful for gathering information, it was decided to use a questionnaire as the data collection tool.

4.6 Data Collection Instruments

For this research project, a questionnaire was used as a data collection instrument to learn about its forms and uses in route design and goods distribution.

I consider the questionnaire to be functional, as it is written in paper format and contains a series of questions. It is called a self-administered questionnaire because it must be completed by the respondent without the intervention of the interviewer.

The questionnaire was designed so that the answers would be based on a Likert scale and multiple choice, taking into account the two variables of the research, which allowed me to obtain valuable information for this study.

4.7 Sampling

According to Sabino (2014), 'The population, or in more precise terms, the target population, is a finite or infinite set of elements with common characteristics for which the conclusions of the research will be extensive. This is delimited by the problem and the objectives of the study'.

This research was conducted with a finite population. According to Sabino (2014), 'Finite population: a group in which the number of units that comprise it is known. In addition, there is a documentary record of these units.'

According to Sabino (2014), 'Intentional or opinionated sampling: in this case, the elements are chosen based on criteria or judgements pre-established by the researcher'.
The sample selected is considered to be adequate to provide the information necessary for this research.

4.8 Data Analysis

4.8.1 Interpretation and Analysis of Information

The data obtained from this research has been studied in order to analyse and interpret these results, using the research tools and producing graphs for greater clarity, understanding and resolution of the issues addressed in this research.

4.8.2 Information Graphs

The results of the research tool is shown in graph format and provides the relevant interpretation.
This interpretation reveals the questionnaire with the actual opinions that supported this research, as well as the results of the analysis once the responses obtained were graphed.

4.9 Limitations

During the research, I faced difficulties in obtaining authorisation to access sources, articles and books to support and sustain the work. There were also delays in receiving the completed surveys.

4.10 Ethical Considerations

The use of a set of moral principles is considered fundamental to the generation of research. Ethical practices were followed during the course of this research. It

is affirmed that all content was generated by the researcher's own investigation. Authorisation was obtained to use information from the company under inquiry, such as the company name, location, employee names, reports among others. The questionaries and surveys were generated with respect, honesty, and integrity by the researcher and participants. Quotes were used in the text accompanied by the necessary references to respect and acknowledge the work of other authors and to develop solid and credible research.

4.11 Section Conclusion

In this research, I considered Russell and Norving's theory of intelligent agents, which discusses the importance of artificial intelligence in supporting or, failing that, to make decisions about the best option to follow. In this case, we would be talking about the relevance this theory would have in the aforementioned recycling plant, in order to provide solutions to the problem detected regarding the best possible options to adopt for the transport route.

To talk about Murphy's Law is to talk about reality, which is evident in the recycling plant, since the department in charge of distribution issues the dispatch order with the intention of delivering the goods timely and safely, which in most cases does not happen due to problematic situations or conditions that may arise at that moment. Therefore, I consider it important to conduct a quantitative investigation, with a hypothetical-deductive approach. This is because, when talking to the CEO, as a researcher, I began to design hypotheses based on the comments made and draw conclusions as to why the company is suffering such substantial financial losses. When selecting the research sample, I was rigorous in selecting the population that would provide me with the data, all of which possessed the following characteristics: reliable, truthful, real, current and, above all, knowledgeable about the subject matter. The research is considered descriptive, as the company is not in the best position to invest and train the necessary personnel in the use of artificial intelligence.

Furthermore, using surveys as tools, allowed me to learn about the reality of the company. From my personal point of view, I believe that this was very helpful for the company, because when I first spoke with the CEO, Director, and General Manager, about the history of the recycling company, its beginnings, and the growth it has experienced over the years, and then about the results of the surveys, it sparked their interest. They asked me for information about artificial intelligence to help them with their route design. It is now a possibility that the company will implement AI into their route design in the medium to long run, proving my research very helpful.

Personally, I believe that working on field design has helped me to understand the company's problems and no less importantly, through dialogue. I would like to reiterate that they are looking to improve and update their delivery route logistics as a result of my research.

