Erasmus University Rotterdam

MSc in Maritime Economics and Logistics

2018/2019

The impact of the Indian demand for coal on freight rates and the future of the commodity

by

Dimitrios Demiris

Acknowledgements

Throughout this section, I would like to thank the people who significantly supported me, in order to complete the MSc in Maritime Economics and Logistics (MEL) and the current thesis.

First and foremost, I would like to express my deepest gratitude to my supervisor, Asst Prof Ted Welten, for his guidance. Actually, without his support and trust, I would not be able to complete successfully my thesis. Moreover, his direct responses to my questions, the motivation he gave me and some to the point tips were crucial, in order to finish my thesis on time.

I am thankful for all of MEL lecturers for both of the theoretical and practical knowledge that they offered to us throughout the whole academic year. The content and the level of the lectures, the numerous assignments and exams, were significant factors, in order to increase our knowledge in Shipping and Logistics sector and prepare us for the global job market.

I would also like to thank the MEL Office, namely Renee, Felicia and Martha, for their quick responses to our questions and concerns. I appreciate their guidance and support, in order to make our adaptation in the Netherlands easier and quicker and their willingness to give solution to any of our problems.

Furthermore, I express my thanks to my fellow students, from whom I learned a lot of useful things through our excellent collaboration in group assignments and also during our leisure time. I am glad to have made some great new friends from all over the world.

I sincerely thank the Greek Shipowners' Social Welfare Company for funding a significant part of my master's fees. Without their financial support, it would be difficult for me, even to be a part of this master. It was an honor for me to be awarded by these people and I thank them for believing to me and my vision and I will never forget their support.

Last but not least, I would like to thank my family and my friends for their psychological support and their confidence through all this demanding year.

Abstract

Coal is the second largest dry bulk commodity, in terms of global trade volumes and it is mainly used for power generation and steel production through thermal coal and coking coal respectively. This means that developing countries, especially those with high-paced growth of population are depended on coal, in order to cover the increased demand for electricity and support the economic growth with new infrastructure. A country, which matches with these characteristics is India and we focus on it, in order to narrow the scope of our research. More specifically, our research investigates the impact of the Indian demand for coal imports on the freight rates. As a first step, we investigated the main determinants of the price of coal, the Indian demand for coal imports and the freight rates, either macro or microeconomic. Using these theoretical determinants, we found data for each variable for the last ten years and we constructed three equations with price of coal, Indian demand for coal imports and freight rates as dependent variables and their determinants as independent variables. For this purpose, we used multiple regression with the method of linking residuals, using Minitab and we also conducted correlation analysis between the variables. As we also predict the freight rates for the year 2023 using these three equations, we constructed three scenarios for the future of coal in India and their impact on freight rates, which give us three different results for each dependent variable. The result for our main research question indicate that there is a positive and significant relationship between the Indian demand for coal imports and freight rates. Regarding the estimation of the future freight rates, the results of each scenario indicate that there will be an upward trend in the freight rates compared to the current situation, provided that the shipbuilding activity remains mild. Based on these results, we conclude that the Indian demand for coal imports is strong enough to affect significantly the freight rates from the demand side.

Table of contents

List of tables

List of figures

1. Introduction

1.1 Introduction

The globalization of production and trade is one of the main characteristics of our era. Total volumes of trade by sea reached 10.7 billion tons in 2017, expanding by 4%, compared to 2016, half of which was due to dry bulk commodities (UNCTAD, 2018). Coal is one of the major dry bulk commodities, after iron ore, and almost every year contributes to the general increase of the total volume of the dry bulk commodities. Actually, the coal trade increased by 5.8% in 2017, compared to 2016, mainly because of the increased demand for imports from countries like India, China, Japan, Malaysia and the Republic of Korea and the exports primarily by Australia and Indonesia (UNCTAD, 2018). One major factor, which is projected to play a crucial role for the total volumes of transported coal, is the uncertainty over the Indian coal trade. Will India increase its domestic production of coal, which would decrease or keep stable the imported volumes? Will it raise the imports of coking coal, due to the increased demand from the steel industry? Is it possible a new regulation for the restriction of the hazardous emissions from coal to be applied in India? These are some important questions for coal in India, which indicates that it is not yet completely sure which of these conjectures will happen in the coming years.

