ABSTRACT: Reliable port throughput forecasts are of the utmost importance for ports. Given the high investment and long time needed to improve the port infrastructure and superstructure, a good balance is required between port development and expected throughput. An over-dimensional port will lead to revenues not covering the capital and operating costs, while an under-dimensional port will introduce delays in the process of cargo loading and unloading, discouraging ship-owners to come back to the port. Adequate port development thus requires reliable cargo throughput forecasts. The aim of this thesis is to forecast the cargo throughput in Portuguese ports using a mix of Multiple Linear Regression (MLR) and qualitative considerations. Port throughput data from the last 15 years is obtained from the various Portuguese port authorities and from Instituto Nacional de Estatística (INE) and is analysed. Economic and industrial indicator are collected from different sources, namely INE, Banco do Portugal, OECD and PorData, aiming at identifying explanatory variables for observed cargo throughput in ports. Cargo throughput is split into categories and compared with the economic and industrial indicators to find similarities. Then a forecast of port throughput over the next 10 years is presented. Considerations are made about the relation between the various ports of the country and how they interact, as well as about the interaction between port throughput and economy. Conclusions are drawn regarding main drivers of cargo throughput increase in Portuguese ports and forecasts are presented for individual ports, the entire port range and different cargo types.

1 INTRODUCTION

Forecasting is a very important but also sensitive topic. When developing the models for this task many problems arise, given the uncertainty on the evolution of different variables. This thesis will try to analyse the situation of Portuguese seaports and develop an objective explanation of the relation between the throughput of ports and the industrial and economic situation of the Portuguese economy. The Portuguese economy has a high degree of openness, and given the high share of commerce passing through ports (about 60%) it can be concluded that seaports play a decisive role in the nation’s economic growth. Most of the goods handled in ports are from or directed to local industries, and given the size of Portugal a direct comparison between industry performance and port throughput is possible.

Data for this study will be gathered from different sources, namely the National Statistics Institute (INE) [1], POR-DATA [2], the Portuguese Ports Association [3], OECD Data [4] and the International Monetary Fund (IMF) [5]. This data will complete and update the data collected by [6]. Afterwards, this data (time series) will be split into categories, following the European NST2007 standard, and these time series will be compared with the economic and industrial data to look for causal relations between them. The aim of this thesis is to investigate this relationships and present a forecast up to 2024 for cargo throughput in Portuguese ports. The forecasts is developed using a mixture of linear interpolation and qualitative considerations. The throughput is forecasted at national level, the national total is then split between the various ports.

In section 2 a literature review will be carried out. In sections 3 and 4 the data about ports and industries will be presented, afterwards in section 5 some qualitative and quantitative relations between the time series are proposed, results are presented in section 6.

2 STATE OF THE ART

Forecasting methods are subdivided in 3 broad groups: qualitative, time series and causal prediction (both quantitative).

Qualitative methods are subjective, they rely on human opinion more than on numbers. This can be done in different ways, through interviews to customers, just with the opinion of managers or sales agents. The most reliable method though is the Delphi, where various experts on the field are congerated and asked to develop a forecast. The opinions are summarized anonymously and the experts are asked to give a new opinion based on the information collected, the process is iterated until a reliable result is reached. This method is valuable because it helps to overcome biases and avoid bringing influences by certain individuals.

Time series forecasts are based on the idea that the future behaviour of a variable depends only on its past development. This simplifies greatly the forecasting process because it reduces the amount of data that needs to be gathered. Different types of time series exist. Naïve method, the most basic, simply assumes that the variable will keep the last known value in the next time step. Decomposition methods take the time series as the sum of different compo-
nents: linear trend, seasonality (for example 1 year cycle), long term cycle and random components. Different de-composition methods exist, all following the same structure. One of the most widely used methods is the auto-regressive integrated moving average (ARIMA) which indicates the union of different mathematical tools under a common name. Also used are grey system methods and fuzzy logic, applications where the incompleteness of information is seen as part of the system and used as a part of the forecast. Examples of this approach can be seen in the papers [7], [8].