5. Analysis and Findings

Presentation of Information

To obtain the necessary information, I first conducted an interview with open-ended questions with the CEO, Director, and General Manager of the MIRALGAR recycling company to learn about the background of the company where my research was conducted. For the proposed objectives, I designed a questionnaire that allowed me to learn about the logistics and organisation of the department in charge of delivery routes (Appendix 1).

Calculating the validity of the questionnaire

I needed to review and verify the aspects that form the basis of what I wanted to measure with an instrument. This is based on theories and sequences ranging from the simplest to the most complex results obtained when applying the instruments, without forgetting that they are measured according to the

research objectives. The priority for the research is to understand the reality of the company in terms of the use of artificial intelligence for transport route designation.

Calculating the reliability of instruments

Any instrument must be valid, otherwise the results of the research may not be considered equally reliable. Reliability describes the degree to which repeated application of a measuring instrument to the same subject or object will yield the same results.

The importance of this is channelled to the degree to which a measuring instrument actually calculates the variable it is intended to measure. 'Content validity refers to the extent to which an instrument reflects a specific domain of the content being measured' (Hernández, 2014).

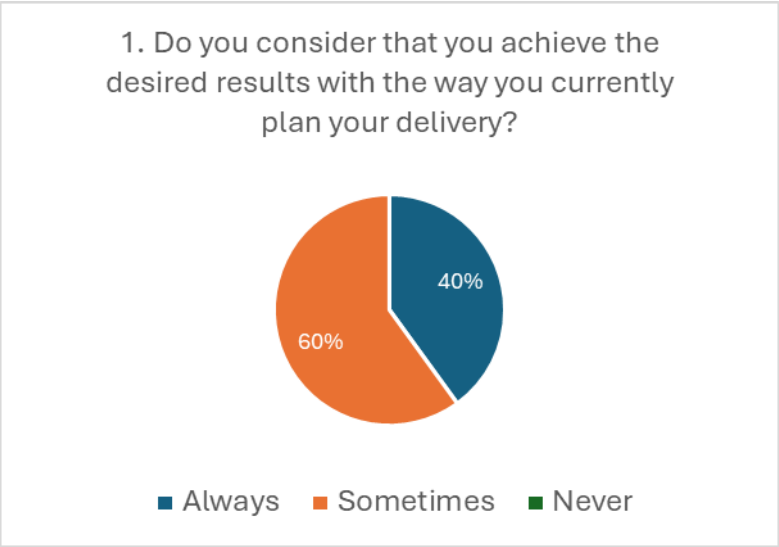
The research was based on theories, which is why it was necessary to conduct documentary research to confirm each of the judgements made in the refinement of the work. From this, it is important to note the validity of the criteria that establishes the value of a measurement tool by comparing it with external criteria and verifying reciprocity.

Treatment description

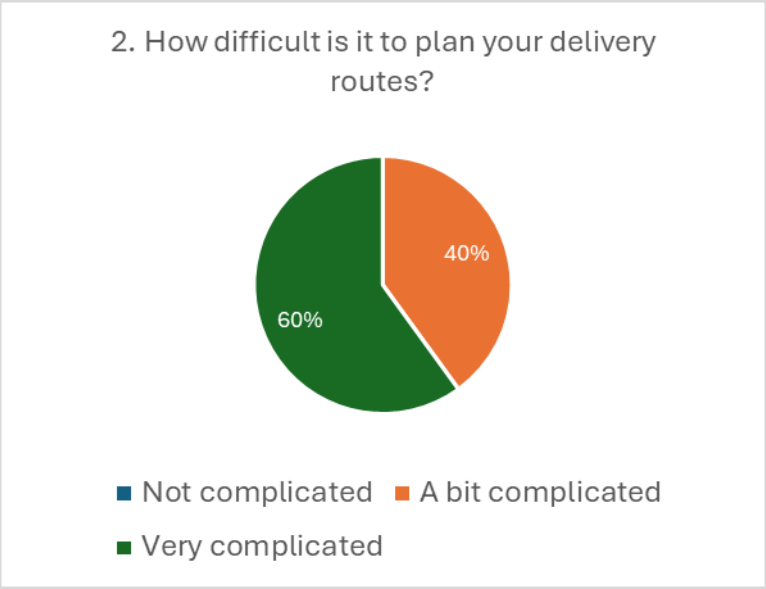
After analysing the above results and the attitudes of the surveyed population, it was suggested that implementing artificial intelligence to improve their delivery route processes would be greatly beneficial.