Nowadays, India is considered the fastest growing major economy globally and in the future it is expected to be transformed to one of the top economies in terms of power (IBEF, 2019). The population has an upward trend during the last 60 years and today has reached to 1.37B people (Worldometers, 2019). The coal is a key factor for the Indian economy for power generation, while the demand remains uncovered by the supply (Satija, 2019). This means that except for the domestic production, the volumes of imports of coal are crucial to cover even partly the demand.

However, according to researches, the coal contributes to the global warming, it creates high levels of radiation and it creates asthma and lung cancer (Ayres, 2016). The combination of the aforementioned, and especially the trend of decreasing the CO_2 emissions, sooner or later might lead to a related regulation, in order to turn to renewable energy.

There have been plenty of conversations about how to avert the worst impacts of the climate change and one of the most usual suggestions is the removal of coal globally if possible. In the United States, the low-priced natural gas is dominant against coal in the power system, nonetheless the coal is still the "king" in other places around the world, such as India (Gross, 2019). Basically, there are two major arguments against coal (Gross & Tongia, 2019). The first one concerns the externalities created by coal, more specifically local pollution and the increase of the greenhouse gas emissions with global negative impacts. The second one regards the feeling that India needs more use of renewables, which are cheaper alternatives, whereas coal is a risky and costly investment. One possible step could be a restriction in the CO_2 that Indian coal power plants are permitted to emit. It is apparent that such a restriction will result in a decrease in the supply of coal. However, as the domestic production of coal in India is not enough to cover the demand, this restriction could lead in the use of renewables. For example, natural gas is an ideal solution for the generation of electricity, as it is inexpensive and "clearer" than coal. This restriction could lead to the gradual establishment and domination of the renewables against coal. Because of the fact that India must meet its growing power needs, as a first step needs both coal and renewable energy (Gross & Tongia, 2019). By this we mean that the demand for coal will decrease gradually and not dramatically in the long run, as the Indian structure of the power industry does not make it easy for both technologies to be grown simultaneously.

According to the aforementioned, our main goal is to investigate the degree of the effect of the Indian demand for coal on the freight rates. Freight rates, as a price, depend on supply and demand of the commodity. India is one of the leaders of the imports and in fact we examine if and to what extent the decrease or the increase, depending on the scenarios, on the demand for coal imports, affects the coal freight rates. First, we need to investigate the main factors that drive the demand for coal in India, and the factors that affect the price of coal. We also need to focus on some macro-economic factors like price of coal and Indian demand for coal import etc. and micro-economic factors such as distance, vessels age and size and check the correlations with the freight rates. Using multiple regression, we will examine the significance of the independent variables to the dependent (price of coal, Indian demand for coal imports and freight rates), and based on the results, we are able to estimate the future freight rates.

1.2 Research question

The main research question of our thesis is the following:

What is the effect of the Indian demand for coal on spot freight rates of coal and which are the future freight rates in 2023 based on our three scenarios?

The sub research questions that will also be investigated in this thesis are:

1) Which are the main factors that determine the Indian demand for coal?

2) Which are the determinants for the price of coal?

3) Which macro and micro-economic factors could affect the freight rates, in order to be included in the model?

4) Which are the main scenarios for the future of coal in India?

5) Are the changes in Indian demand for coal imports able to affect dramatically the freight rates?

1.3 Motivation

My interest to commodities and trade factors, motivates me to conduct this research. India's economy looks promising and it highly depends on coal, both through domestic production and imports, which is the second largest cargo regarding dry bulk. It is interesting to examine the effect of the Indian demand on freight rates, especially for the next years that will be challenging for the power sector for both coal and renewables plants in India. Developing this kind of scenarios, will help the ship owners to understand the degree of importance of Indian demand for coal on the freight rates for this particular cargo and how these changes that will be presented through the scenarios will affect the freight rates of the coal, in order to determine if it is worthy to focus on this commodity to transport for the next coming years.

1.4 Thesis Structure

In this particular thesis, our main objective is to investigate the effect of Indian demand for coal on freight rates. In order to be led to a reliable conclusion we need to design a decent structure, which consists of five chapters.

In Chapter 1, we introduce the problem and by setting our main and sub research questions we get the main goal of the research.

