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Resumo A company in the boat industry transferred production of boats from a facility in Poland to a facility in Portugal. This transfer happens due to capacity constraints in the origin facility. Trucking the boats from Portugal to Scandinavia (main market) was very expensive and representing an increase of greenhouse as emissions. In this context was developed this project with the goal to find a cheaper solution to deliver boats to Scandinavia that at the same time could offer a more environmentally...

Developing intermodal freight transport solution to boat industry

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Abstract: A company in the boat industry transferred production of boats from a facility in Poland to a facility in Portugal. This transfer happens due to capacity constraints in the origin facility. Trucking the boats from Portugal to Scandinavia (main market) was very expensive and representing an increase of greenhouse gas emissions. In this context was developed this project with the goal to find a cheaper solution to deliver boats to Scandinavia that at the same time could offer a more environmentally sustainable alternative. For some boat models (the smaller ones) were analysed the possibility to fit 2 boats in a container. If we could use containers to ship boats by sea and complement last mile with road transport, we might have big impact on freight. Investigations were done comparing both solutions and freight costs. When we verified that it was possible, we had also to analyse the unloading condition at the destination. How the customers will unload the boats from the container. Which equipment will be needed. Some tests were performed, and a special platform were developed to help the customer at unloading mo-

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ment. This platform needs to be sent inside container to each customer at the first shipment. Will be reused for the next ones. The last point to take in account was the fact that the container must be on the floor in order customer can pull out the boats, for that the delivery of the container must be done with a side loader. After this investigation new calculations were done to have all associated costs. Project was tested and implemented afterwards for 3 different boat models. The saving of 60% in freight comparing with initial solution were one of the main advantages.

Keywords: Combined transportation; Container shipment; Environmental impact; Freight costs.

1. Introduction

In 2019 the road transportation represented 52% of the goods transport activity in European Union. The maritime mode was responsible only for 28.9% of the modal split [1]. Comparing the distribution of these percentages during the last 10 years we may say that partition has not changed, what means that still exists a lot of work to be done to achieve a more equitable distribution between these two transport modes.

The diesel price increases together with the penalties introduced in the main cross countries in Europe related with vehicles class emissions are creating barriers on road transportation and impacting the freight cost to the large corporations. At the same time all the European policies related with greenhouse gas emissions arising from transportation are pressing the companies to adopt solutions to reduce these emissions. Knowing the road transportation is the mode that represents the biggest values related with CO_2, PMc and NO_x emissions in grams per ton per kilometre, is urgent to change behaviours[2-4].

Nowadays the majority of companies seek for different approaches to reduce costs fostering all projects related with wastes reduction or elimination. One way to achieve this is to shift the logistical operation itself. This project was carried out in a company from the naval sector more precisely on the transport planning department. The objective of this project for the company was to evaluate the benefits of shifting from a unimodal road transport to a combined transport solution. The main issue was the freight cost to transport the boats from the plant in Portugal to the Scandinavia customers. After a production relocation from a facility in the north of Poland to a facility in the north of Portugal due to production costs issue a new challenge arise mainly related with the transport cost. Having Scandinavia, a proportion of 26% of the company sales the impact to act on this market will bring good savings to the business. The outbound flow of the company is carried out in two different ways, road transportation for most of the boat models and sea transportation mainly used

to reach oversea customers. After the production relocation some alternatives were evaluated to reduce the freight costs but also to have the less impact on the environment. Despite that all boats to Scandinavia were being shipped by road at the beginning. During the study were analysed the freight cost reduction, service level, third leg requirements, seasonality, and the environmental impact. The major results were a significant reduction on the freight price [5] and a positive impact on the ecological footprint. Despite of these results also were evaluated the transit time for the new solution and the impact to the final customer balancing with the freight reduction. In conclusion this change requires a logistic reorganization and some adaptations to keep a good service level for the customers and keep their expectations.

This paper is divided into five sections, namely, introduction, literature review, methodology, case study analysis, which is divided into three subthemes: actual situation, investigation and analysis of the new solution and results discussion. The last section refers to the conclusions related with the new solution.