The interpretation of the results provides a general understanding of how the logistics department works in terms of delivery route distribution and its consequences.

Questionnaire results



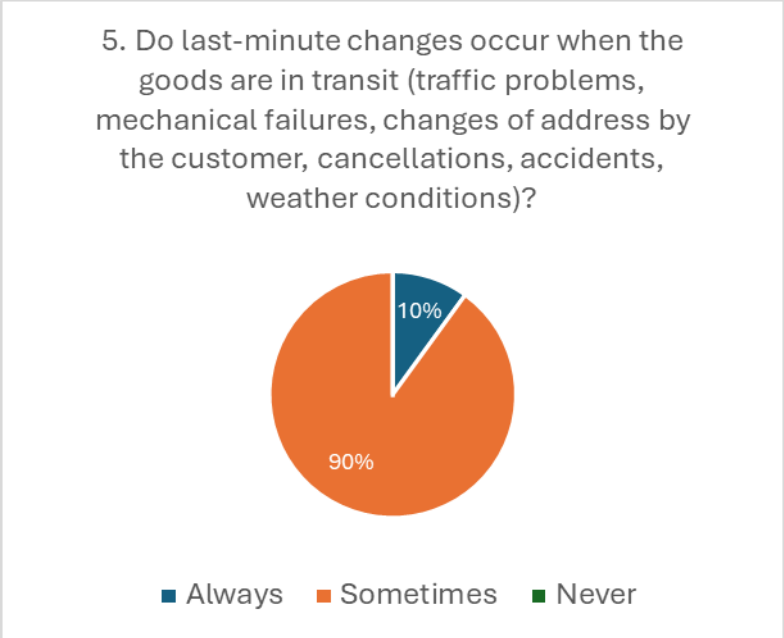
It was observed that 60% of participants considered that desired results are only sometimes achieved in route planning, while 40% consider that this is always the case. It is clear that the process needs to be optimised, as continuous delays are very prominent according to participants.



It was observed that 40% of participants find it somewhat difficult to plan routes and 60% say it is very difficult. They comment that it is a process that requires a lot of time and effort.

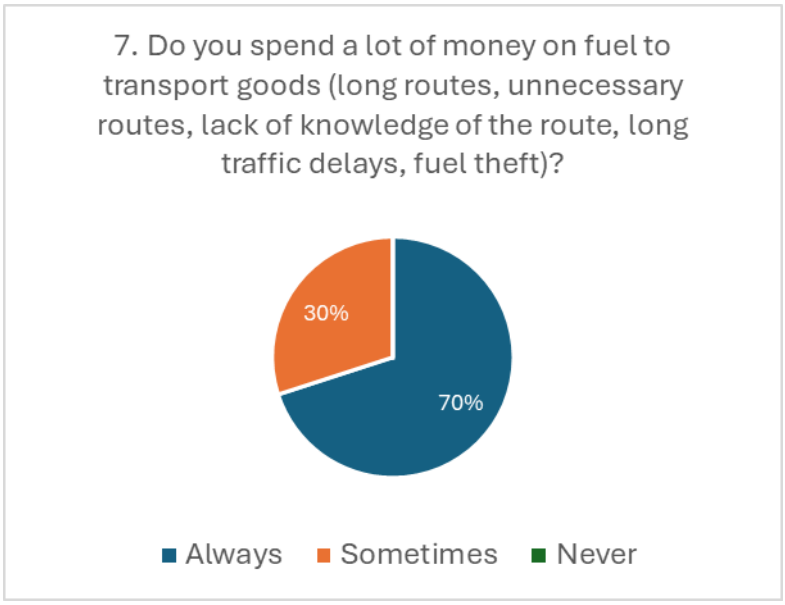
It was observed that 100% of participants confirmed that they do not use any software or programmes for route planning. They commented that they decide which routes to take based on their own knowledge and that they explain the routes to drivers when necessary.