In Chapter 2, we present a broad literature review, which contains the analysis of the factors that we will use in the following chapters, in order to solve our problem. We begin the chapter with our initial research framework. In theoretical overview, we analyze the types of commodities according to the transport characteristics, in order to connect it with coal and focus on its characteristics. Afterwards, we present the main exporters, importers and producers of the coal and then we focus on the case of India, regarding its economic growth and the addiction of the Indian economy to the coal. Moreover, we mention the main suppliers of coal to India and we construct the scenarios for the potential demand of coal in India. Last but not least, we examine the key micro and macro-economic determinants of the Indian demand for coal, of the price of coal and of the freight rates. Furthermore, in the theoretical review, we present the previous researches regarding the micro and macroeconomic determinants of the freight rates and the impact of changes in demand on freight rates.

In the third chapter, we demonstrate our methodology and data collection.

In Chapter 4, we construct three equations, one for Indian demand for coal imports and its determinants, another one for the price of coal and its determinants and another one for the freight rates with its determinants. Using correlation analysis and multiple regression, we will be able to investigate which micro and macro-economic factors are correlated with coal price, Indian demand for coal imports and freight rates. Based on this and the scenarios that we construct in Chapter 2, we predict the values of the price of coal, the Indian demand for coal imports and the freight rates in the future for each scenario. Conducting this sensitivity analysis, will give us the answer in our main research question, whether the Indian demand for coal imports is strong enough to affect the freight rates.

In Chapter 5, straight after presenting our findings, we compose our conclusion, answering to our main research question and the sub-research questions. We also cite our limitations on the research regarding the data and the model used and we suggest areas for further research.

2. Theory

2.1 Research framework

As we stated in introduction, our research will be focused on the effect of the Indian demand for coal on freight rates and we will also predict the freight rates in 2023, based on our own three scenarios. Our initial framework is presented in Figure 1.