2. Literature review

During the last years we have witness an increase interest with the planet and with all types of environmental pollution. Since the release of the white paper [4, 6] several studies have been done, goals were defined, and strategies delineated to reverse the actual situation. The main objective of European Union is focus on how to reduce the emissions to the environment of CO_2, that cause climatic changes and PM_{10}, NO_X and SO_x that provoke air pollution[7]. The specific objectives of the White Paper are to reduce the greenhouse gas emissions in 60% until 2050, limited the congestions and reduce the oil dependency to achieve a more sustainable transport system[8, 9]. Is important to highlight that during the last years the greenhouse gas emissions have decreased in all sectors except on transportation, specifically on road transport the increase was almost 28%[2]. In the EU the transport is responsible for a quarter of greenhouse gas emissions and road transport represents 72% (in 2019) reason why European Union advocate that the green mobility must be the new permission to grow in the transport sector[3].

The goal is that Europe become the first continent climatically neutral in 2050 developing more sustainable transportation and bringing more significance to Short Sea Shipping. Due to that it was clearly defined a list of sustainable activities where the maritime transportation is included[10].

One of the ways to reduce Greenhouse gas emissions is to perform a modal shift or to take advantage of a combined transportation selecting the less pollutant modes in this specific study a combination road/sea/road. According to [11] the first transport

(pre-haulage) will be a road transport until the port, the second long-haulage distance will be by sea and the third one (post-haulage) by truck again until cargo reaches destination. As the longer distance will be performed by sea and as the maritime mode is less pollutant than the road mode is expected that this combined transport will have a positive impact on greenhouse gas emissions. [9]have simulated many shipments and found that combined shipments are less polluted than road- only.

Even choosing maritime transportation as the main transport mode and knowing that is the one representing less impact on the emissions to the atmosphere comparing with road transportation[7] in fact is also important to work on cutting the ships CO_2 emissions to the environment. One way to decrease these ships emissions is through the speed reduction. The slow steaming is a way to decrease the average speed of the ships. Since 2007 the main maritime operators (Maersk and CMA CGM) started this exercise with a thinking of fuel safe [12]. During the last years the slow steaming has been used for other reasons like capacity reduction, cargo value, cost saving and greenhouse gases reduction. Currently IMO regulations keep encouraging slower speed which addressing ships to achieve a certain level of energy efficiency [13, 14].

Is also important to mention the significance of the European ports and how they have been grown in a functional way to allow the modal transference between transport modes [3] in their hinterland. Ports aren't anymore a piece of land without continuity, but they are the way to connect efficiently the supply chains and contribute for a more sustainable transport network. Following the various EU guidelines to reduce GHG emissions the main European ports are implementing sustainable measures to become more cleaner and environmentally friendly. Depending on port authorities these actions can be extended to port hinterland and all connected activities like handling, warehousing, interfaces, and transportation forcing them to change and adapt to the new reality. The common line for all these strategies is to penalise the more polluted activities depending on fossil fuels and promote the more sustainable ones. Apart of the measures extended to the port hinterland also inside ports cleaner measures are applied as the case of using new equipment to improve the cargo handling and allowing ships to be moored at the ports with the engines switched off and use power provided by the port[15, 16]. This energy supplied from ports should provide also from renewable sources decreasing the ecological footprint. To shift from one mode transportation (truck) to a combined solution (sea/truck/sea) is important that ports are adapted to provide the right interface that minimize the mode transference time, cost and resources needed. Is also key a good connectivity and that all parts involved work together to achieve the best results for all players.

The transport companies have also to adapt their trucks using hybrid or electrical engines that now are more reliable for short distances than bigger ones. These companies need to understand that are the best partner as a complementary solution than a solution for the entire problem. They need to adjust to the new reality.

3. Methodology

Methodologically this work started with a literature narrative revision in the way to explore the merchandise transport trends and the actual state, crossing gathered information with the goals that trigger this work. The research was initiated considering as base the requirements of a literature systematic review through EndNote19 software, however the option was to filter out the results by the newest articles, with the key words (transport cost, multimodal solutions, environmental impact), presenting relevant summary and title, ending adding technical reports.