It was observed that 80% of participants say that there are sometimes delays in delivering goods, and 20% say that there are always delays. They comment that this is due to traffic, drivers not knowing the route, and mechanical breakdowns.

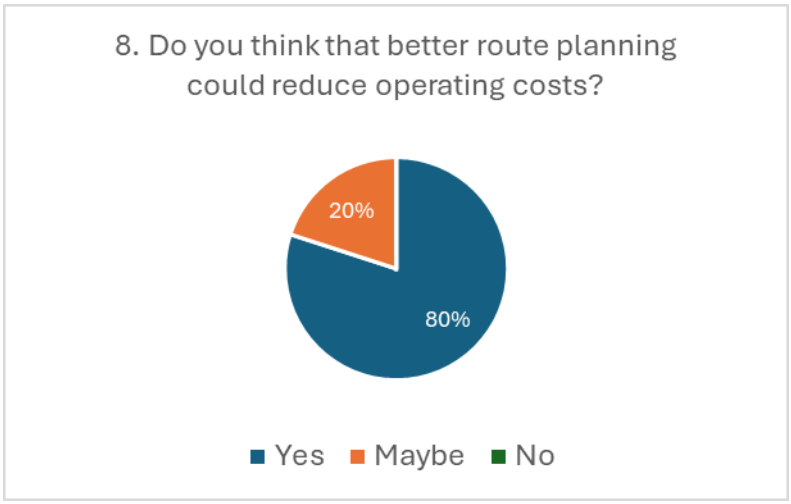


It was observed that 90% of participants confirm that unexpected situations arise when goods are in transit, and 10% say that this always happens. They comment that car accidents often cause high levels of traffic and that vehicles sometimes break down, forcing drivers to stop on route.

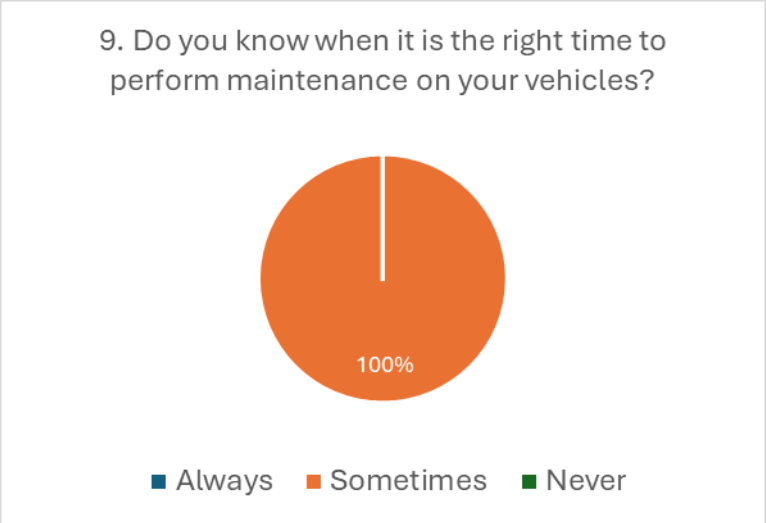
It was observed that 90% of participants consider transport logistics to always be a costly process, while 10% say that this is sometimes the case. They comment that high levels of fuel are consumed, a lot of overtime has to be paid, vehicles require continuous maintenance, and, on occasion, goods are stolen.