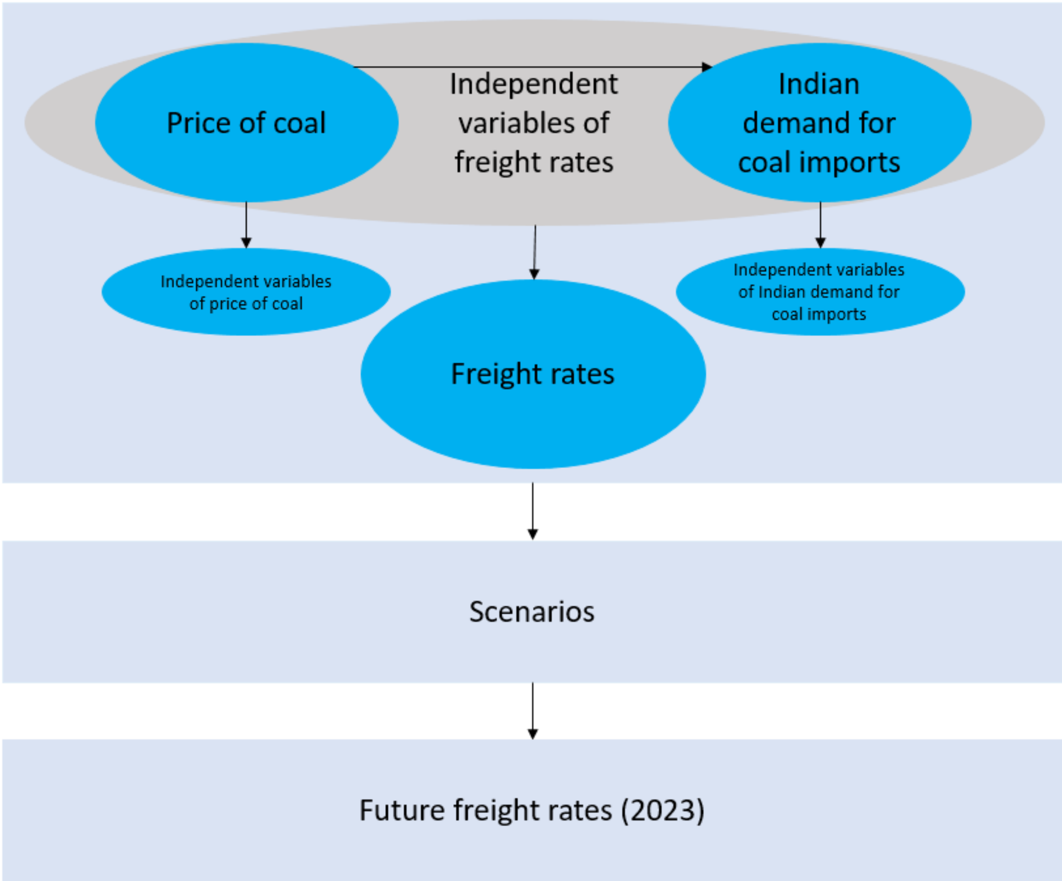

Figure 1: Research framework (Source: Own construction)

Based on the figure, we estimate that the price of coal is a main determinant of the Indian demand for coal imports and both of them determine the freight rates. Thus, we begin our research with the price of coal and its determinants, we proceed with the Indian demand for coal imports and its determinants, including the price of coal and we complete it with the freight rates and its determinants, including both of the aforementioned factors.

The determinants of the price of coal are the price of the alternative fuels, the law of demand and supply, the weather conditions and the governmental regulations. Moreover, the determinants of the demand for coal imports are the demand for electricity generation and steel production, the domestic production of coal, the Indian GDP, the price of coal and its substitutes. Regarding the freight rates, the main determinants are based on supply and demand for sea transport. Every determinant, is analyzed in the theoretical overview.

Afterwards, we build our three scenarios for the future of coal in India, as stated in the introduction and using the procedures of the previous steps, based on the dependent and independent variables, we calculate the future freight rates in 2023. The scenarios will be analyzed further in Chapter 2.

2.2 Theoretical overview

2.2.1 Types of commodities according to the transport characteristics

There are four major markets: the liquid bulk market, the dry bulk market, the specialized cargo market and the general cargo market (Giziakis et al. 2010). The liquid bulk market, transported by sea contain the crude oil and the oil products, the Liquefied Natural Gas and the Liquefied Petroleum Gas, the heavy chemicals and the liquefied chemical gases. The dry bulk market is divided in two parts, the five major bulks and the minor bulks (Giziakis et al. 2010). The largest commodity of the five major bulks is the iron ore, which is the major raw material for the steel industry (Giziakis et al. 2010). The second one, is the coal, which can be either coking coal or thermal coal. Thermal coal is used on fuel power stations (Stopford, 2009). The three remaining main dry bulks are the grains, which its trade is affected by seasonality, the bauxite/alumina and phosphate rock (Giziakis et al. 2010). The minor dry bulks include steel products, forest products, cement, fertilizer, non-ferrous metal ores, sugar, salt and sulphur (Giziakis et al. 2010). Specialized cargoes consist of refrigerated cargoes, which are divided into frozen, chilled and controlled temperature cargoes, and vehicle cargoes, while in general cargo category belong the containers, which dominates nowadays against the pallets (Giziakis et al. 2010).

2.2.2 Coal

Coal is a combustible rock, which consists mainly of carbonized plant matter, found mainly in underground seams. It has been used as an energy source throughout the human history (Pines). The formation of coal began roughly 300 million year ago (World Coal Association, 2019). The build-up of various sediments, such as silt, in combination with tectonic movements dug swamps and peat bogs into high depths and through high temperatures and pressures, peat was transformed into coal (World Coal Association, 2019). Coal was by far the dominant source of energy during the 19th century and especially during the Industrial Revolution (Bouchentouf).