As the objective of this study consist in solving a concrete problem of a company e simultaneously foment the literature the chosen methodology was critical action-research[17] .

The proposed solutions were evaluated in a multi-criteria quantitative perspective covering the transport cost (directly supplied by forwarding companies) and the total GHG [7] emissions. Associated with that were also considered the related lead times for the new and actual solutions and correspondent impact.

4. Case study analysis

This study was developed in the only European production facility of an American corporation leader in marine recreation. This plant located in Portugal is currently producing 13 boats a day from 42 different models and 3 different brands. The Sweden and Norway markets are the only destination of one of the brands that represent 12 models from the 42 produced. This brand is also the only one that currently sell the boats already with the engine rigged. Due to that fact is not possible to optimize the loading of the boats on the trucks. Meaning that each truck only can transport two boats. If engines were not rigged on boats, it will be possible to load at least 3 boats per truck. From the 12 models with destination to Scandinavia 5 of them has less the 5.80m of length. For the other 7 models the length is from 5.80m to 7.88m.

4.1. Initial situation and study development

All boats to Sweden and Norway were planned making combinations of 2 boats each shipment. Boats were being loaded on trucks and shipped by road directly to final customers. This arrangement is driving high freight costs and having a big contribution for the greenhouse gas emissions. Due to these reasons, it was important to try to find an alternative that could help reducing the freight costs and help to protect the environment. Knowing that a cheaper solution must involve at least a part of maritime mode the company transport team explored some alternatives to understand which one should be studied.

The first option considered was to ship boats using flat rack equipment, it was possible to add two boats in each flat rack for the smaller models but for the bigger models only one boat could be shipped per flat rack. After financial viability study the cost was too high (approximately 3 times the price to ship by container) and the lack of equipment that exists in Portuguese ports to have flat racks available for shipment could affect the lead time if this option were chosen.

The second possibility verified was to ship the boats using an automotive Ro-Ro vessel out of Vigo port that was having a direct line to Drammen port in Norway, however for Sweden the service required transhipment at Bremerhaven port before reaching Wallhamn port in Sweden, this solution were more expensive, the transhipment in Bremerhaven could result in a longer lead time and cargo will be exposure to potential damages due to more handling operations, because of that it was decided to study a third option.

The third option explored showed that the more competitive solution in terms of freight was to ship boats by container, but for that only could be considered for the study the shipment of the models with less than 5.80m length and 2.35m wide because for the remain models the boat dimensions are too big to fit in containers. As 5 models were on this range and represents 29% of the total shipments to Scandinavia the company management team selected this option as a priority to analyse and explore.

Based on the different possibilities mentioned above and taking in consideration the service level, quality and cost to the final customer it was decided by the management team to deeply explore the third option.

4.2. Solution proposal and analyses

The first step was to prepare the financial viability study to ship boats by container to the most important destinations in Sweden and Norway. When the boats were shipped by truck the transport was done until customer door what means for the sea solution transport must be also door-to-door based on a DAP (Delivered at Place) incoterm. For that reason and because dealers from this company are small stores without unloading bay it was important to take this aspect in consideration and find a solution for the boats to be unloaded from containers saver and without no damages in every single location. The best solution was to deliver the container from port to dealers using a side loading truck to allow the container to be unloaded from the truck to the floor with a crane from the truck itself. After the container is on the floor the dealer can open it and pull the boats out. This solution was tested first at the Portuguese plant to understand if could work. During the test the company find

out that to take the boats out from the container dealers would have to override the height between the floor and the container (around 30 cm) to avoid damages. It was then developed a metal platform like a small access ramp with the same height of the distance between floor and container to place on the floor outside of the container and allow the descent of the boat until the floor. The platform will be sent to every dealer in the first shipment and after that they should keep it for the next ones.