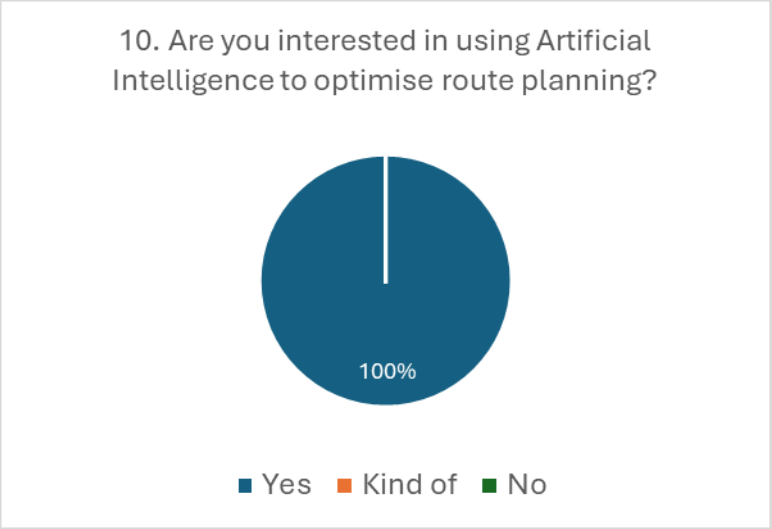
It was observed that 70% of participants say they always pay large amounts of money for fuel, while 30% say they sometimes do. They comment that there are occasions when drivers have to fill up more than five times a day and mention that fuel theft by drivers themselves occurs.



It was observed that 80% of participants agree that better route planning could reduce operating costs, while 20% say maybe. They emphasise that if there were not so many delays and mechanical failures, they would not have to pay so much overtime and high maintenance costs. Others mention that they have heard of advanced programmes and technology, such as Artificial Intelligence, that can help in this regard.



It was observed that 100% of participants only occasionally know when it is the ideal time to perform maintenance on transport vehicles. They comment that there are times when they only know it is necessary when the vehicle shows obvious faults such as oil leaks, noises or vibrations, brake failure, tyre blowouts, among others.



It was observed that 100% of participants said that the use of Artificial Intelligence to improve route planning is very interesting. They commented that Artificial Intelligence is a very popular tool nowadays that has brought many benefits that help the working world and that it would be very impressive if MIRALGAR started implementing this technology.

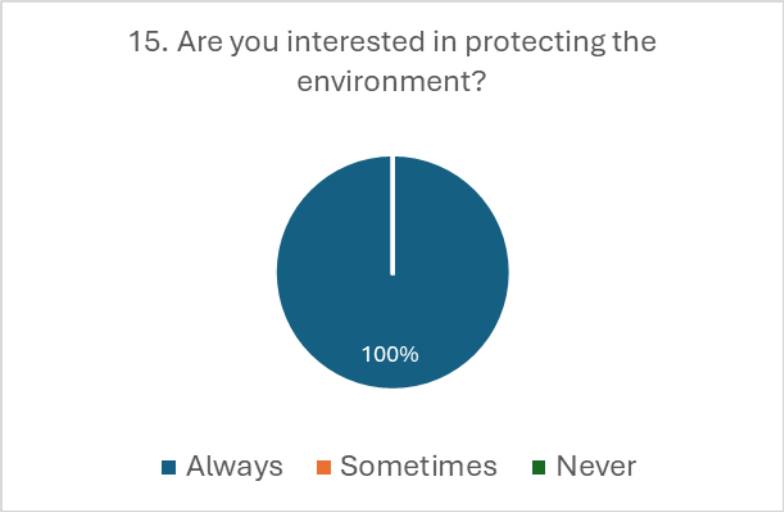
It was observed that 100% of participants sometimes feel satisfied with the communication between the logistics manager and drivers. They comment that there are situations where drivers only sometimes notify the manager of last-minute problems or changes when they are delivering goods, while the manager thinks that everything is flowing smoothly when this is not the case.