2.2.2.1 Types of coal

Coal is divided into two main categories, low rank coal and hard coal (Kay, 2019). Low rank coals include lignite and sub-bituminous coal. Lignite or “brown coal” is the youngest type of coal, has the lowest quality and accounts for 17% of the coal reserves globally (Afework et al., 2018). Lignite Energy Council states that 79% of lignite coal is used for electricity generation, 13.5% for synthetic natural gas generation and 7.5% for the production of fertilizer products (Lyons Sunshine, 2018). Sub-bituminous coal or “black lignite”, which accounts for 30% of coal reserves globally, is classified between lignite and bituminous coal, according to the rankings used in the United States and Canada (Kopp). It is non coking and its combustion can cause high emissions of particulate matter (PM), sulfur oxides (SOx), nitrogen oxides (NOx), and mercury (Hg) (Lyons Sunshine, 2019). This particular type of coal is used in steam generation for electricity production and is able to be liquefied and converted into petroleum and gas (Afework et al., 2018). Hard coals include bituminous coal and anthracite (Kay, 2019). Bituminous coal, or “soft coal” is the most abundant type of coal and the second highest quality of coal (Kopp). The two types of bituminous coal are the thermal coal and the metallurgical coal, which are the main types of coal that are transported by bulk carriers by sea and account for 52% of the total coal reserves globally (World Coal Association, 2019). Thermal coal or “steaming coal” is mainly used for powering plants, which produce steam for electricity and other industrial uses, whereas metallurgical coal or “coking coal” is used for the production of iron and steel (Lyons Sunshine, 2019). The combust of bituminous coal causes significant health risks, due to the increased SOx, NOx, CO and CO2 emissions (Afework et al., 2018). Last but not least, anthracite or “hard coal” is the most mature coal and contains the highest rate of carbon from any type of coal (Kay, 2019). Anthracite is deemed the cleanest burning coal and it produces more heat, but less smoke (Lyons Sunshine, 2018). It is used mainly for home heating and accounts for just 1% of the world’s total coal reserves (Kay, 2019).

2.2.2.2 Uses of coal

Nowadays coal is used chiefly for the generation of electricity, known as steam coal, and for the manufacturing of steel, known as metallurgical coal (Bouchentouf). Coal is of paramount importance regarding the electricity generation, as coal-fired power plants fuel 41% of global electricity (World Coal Association, 2019). Moreover, 70% of steel produced uses coal (coking coal), which indicates that the global steel production depends highly on coal (World Coal Association, 2019). In order to produce one ton of cement, around 200 kg of coal are required, which points out that coal is also important for the construction industry. Furthermore, the contribution of coal in the transport sector is significant, through the liquid fuels from coal, as alternatives to oil, and the aforementioned raw materials, which are crucial to build transport infrastructures. There are already being developed some coal-to-liquids demonstration plants in China and this type of plants cover 20% of South Africa’s transport needs along with 7.5% of jet fuel (World Coal Association, 2019). This kind of fuels are Sulphur free, with low particulate matter, oxides of nitrogen and are able to reduce the CO2 emissions up to 46%, in comparison with the conventional oil products, in case coal and biomass are combined with carbon capture, use and storage (World Coal Association, 2019). According to the International Energy Agency coal-to-liquid fuels can be produced with significantly lower cost compared with gasoline. Last but not least, coal could also play a vital role in the electrification of the transport sector, which is important, as electric vehicles’ production is expected to have an upward trend in the next decades, due to the increased sustainability trend.

2.2.2.3 Main exporters, importers and producers of coal worldwide

The following table (Table 1) indicates the main coal exporters by exported volumes, the trade value and the percentage of the total value of exports globally in 2018.

Table 1: The major coal export countries in 2018 (Sources: UN Comtrade & World's Top Exports)

Country	Exported volumes (million tons)	Trade value (billion US$)	%World Total
Australia	382	47	36.9
Indonesia	343	20.6	16.2
Russia	199.5	17	13.4
United States	105	12	9.4
Colombia	84	6.6	5.2
South Africa	77	6.2	4.9
Canada	34	5.8	4.5
Mongolia	36.5	2.8	2.2

The major exporters of coal are Australia, Indonesia, Russia and the United States. Other countries that export considerable quantities of coal are Colombia, South Africa, Canada and Mongolia. The total value of coal exports was $127.6 billion in 2018, of which the aforementioned countries carried out 92.7% of the global coal exports, by value (Workman, 2019).

In the next table (Table 2) we present the main coal importers by exported volumes, the trade value and the percentage of the total value of exports worldwide in 2018.

Table 2: The major coal import countries in 2018 (Sources: UN Comtrade & World's Top Exports)

Country	Imported volumes (million tons)	Trade value (billion US$)	%World Total
India	280	30	19.7
Japan	210	25.3	16.7
China	281.2	19.6	12.9
South Korea	131.5	16.5	10.9

The major importers of coal are India, Japan, China and South Korea. The total value of imported coal was $152 billion in 2018 (Workman, 2019). China seems to be marginally the largest importer of coal ahead of India. However, according to Clarksons' Report for dry bulk commodities (2019), due to the projected increased imported volumes of both thermal and coking coal (4-5%) in India in 2019 and the downward trend of imported thermal coal in China (-8%) compared to 2018, India will be the largest importer of coal in 2019 and 2020.