Figure 1. Platform developed to help on unloading moment

Another test was done this time with the side loader truck and the platform. The boats were successfully unloaded from the container without no damages. Another important factor that was analysed was the lead time of this new solution. By truck takes 5 days from Portugal to Sweden and 6-7 days from Portugal to Norway but for the container shipment the lead time will be around 20 days. As the boat sales have the pick season from March to July the use of this solution could be done during the low season to not impact the summer sales.

Figure 2. Container loaded with 2 boats and the platform

4.3. Results

The project was implemented in 2021 and the main results appears with the first shipments to the same destination (postal code) in each country (Table 1). Using the container shipment, the freight cost had an immediately reduction of 50% for Swedish destinations and more than 60% for the Norwegian destinations. The cost of the platform to help on the unloading it has a residual impact on the project having a unit price of 550€ that needs to be deductible in all the first container shipment to the dealers. Taking in consideration the increase on the lead times we conclude that this solution can be used only during a specific time of the year to not create impact on the summer sales. The freight price for the sea shipment presented bellow already include the first leg of the transportation in Portugal from the plant to Leixões port and the third leg of the shipment by road being done with a side loader at the destination country.

Table 1. Comparison between both modes and destinations

Destination	Sweden	Norway
Postal code	13771	3036
Road cost - truck	7,010.00 €	8,070.00 €
Lead time truck	5	7
Sea cost - container	3,467.00 €	2,658.00 €
Lead time sea	20	20
% cost decrease	50.54%	67.06%

In terms of greenhouse gas emissions[7] we can analyse below (Table 2) the emissions of CO_2, PM_C and NO_x by grams per ton per kilometre and conclude that using a short sea solution to ship our boats instead of a road shipment we can have much less pollutant emissions.

Table 2. Representative emissions factor per mode

Mode	Vessel/vehicle	CO_2 (g/tkm)(WTT)	PM_c (g/tkm)(TTW)	NO_x (g/tkm)(TTW)
Road	Medium truck	259	0.017	1.75
Short sea	General cargo	15	0.005	0.25

For this specific case we can analyse for example the carbon emissions for both transport modes (Table 3). Calculations were made taking in consideration that each boat weight in average 1 ton (987Kg for the boat in study). Considering also that the distance for the first leg in Portugal and for the third leg in Sweden and Norway (from Stockholm and Oslo) until the destination were not considered because this distance is lower than 200 km what represents less than 3% in the total kilometres in each country.

Table 3. Calculation of CO2 emissions for both destinations and the correspondent reduction

Destination	Sweden	Norway
Distance (km)	6,958	6,470
Distance (Nautical miles)	1,767	1,394
Nautical miles (mi)	3,273	2,582
Boat weight average (Kg)	1,000	1,000
CO_2 road	3,604,244	3,351,460
CO_2 sea	98,190	77,460
CO_2 redution	97%	98%

During the development of the project it was created a support management transport tool that have two databases: (1) costs related with routes by unimodal (road) or multimodal transport (sea and road), as well as related lead times; (2) greenhouse gas emissions associated with each route[7].

5. Conclusions

The major objective of this study was to solve the main issue of an enterprise related with high freight costs to transport boats from Portugal to Scandinavian countries after a production relocation. As a new transport solution was evaluated another important aspect considered was the greenhouse gas emissions. This new solution should be more sustainable and with less impact on environment. The main freight forwards were consulted to provide best tariffs for container shipments by sea. After first prices received it was understood that it was a possibility to use this transport mode. It was cheaper and more sustainable than trucking. Others important aspects were evaluated like service level, third leg (post-haulage) requirements and seasonality. A real test was done to justify the study and implement the solution. The main conclusions showed a saving of more than 50% on the freight cost and a CO_2 emissions reduction of more than 90%. Despite the transit time increase with the new solution this could

be compensated if used during low season where the lead time is not so important for the customer. Like this customer can benefit of freight reduction, with a more sustainable transport service and keeping a good service level. The reduction of the sea freight with the reduction of CO_2 emissions made this solution a winner for this company but also very important to be aligned with EU policies and regulations to be more sustainable and decrease the use of fossil fuels protecting the planet.

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