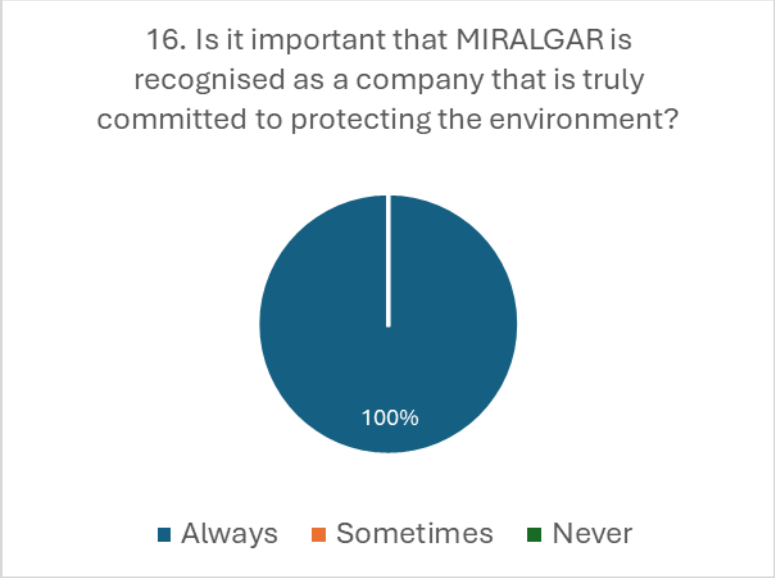
It was observed that 100% of participants stated that the company has suffered several incidents of theft of goods during delivery. They commented that this has happened when drivers have had to stop at petrol stations to refuel, that it is impressive how quickly the rear doors of the trucks can be opened, and that this

has had serious consequences in terms of financial losses and the need to clarify the situation and compensate customers.

It was observed that 100% of participants said that they had sometimes had unsatisfactory experiences with customers due to poorly estimated delivery times for goods. They commented that it was very uncomfortable to have to explain to customers when their goods would not arrive on the date or at the time they had been given, and that on some occasions this understandably increased the level of discomfort.

It was observed that 90% of participants would be interested in taking advantage of return trips once goods have been delivered, and 10% said they would sometimes be interested. They commented that it would be a good idea to increase profits and create more brand and service recognition.





Graphs fifteen and sixteen show that 100% of participants are highly committed to the environment and want the company to be recognised as a green company. They comment that, as a recycling company, caring for the environment is automatic and essential, that it is extremely important for them to be able to contribute with all the necessary practices that help to care for our planet, and that they are always willing to follow the necessary requirements to be part of this.

6. Discussion

It is worth mentioning that this section presents a series of conclusions in accordance with the objectives set out.

We currently face a complex society which, due to globalisation and competition, is struggling to maintain its place, and companies are no exception. Therefore, logistics is the backbone of these companies, as it is responsible for strategically connecting services, people, and resources. Thus, the best ways or strategies must be sought to be implemented, in this case, an adequate plan for the transport route of goods.

It should be noted that, in the case of goods distribution and transport, according to the information obtained in the state of the art, companies that plan conscientiously i.e., identify risk factors, safety in terms of maintenance, the vehicle fleet, driver training and use of high-security locks on vehicles to safeguard goods, anticipating possible unforeseen events during transport.

On the other hand, there is also talk of establishing communication with companies based in the most frequent destinations, with the aim of scheduling double services, i.e., delivering goods and returning with others, in order to reduce the costs involved in transfers.

I agree with Maslowski's idea about transport logistics, as with proper operational organisation, the best route can be found to transport goods from their point of origin to their final destination, creating an image of commitment and responsibility for the company.

I consider that graph theory should be present in logistics departments because, thanks to its structure in which graphs are responsible for visualising distribution networks, with nodes representing points of origin and edges representing the links that generate possible connections between them, routes and distances to

be travelled, thus facilitating the choice of the most ideal and suitable route for the transport and delivery of goods.

I believe that artificial intelligence is a key element in improving transport route design, although my position may be somewhat controversial, as I would argue that artificial intelligence can perform activities that are generally carried out by human beings. I completely agree that it is a very valuable tool for logistics or, as it is now being called, “new logistics”. This concept is supported by other researchers, whom I mention in my research, who talk about the influence it currently has due to its ability to solve problems flexibly and effectively, based on mathematical methods.