Causal model are used when we know and have data about the variables that influence our forecasting objective. They mostly take 3 forms: regression analysis, system dynamics and artificial neural networks (ANN). Regression analysis indicates the act of comparing the variable to be forecasted with one or more other variables that should be related to it. It can be linear, nonlinear, single or multi-variable, and usually involves using a least square method to get a function that relates the variables. System dynamics is a broad definition that encompasses different approaches, it is generally the act of considering a group of variables and their reciprocal influences. It may be carried out by writing down a system of equations and solving it, generally by means of a software that takes care of the numerical solution. ANN is a term referring to any algorithm whose steps have a behaviour similar to neurons. The ones usually used for forecasting are Multilayer Perceptron (MLP). These consist of different layers of neurons that take different time series as in-put and develop a nonlinear equation to relate the in-puts with the desired outputs, MLP work iteratively to fit the function to the existing data, once the fit is good enough the future values of the function are then extrapolated. Examples of these causal forecasts can be found in [9], [10].

Once forecasts are produced there is the need to validate the model: it is common to use only the first 70/80% of the data to fit the model. Then the forecast is compared to the rest of the data and the error is calculated using different formulas (the most used is root of the mean square difference).

Regarding the state of forecasting in the ports literature, publications about forecasting can be subdivided mainly in 2 big groups: academic papers and private firms’ publications. Academic papers are focused on the mathematical aspect of forecasting, different models are thoroughly explained and applied to the time series, to benchmark which method works best in certain conditions. Otherwise, variations on existing models or mixtures of models are developed and examined. These papers usually don’t focus on the act of forecasting itself but more on the creation of a suitable model. Private firms’ publications, usually commissioned by the port authorities concentrate instead on a deeper analysis of the specific situation and develop a forecast which is more about explaining how the different variables are related instead of having a strong mathematical model.

Two books about port planning, [11], [12], insist on the importance of studying profoundly the hinterland of the ports, to understand which are the main drivers of the cargo throughput. They also note that any port that’s trying to develop a forecast usually uses a combination of basic methods, tailored on the data available and the characteristics of the hinterland. Given the high sensibility of port throughput to one-of-a-kind unpredictable economic events (wildcards) it is wise to prepare some different future scenarios, guessing the most important socio-politic developments of the future years. These scenarios will then influence the forecast in different ways.

When analysing the economic and industrial situation of the hinterland an exhaustive report about the UK ports [13], shows that the main aspects to study are: energetic policy of the country, oil and coal are one of the main cargos trans-ported by the shipping industry worldwide. Therefore knowing from where a country plans to get its energy is fundamental. The car market should also be studied, as it drives the RoRo traffic; Heavy industries, such as cement, oil and chemical products, steel mills and mines are the other big drivers of cargo movement; Containerized cargo on the other hand encompasses many different items, so it is usually related to GDP, like in [14], [15]. The local industries should also be analysed to know which ones are the important export and import cargos for their functioning.

Regarding the different forecasting techniques, they are used for different situations, when developing a broad forecast different methods are put together, usually a mixture of system dynamics and multiple linear regression [16]. Most authors focus on a single time series, for example the container throughput of a major Asian port [7], [17], [18] and analyse it with different models, checking the advantages of one over the others.

Some remarks worth noting are about the traditional statistics assumptions that are still used in the forecasting field. First of all it was shown [19] that model fit and forecast performance cannot be achieved at the same time. Overcomplicating the model to get a better fit to past data decreases the forecast precision. Also a study on freight rate cycles [20], points out that past data time series do not follow normal distribution, thus trying to fit a model using the root of the mean square as estimator is not correct. However freight rates and port throughput are very different variables (even if surely related), thus it’s not clear how to apply this information to a port throughput forecasting.

It is also important to understand the relation between the different ports s knowing how these relations evolved throughout history helps seeing pat-
terns in the flow of cargos and understanding competition issues between ports [21], [22].

Regarding the forecast horizon, in all the publications analysed that actually forecast a time series, the interval is symmetrical, which means that the number of forecasted time steps are the same as the number of past time steps analysed.

After examining the state of the art, the data gathered will be presented and analysed, then in chapter 5 a forecasting methodology will be presented.

3 GEOGRAPHICAL AND INDUSTRIAL OVERVIEW

The geographical and industrial conformation of Portugal is analysed, to have a deeper understanding of where the ports are, how they relate to each other and with their hinterlands.