Finally, yet importantly, in Table 3 we point out the global top 10 coal producers, in 2017, by total output and its percentage change, in comparison with 2016.

Table 3: The top 10 coal producers worldwide in 2017 (Source: China Coal Economic Research Association; sxcoal.com)

Countries	Output (million tons)	% change compared to

		2016
China	3,520	3.3
United States	715	7.9
India	712	2.9
Australia	567	0
Indonesia	477	4.6
Russia	408	6.3
South Africa	254	1
Germany	176	0
Poland	127	-3
Kazakhstan	111	7.8

Traditionally, China is by far the largest producer of coal. However, it is not included in the list of the major exporters of coal, because of the increased demand for coal in China, most of this output is not exported to other countries, but it is kept to be used domestically. The same applies to India and other countries that are not included in the Table 1, despite the fact the they are major producers of coal. On the other hand, we observe that most of the produced quantity of coal in Australia and Indonesia is exported to other countries.

2.2.3 Coal in India

In this section, we focus on coal in India, by analyzing its importance, which comes through the significant economic growth and the increased requirements for energy consumption. We also analyze the main suppliers of coal to India in 2018 and the scenarios regarding the future demand of coal in India, which are important for the sensitivity analysis in Chapter 4.

2.2.3.1 The importance of coal in Indian economy

India is the sixth largest economy in the world, in terms of nominal GDP, $2.61 trillion in 2018, and according to IMF it is expected to overtake the United Kingdom to become the fifth largest economy globally (Silver, 2019). The growth rate is over 7% during the last two years, which makes it the fastest growing economy in the world and according to United Nations report, it is projected to reach at 7.1% in 2020 (Business Today, 2019). India's economy relies mostly on service industry, agriculture and industry like power generation, chemical sector etc. (Page, 2018). Especially power is the most important factor for industrial and business set up (Gyan, 2016). Moreover, India is the second most populous country worldwide with population 1,37 billion. The demand for power is huge, as the International Energy Agency estimates that over 300 million of the Indian population does not have access to electricity and in the grounds of the rapid economic growth numerous industrial and business set ups will be required. International Energy Agency also estimates that the Indian energy consumption is projected to exceed the OECD Europe's combined energy consumption by 2040 and approach that of the United States. "Make in India" campaign states that for the development of India, a large rise in energy is necessary. India is the third largest energy consumer in the world and its energy use is expected to grow rapidly in the future mainly due to economic development and urbanization (Penney & Cronshaw, 2015). More specifically, India’s energy consumption grows by 4.6% per year, which makes it the fastest one in the world. Therefore, coal is crucial factor to help India cover its future energy needs (World Coal Association, 2019).

Almost 80% of coal in India is used for electricity generation (Tongia & Gross, 2019). Renewable energy is not yet ready to completely replace coal, due to the increased demand for electricity generation. Despite the fact that removing coal entirely from power generation is a common goal, very few countries have implemented realistic policies. Moreover, coal is very important for Indian economy, as it supports the society with levies, profits from mining companies like Coal India Limited, which is the largest mining company in the world and produces 84% of India’s thermal coal, and subsidizations to railway passengers (Tongia & Gross, 2019). Moreover, the employment in some of the poorest regions in India, depends highly on coal industry. According to the aforementioned, a significant challenge is created for the government to manage the decline of the dominance of coal. One possible way to face this challenge is to make the Indian coal cleaner, by using cleaner coal-fired plants with less emissions.