There are also countless advantages, including the fact that AI can work more efficiently than a person, as it is designed to work long hours without rest, as well as perform and solve multiple tasks (regardless of their degree of difficulty) even faster than a human being. Artificial intelligence also has a very low probability of making mistakes during operating, which is why thousands of users turn to it to achieve more accurate results.

Analysing the advantages offered by artificial intelligence, in addition to those mentioned in previous paragraphs, I would highlight improved efficiency and cost reduction, customer service and the design of more functional routes. Last but not least, it also generates less pollution for the planet.

Within information discrimination, using Russell and Norvig's intelligent agent theory, I identified part of the answer to my research question, which is: ‘How does the use of artificial intelligence influence the distribution and transport process for route optimisation, in order to reduce operating costs for the MIRALGAR recycling company?’ This is because the intelligent agent they mention can receive countless files, signals and numbers, and I always interpret that it will provide me with the best option for designing the delivery route, although I also reflect and analyse that the person in charge of entering the data

must be very careful, as the agent will make the decision based on the information received.

This brings me to Murphy's Law, which states that even the best human plans and the best planning agents are prone to failure or delay, although it should be noted that this would be in situations beyond their control.

The objectives proposed in this research were achieved because the advantages of using artificial intelligence to improve transport routes were made known, which sparked the interest of the main members of the company's organisational chart.

I would like to confirm the hypothesis of my research: 'If the recycling company implements the use of artificial intelligence, it will improve its distribution processes and reduce costs.' This is because it would be a tool that would allow them to position themselves as a responsible and committed company in terms of deliveries and also as an environmentally friendly company.

Within the quantitative research methodology, I managed to find a balance in the sense that, given the company's lack of financial resources, the description of its situation, the analysis and interpretation of the questionnaire allowed directors and managers to reflect on the urgent need to implement artificial intelligence and the importance of training staff when installing artificial intelligence equipment in order to reduce costs and improve the services they offer to their customers. Furthermore, MIRALGAR, as a recycling company, is clearly committed to contributing to the protection of the environment, and it was impressive for the members of the organisation to learn that, with the use of AI, they can continue to collaborate and obtain added value in this area.

I am therefore satisfied with the results obtained and with having contributed in some way to solving the problem posed.

7. Conclusion

The conclusions presented below are limited in nature and are only valid for this research project.

Our world is becoming increasingly globalised, with technology constantly evolving and making surprising advances. I conclude that transport logistics must keep pace, as it has proven to be a vital area for companies that want to achieve success, and its importance will continue to grow.

Throughout this research, it has been demonstrated that Artificial Intelligence can be used in a positive way, as a powerful tool for assistance, optimisation and safety in the world of freight transport logistics.

I will start with the conclusion I reached in the research question "How does the use of Artificial Intelligence influence the distribution and transport process for route optimisation to reduce operating costs for the recycling company MIRALGAR?

After having analysed and reflected on the detected problem, I can affirm that it will have a significant influence, since it would facilitate and optimise the planning process to determine the best route, i.e. the appropriate one, to reduce the economic losses that are affecting the company, On the other hand, it could also be observed that it affects the image of the company, either by its delays, i.e. it is projecting a negative image, which will have an impact on the possibility of having more customers interested in contracting its services, or in the purchase of any material that the company sells.

I am satisfied to note that the general objective of the research was met, since, when I explained to the company's directors, the influence of implementing artificial intelligence in their logistics processes, it would have an impact that would be reflected in their economy. It is also worth mentioning that I told the

team that in addition to the programmes; by equipping the vehicle fleet with locks and security systems, everything would flow with greater security and would protect their units and goods.