Ports located in the Portuguese west coast have been collectively called “Portuguese Range”[23], they constitute a multi-port gateway region, situated at the far west end of Europe. They have the potential to be the gateway for cargo directed towards Western Europe, sitting at the extreme of the European rail freight corridor n°4. In the past years the throughput of the Portuguese ports grew, together with the connections between Portugal and Spain.

Figure 1 shows a map of Portugal with the main ports and industries. It is evident how the range can be divided in 3 groups of ports: Northern ports, Viana do Castelo, Leixões, Aveiro and Figueira da Foz; Central ports, Lisbon, Setubal and Sines; Southern ports, Portimão and Faro.

Lisbon is the capital of Portugal, the port terminals are distribute on the two shores of the Tejo River, the port expansion is today hindered by the city, and no space is left around the terminals to improve them. Lisbon is the 3rd national port, handling 14% of the cargo throughput of Portugal. Lisbon works as a hub for the many industries located along the two sides of the river: steel mills, chemical factories, paper and fertilizer factories, as well as several power plants.

Leixões is the 2nd port of Portugal, handling 24% of the national throughput. The port is located 4 kilometres north of the estuary of the Douro River, where the city of Porto is. It is an artificial port. The northern region of Portugal is densely populated, in the hinterland of the port there are several industries: a steel mill, refinery, paper factories, mines and wood and cork harvesters.

Sines is located in the south of Portugal, along the Atlantic coast. The port came into operation only in 1978 but is already the main Portuguese port, handling 45% of the cargo. Given the deep waters surrounding it, it is the port of choice for the bigger vessels docking in Portugal. Its container terminal, opened in 2004, is handling mostly trans-shipments. Sines is the main energetic hub in Portugal, with the only coal power plant of the country located nearby and refineries and chemical factories located around the city. In its hinterland there are also marble and copper mines, as well as paper factories.

Figure 1 - Main ports and industries of Portugal

Setubal is located 40 kilometres south of Lisbon, it’s the 4th national port, handling 10% of the cargo. The port’s throughput is much less than the maximum capacity, and it still has plenty of space for future expansion. It is the main RoRo port of the country, thanks to a nearby car factory, as well as the main cement port of Portugal. In the hinterland of the port, mostly shared with the port of Lisbon, there are several paper factories, as well as copper and marble mines.

Aveiro is located 70kms south of Porto, in an inland lagoon, Ria de Aveiro. The port infrastructure is quite recent, thus is well organized and safe from congestion issues that can harm older ports. In the hinterland of the port there are several cement factories, chemical refineries, paper and glass factories.

Figueira da Foz is located halfway between Porto and Lisbon, the port develops around the estuary of the Mondego River, and it is mostly a short sea port and serves local factories. In the hinterland there are some cement, paper and glass producers.

Viana do Castelo is situated in the far north region of Portugal, it is mostly a short sea port. In its
hinterland there are a paper factory, a mine and a wind turbine factory.

In the southern coast of Portugal there are 2 other small Ports: Portimão has a big cruise terminal and Faro has a dry bulk terminal used to export cement produced in the nearby factory.

4 ANALYSIS OF CARGO THROUGHPUT IN PORTUGUESE PORTS

To perform the forecast a variety of data was gathered from different sources, data gathered includes:
• Tons loaded and unloaded, in the main ports of Portuguese mainland (Lisboa, Leixões, Sines, Setúbal, Aveiro, Viana do Castelo, Figueira da Foz and Faro), subdivided in categories (dry bulks, liquid bulks, general cargo, containers and ro-ro), as well as the cruise passengers, where present;
• The main categories of cargo handled in the different ports, to have a deeper understanding of which are the main drivers of port throughput;
• Econometric indicators, related to the Portuguese (and world) economy, like Portuguese GDP, population, inflation, domestic consumption and finally world GDP;
• Industrial indicators, the yearly performances of different sectors of the industry related to the main goods traded in ports, this includes tourism, alimentary, metallurgic, cement and glass, petroleum and chemical industry, as well as the production of vehicles and the yearly production of electricity, subdivided by the different sources of energy.