Within the first specific objective, which was to spark interest in the use of artificial intelligence, I noticed that what most caught their attention was when I explained that, through the use of artificial intelligence, they could find safer ways to deliver their goods and at the same time they could take advantage of the fact that the unit would not return empty, which would amortise the cost of fuel and the driver's salary, among other things. Also, by working with artificial intelligence, they could cut staff in the logistics area and use those salaries for another position or to maintain and update the equipment.

The other objective of knowing how they plan their distribution routes, allowed me to understand why the company has economic losses, because it is very simple, there is no protocol, that is, the production department notifies the logistics department that they must send certain goods and this is limited to saying: ‘load the unit or trailer 25’, because they are numbered, they just tell the driver: ‘tomorrow you leave’ and tell him the time, and where he is going and he only goes to collect the card for the diesel. The driver is free to take the way he wants, so, as has been said, this increases overall costs. Therefore, it was suggested to give the driver the destination and the route to make the delivery faster and more efficient.

MIRALGAR is a company that has a small variety of logistical problems, but really significant ones, and it is pleasing to know that with all the inputs that artificial intelligence has brought, they can help MIRALGAR to solve them and also put them in a stronger position within the market, as it is a company that has strived to operate healthily and ethically to stand out in the industrial sector.

This research has given me a new perspective on the importance of keeping up with current technology to remain competent and competitive in the market,

that if my freight vehicle is delayed there is a ‘plan b’ to remain profitable and efficient. ‘Logistics is considered complicated and expensive, but there is a way to make the process easier, more enjoyable and save money,’ through Artificial Intelligence.

In general, they were given some recommendations to improve their route design processes, such as having the department indicate the shortest route, maintaining the vehicle fleet, training drivers in the use of GPS, offering economic incentives to drivers who are responsible when transporting goods, ensuring that the units do not return empty, and updating logistics personnel so that they can offer a better service in their department.

There is still a long way to go, but the completion of this work allows me to see better perspectives in the results that were obtained, as well as to increase my cognitive heritage, after having discriminated the bibliography consulted for the present research.

Appendices

Appendix 1:

Questionnaire

1. Do you consider that you achieve the desired results with the way you currently plan your delivery?
   a) Always
   b) Sometimes
   c) Never

2. How difficult is it to plan your delivery routes?
   a) Not complicated
   b) A bit complicated
   c) Very complicated

3. Do you use any programmes/software to plan your routes?
   a) Always
   b) Sometimes
   c) Never

4. Have you experienced delays in the delivery of goods?
   a) Always
   b) Sometimes
   c) Never

5. Do last-minute changes occur when the goods are in transit (traffic problems, mechanical failures, changes of address by the customer, cancellations, accidents, weather conditions)?
   a) Always
   b) Sometimes

c) Never

6. Do you find transport logistics expensive?
   a) Always
   b) Sometimes
   c) Never

7. Do you spend a lot of money on fuel to transport goods (long routes, unnecessary routes, lack of knowledge of the route, long traffic delays, fuel theft?
   a) Always
   b) Sometimes
   c) Never

8. Do you think that better route planning could reduce operating costs?
   a) Yes
   b) Maybe
   c) No

9. Do you know when it is the right time to perform maintenance on your vehicles?
   a) Always
   b) Sometimes
   c) Never

10. Are you interested in using Artificial Intelligence to optimise route planning?
    a) Yes
    b) Kind of
    c) No

11. Are you satisfied with the communication between drivers and the logistics manager?
    a) Always
    b) Sometimes
    c) Never

12. Have you suffered significant losses/theft of goods while they were in transit for delivery?
    a) Always
    b) Sometimes
    c) Never

13. Have you had any bad experiences with customers as a result of late delivery of goods?
    a) Always
    b) Sometimes
    c) Never

14. Would you like to be able to take advantage of return trips to the company once the goods have been delivered and the vehicle is empty and has no more goods to deliver?
    a) Always
    b) Sometimes
    c) Never

15. Are you interested in protecting the environment?
    a) Always
    b) Sometimes
    c) Never

16. Is it important that MIRALGAR is recognised as a company that is truly committed to protecting the environment?

a) Always
b) Sometimes
c) Never

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