Data was gathered from different sources:
• Instituto Nacional de Estatística (INE) [37], provides yearly publications called Estatísticas dos Transportes e Comunicações and Estatísticas da Produção Industrial. From here it was retrieved the amount of tons loaded and unloaded, for each port, for each category as well as the industrial indicators, INE publications go from 2001 to 2014.
• Port authorities publish a yearly account of the port throughput, all the available information from the past years was gathered, given the individuality of each port authority the data is not homogeneous, for some ports only 5 years of data is available, for some others there is no distinction between loaded and unloaded cargo. The ports analysed are Lisbon, Leixões, Sines, Setúbal, Figueira da Foz, Aveiro, Viana do Castelo, Faro and Portimão.
• Economic indicators were taken from 3 different websites: PorData, a Portuguese data aggregator, OECD data, the database of OECD countries and the International Monetary Fund.

4.1 Ports data

Lisbon is dry and liquid bulk importer, as well as an important container port. Dry bulk throughput has been stable in the past years, unloaded tons account for 80% of the total, and mostly handles cereals and scrap metal. Liquid bulk also remained stable, also here unloaded tons account for 80% of the total, and mostly handles diesel, fuel oil and ammonia. General cargo decreased steadily in the past years, now it is mostly loaded cement. Container throughput grew until 2003 and then stagnated, the throughput is close to the maximum capacity of the terminals. The loaded tons are twice the unloaded ones. As always, when talking about containers, it is difficult to say which good are transported, given the variety of good loaded onto them. Cruise passengers throughput grew steadily in the past years, passing from 10 to 50 thousands of passengers in transit in the years analysed.

Leixões is dry and liquid bulk importer, as well as an important container port. Dry bulk throughput has been stable in the past years, unloaded tons account for 85% of the total, and mostly handles cereals, metal scraps and wood chips. Liquid bulk also remained stable, also here unloaded tons account for 75% of the total, and mostly handles crude oil and oil products. In the years analysed loaded tons grew slightly while unloaded tons decreased. General cargo grew slightly thanks to a shift between unloaded and loaded tons that happened around 2009, now more than 80% of the throughput are loaded tons, mostly iron and steel products. Container throughput increased linearly in the years analysed, now reaching the maximum capacity of the terminal. Cruise passenger throughput stagnated until 2008 and then surged rapidly.

Sines is the main container port of the country, but is also a very important dry and liquid bulk importer. Dry bulk throughput has been constant in the past years, with 97% of the throughput coming from coal unloaded. Liquid bulk throughput has been rising slightly, with unloaded tons being twice the unloaded tons, crude oil, oil products and LNG are the main traded goods. General cargo had low importance in the port up to 2006, when it became an outlet for the paper factories in the hinterland. Container throughput grew exponentially since the opening of the terminal in 2004, Transshipment is very important, accounting for an average of 80% of the throughput each year.

Setubal is the main RoRo port of Portugal, but dry bulks and general cargo are also important for the port. Dry bulk throughput has been stable in the years analysed, loaded items grew, thanks to the cement production, while unloaded decreased. Liquid bulks throughput declined linearly in the years analysed, mostly due to the closure of the nearby power plant. General cargo had a shift between import and
export around 2007, now most of the throughput is coming from exported cement and paper. Container throughput in the port has been growing steadily in the past years, mostly loaded cargo, but the terminal is still much underused. RoRo throughput decreased steadily until 2009, now it is stable.

Aveiro handles mostly dry bulks and general cargo, as well as some liquid bulks. Dry bulk throughput has been growing steadily in the past years, now loaded and unloaded cargo are equal, the most important goods are cement (exported) and wood and glass scraps (imported). Liquid bulk throughput also increased, mostly unloaded cargo, with oil and chemical products accounting for 75% of the total. General cargo throughput also grew significantly, mostly loaded cargo, with cement and paper having the biggest share of throughput.

Figueira da Foz handles mostly dry bulks and general cargo. Dry bulk throughput has been increasing in the years analysed, loaded and unloaded tons have the same importance, with clay and salt being loaded while glass and wood scraps are unloaded. General cargo also grew in the years analysed, with loaded cement being the main component of this growth, together with paper, while some wood scraps are unloaded.

Viana do Castelo is a small port handling cargo on short sea routes. Dry bulk throughput has been continuously decreasing in the past years, actually the port exports minerals from nearby mines and imports cement. Liquid bulk throughput has been decreasing till 2010, when the port stopped importing oil products and started exporting the ones coming from the nearby refinery of Leixões. General cargo throughput decreased in the past years, with unloaded tons almost disappearing, while loaded tons, mainly paper and wind turbines, grew.

The port of Faro has a very small and unstable throughput, nowadays the main cargo handled is exported cement with general cargo ships, accounting for 99% of the throughput of the port.

Portimão is a renewed touristic destination, the throughput in its cruise terminal has been rising in the years analysed.

After analysing the throughput port by port some general conclusions are:

- Export has been ever-rising in the past 14 years, while import remained stable.
- Traffic is slowly moving towards the biggest ports, with the smaller ones handling mostly national trade routes (hub and spoke model), different ports also specialize in different type of cargo, the main example of this be Sines with containers and Setúbal with RoRo.
- Containerization is driving the general cargo handling down, imports which once were coming through general cargo ships are now coming in containers, except for cargos which are handled in bulks which are bigger than containers, like wood, cement, paper and steel products; this articles are driving the general cargo exportation up.
- While the amount of TEUs loaded and unloaded is the approximately equal in all the years analysed, the amount of tons loaded is consistently 40% higher than the tons unloaded, this because many empty containers have to be unloaded from ships in order to load them with goods to be exported.
- Liquid bulk unload is also decreasing, due to the increase of alternative sources of energy, while the export of petroleum products is increasing, same thing happens with dry bulks, but here cement is driving exports up.
- Passenger traffic is ever increasing as Portugal is becoming more and more a well-known touristic

![Figure 2 - Cargos loaded on ships in Portugal, split by NST2007 categories](image-url)
From the INE publications on transport, data about the categories of cargo are obtained. This categories are in line with the European NST2007 standard, and are a helpful insight into what drives the growth of throughput in ports. Loaded tons, shown in Figure 2, show that the main driver of the growth is cement, oil products, transhipped containers and paper. Unloaded tons, shown in Figure 3, are more constant over time, but nevertheless interesting.

5 METHODOLOGY

After analysing the state of the art of forecasting and the throughput data available from past years a forecasting methodology is investigated.

Initially it was tried to use Artificial Neural Networks (ANN), but in spite of having a significant amount of data available, each time series is quite short (13 years), making ANN impossible to use. Afterwards the suitability of Auto Regressive Integrated Moving Average (ARIMA) method was investigated, which also resulted impossible to use. A quick comparison of various papers shows that ARIMA is usually applied on time series with at least 50 data points, while ANN are applied to series with more than 100 points. These techniques also excel when applied to series with an important fluctuating component. This is not our case since the data analysed has, mostly, a linear trend behaviour.

Considering all the data available the ideal method to use is multiple linear regression, which could map the performance of the industries and GDP to the throughput of ports. Here it is important to remember that the throughput data is available for each port, while the industrial and GDP data is available at national scale. So the regression is to be used on the national aggregate of throughput for each category. Each cargo throughput time series is analysed together with the industrial and economic time series which can be related to it.

Economic and industrial data is taken from the INE and OECD websites. Industries are split into categories, for each category there is data available about sales per year, subdivided in national and foreign sales. This data however is in Euros, for the purpose of forecasting throughput it would be better to have data in tons. To try and overcome this problem all the time series in Euros are corrected for inflation, making them at constant price 2014. The industries analysed are: iron and steel, vehicle, cement/glass, oil products, chemical products, alimentary, wood, paper and tourism.

Data about energy consumption is also gathered from PorData, split by the means of production of energy: coal, oil, LNG and renewable energies.

Economic data was gathered from OECD and PorData websites. This data includes the GDP of Portugal and its main economic partners: EU15, USA and China, as well as Portuguese domestic consumption and World GDP.

To help forecast the throughput of transshipped containers in Sines, which is not related to the Portuguese economy, data about the main transhipment hubs of western Mediterranean is gathered. To understand what drives the growth of transhipment ports.

To develop a forecast, a possible relation between the various categories of cargo throughput and the economic and industrial data is analysed. The categorisation of industrial sales and cargo throughput is very similar, thus a direct relation between the two is established and linear regression is carried out. For some time series the regression is multiple, for example for the throughput of secondary raw materi-
als, these are a combination of glass, wood and metal scraps, thus the throughput is related with the iron and steel, paper and glass industry. Linear regression gives mixed results, some throughput series have correlation up to 98%, some as low as 25%. However, forecasting using regression requires to have access to forecasts of the explanatory variables. Consistent data for the next 10 years was impossible to find, except for the GDP time series. This data was used to develop a forecast for container throughput in the paper [24].

Given the impossibility to use multiple linear regression with the industrial variables it was chosen to simply use linear interpolation to project the past trend in the future.

Even if it looks simplistic, this method permits taking into account some specific behaviour of the time series that linear regression would have not. For example, the economic crisis of 2008 scrambled the data, changing considerably the trend for more than one category of cargo. In the time series in which this happen it will be taken into account using only a subset of data to calculate the trend. The trend will be calculated with Microsoft Excel, using the LINEST function.

After making a forecast for each category of cargo it is necessary to split the results between the various ports. The past trend is analysed, looking for patterns in the national distribution of cargo throughput in each category. Relationships between ports are investigated, checking how much of the total cargo goes through each port. Even when the throughput in the various ports is unstable, the throughput of the two big groups of ports has a smoother variation. This property is taken into account, keeping the balance between the two groups. This considerations are then used to estimate the percentage of cargo that will pass through each port in the future.

6 RESULTS

After developing a forecast the results are presented, subdivided in category first and then by port.

Products of forest and agriculture, this category includes cereals, fruits, vegetables and raw wood. The throughput (mostly unloaded) has been increasing slowly in the past years, probably due to an increase in manufacture of alimentary products and paper, the main port is Lisbon, handling more than 50% of the national total. This linear growth is supposed to continue.

Crude oil and LNG. The throughput in the years analysed has been incredibly stable. Crude oil and LNG is only unloaded in Sines and Leixões, the throughput, together with the forecast is shown in Figure 4. It looks like LNG unloaded in Sines will continue unchanging, crude unloaded in Sines will decrease slightly while crude unloaded in Leixões will increase slightly, keeping the total constant.

Minerals. The loaded tons have been increasing linearly in the years analysed, triplicating between 2001 and 2014, this linear growth is supposed to continue. Unloaded tons look stable since 2005, last year’s value is used as the future value. Mineral throughput is shared between all the ports, 70% in the central ports and 30% in the northern.

Food products. The loaded tons, shown in Figure 5, have been growing constantly last years, this growth will most likely continue, due to the growing international fame of Portugal. The unloaded tons stagnated, this stagnation will also continue.

Wood, cork and paper. Here it is interesting to note how the exports grew considerably while the industrial sales stagnated. Loaded tons, shown in Figure 6, were constant until 2009, then they grew rapidly and slowed down, the growth is supposed to continue the present trend (2011 onwards), most of the throughput comes from the northern ports. Unloaded tons decreased up to 2005 and then started increasing slowly, this trend is supposed to continue.

Coal and oil products. Coal is only unloaded in Sines to power the nearby power plant, the throughput has been stable for the years analysed and it is supposed to continue. Oil products are loaded mostly in Leixões and Sines, throughput in both ports
have been increasing in the past years, in Leixões slightly faster than in Sines. Products are unloaded in all national ports, the total is slowly decreasing.

Chemical products. Loaded tons grew rapidly in the years analysed, passing from 700 to 1800 thousand tons from 2001 to 2014, this trend will most likely continue in the future. Unloaded tons have also been increasing, slower than the loaded, this trend will also continue.

Non-metallic mineral products, cement and glass.

Export of this category, shown in Figure 7 has been growing in the past years. However, currently Setubal’s port reached its limit of throughput, and the international situation of the market is not encouraging, thus the growth is supposed to slow down in the future. Unloaded tons decreased almost to zero in the past years, this asymptotic trend is supposed to continue.

Metallic products. The loaded tons, show in Figure 8, have been increasing in the past years, this trend is supposed to continue. Unloaded tons have been stable for the past 7 years, last year’s value is projected to the future. For this category the 2008 crisis marked a shift from import to export.

Transport material. RoRo throughput in Setubal is analysed, the throughput have been decreasing in the past years, but lately it reached a plateau, this throughput is supposed to continue in the future.

Secondary raw materials: wood, metal and glass scraps. The loaded tons have been stable for the past 5 years, this is supposed to continue. Unloaded tons have been growing constantly, thanks to the growth in production of steel products, paper and glass, this trend is supposed to continue.

Unknown cargo, containers transhipped in Sines.

For this the forecast of the paper [24] was used. Since the opening of the terminal, transhipped containers accounted for 70/90% of the total. In the future it is supposed that the amount of transhipped container will grow up to 90% of the total, unloaded and loaded tons are equal.

Cruise passengers. The amount of passengers in traffic has been growing linearly for all 3 ports analysed, this trend is supposed to continue.

After analysing the cargo throughput category per category, the number are summed to get the throughput of each port. The result is that throughput will grow in all the ports, both loaded and unloaded tons, the only exceptions are the unloaded tons in Setubal, due to the decrease of oil products throughput. The overall throughput of the ports analysed is shown in Figure 10.

7 CONCLUSIONS

For this thesis data has been gathered from several different sources, all of them public.

As years go by, Portuguese economy is opening more and more. Even so it comes as a surprise that the throughput of ports grew so much. In the 14 years analysed, the throughput (net of the transshipped containers in Sines) grew at an average of 2.1% per year, while the GDP more or less stagnated.

What looks evident from this study is that trying...
to make forecasts in this field is extremely complicated. The whole sector, even while being one of the main drivers of the world economy, is based on hard competition between very few players. This makes the whole system easily subject to big shocks that can start from problems that arise simply from blindness to change and unneeded optimism, the example of the Chinese economy is the most explicit.

However, even if maritime shipping is sensible to small perturbation, it is still driven by the world economy which is a big ensemble of small realities, and thus any shock can alter the balance for a while but the whole machine in itself is unstoppable.

This instability of the market makes strict mathematical methods inadequate for forecasting. Expert opinion is more valuable than long time series because of their ability to consider out of the norm events.

It looks sure that Portuguese ports will continue to prosper in the future, Sines port still has the potential to grow as a transshipment port, given good decisions made by the port authority. The increasing international reputation of Portugal will most likely drive the food exportations up. Portugal is also home to some of the biggest paper factories in Europe, this will most likely keep the prices competitive for the future and help the throughput keep its consistency. Future outlooks for cement are not good, given the Chinese situation. Also for the metallurgical industry the conditions of the Chinese economy will most like have some negative influences. The recent oil crisis may have an impact on oil refineries and probably slow down the growth, this effect will however be small, given the fact that most of the output of refineries is consumed in the country.

It is interesting to note also how, if the containers transshipped in Sines are not considered, the Northern ports are growing faster than the Southern ones, this is a reflection of the higher industrialization of northern Portugal, as well as the proximity of higher industrialized regions of Spain.

Publications about forecasting which concentrate on providing data for the future are usually made by private companies, which employ a team of people dedicated to the job. The work is also commissioned by port authorities or terminal managing companies, which provides to the companies all the data necessary. Unlike this thesis, where most data used is the one publicly available, complemented by some data obtained on request from the port administration. However, in some cases the actual data was not actually disclosed.

Considering the short time window analysed, the 2008 crisis makes the matter even more complicated, effectively scrambling the data, destroying past trends. It is also evident how, for many categories of cargo, the 2008 crisis marked a moment in which the economy switched from import-based to export-based. This change is substantial, and happened so recently that any new trend in cargo throughput didn’t have much time to manifest.

For future reference and more in-depth research: one possibility to move from a qualitative to a quantitative forecast would be to collect a greater amount of past data. One example could be four-monthly data from the past 20/25 years, this data should be separated in cargo categories for each port, making a distinction between loaded and unloaded cargo. With this amount of data if could be possible to use neural network forecasting. With this approach it will be possible to see hidden relations between the time series, including through which ports the flow of goods passes. Another advantage of this method is that it does not require forecasts for the explanatory variables, like linear regression does.

8 REFERENCES

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