To meet its growing energy requirements, India has to combine both coal and renewable energy. The Indian Government aims to expand the capacity of renewable technologies to 175 gigawatts in 2022, and its coal-fired electricity generation capacity to 318 gigawatts (Penney & Cronshaw, 2015). Large portion of this coal-fired electricity capacity uses the low cost subcritical technology, yet it uses more coal and produces more CO_2 emissions (Penney & Cronshow, 2015). However, all new coal-fired projects in India are required to use supercritical technology or even better ultra and advanced ultra-supercritical technology, as they use less coal and produce less emissions. This kind of technology requires high quality of coal, which is not available in Indian reserves. This means that the demand for imported coal will be increased, especially from Australia, which has large deposits of high-energy and low ash coal to be used in the new coal-fired plants. Regarding the renewable energy, the Indian government is actively promoting the related technologies, in order to meet its environmental goals, especially in large cities like Delhi, where the air quality is very low, by using energy systems with battery storage, lighting and solar power (Penney & Cronshaw, 2015). In fact, India does not need further new investments in coal-fired power plants, but in new technologies in these plants, in order to control their pollution (Tongia & Gross, 2019).

All in all, the main challenge for India is to balance the economic growth, which require more and more energy consumption, with limiting the carbon emissions.

2.2.3.2 The main suppliers of coal to India

In Table 4 we indicate the main suppliers of coal to India in 2018, by volume and trade value.

Table 4: Top 5 suppliers of coal to India in 2018 (Source: UN Comtrade)

Country	Imported volumes (million tons)	Trade value (billion US$)
Indonesia	125.5	8.3
Australia	62.7	11.5

South Africa	43.8	3.8
United States	19.2	2.5
Canada	5.5	1.1

The major coal supplier of India is Indonesia with 125.5 MT and $8.3 billion trade value. Nevertheless, we observe that the trade value of Australian coal is much higher, compared to Indonesian one, even if the latter is exported in double quantities to India. This is because of the fact that India imports mainly lower quality of coal, thermal coal from Indonesia (Reuters, 2018). India is the third largest producer of thermal coal globally. Nevertheless, the output is not enough to meet the demand, thus India relies on imports, mainly from Indonesia, due to low cost and also some Indian companies own Indonesian mines. On the other hand, Australia, the second largest supplier of coal to India, exports almost only coking coal to be used in steel production, the price of which is much higher than the thermal coal (Reuters, 2018). In fact, South Africa is a competitor of Indonesia, as it exports thermal coal to India. The only difference is spotted in the quality of the South African coal, which is higher compared to the Indonesian one. However, South Africa's high quality thermal coal depletes, which might affect the exported volumes to India in the future (Tsedu, 2016). The coal imported by the United States and Canada is mostly coking coal. This particular trade seems to have high potential, due to the supply disruptions from Australia to India, caused by a flood in one of the main producing regions in Australia in February and a cyclone, which took place in Queensland in 2017 (Varadhan, 2019). The demand of coking coal is projected to increase more than double in 10 years, as the country aims to increase the crude steel production to 300 million tons by 2030 (Varadhan, 2019).

2.2.3.3 Scenarios for the potential demand of coal in India

In this section we develop three different scenarios for the future demand for coal in India, based on the literature stated in section 2.3.1.

To begin with, India has invested in numerous coal-fired plants, in order to increase the energy production and meet the required demand. To increase the energy production, coal production is also required to be increased. As India has the fifth largest coal reserves in the world and coal-fired plants have an upward trend, India has great potential to increase further its domestic production to cover its energy needs and increase its self-sufficiency. Paris climate agreement, which India has signed, does not set a deadline for the gradual reduction in the use of coal, but only demands the decrease of the emissions resulted per unit of economic activity (Panda, 2019). Thus, in order this option to become more realistic, new technologies must be introduced to make the coal cleaner. By this scenario, we believe that the continuous upward trend in the demand for coal imports will stop and at most could remain stable or slightly decline.

One more possible scenario for the future, is the raise of imports of coking coal, which is created by the increased demand for steel production. India's steel demand is projected to increase by 7.3%, which makes it possible for India to become the second largest steel user worldwide, overtaking Japan, by the end of 2019 (Szewczyk, 2019). Furthermore, India is projected to become the largest importer of coking coal in seaborne trade by 2022, based on Tata Steel's estimations. Last year, India covered 85% of its coking coal demand through imports and by 2022 the demand is expected to increase from 56 million tons to 67 million tons (Business Today, 2018). Another fact, which indicates the future increase in the demand for cocking coal imports, is that the government of India has set a goal of increasing the crude steel capacity to 300 million tons per year by 2030, as the steel consumption per capita will increase from currently 61 kg to 158 kg (Lu & Yi Le, 2018). Australian exporters are the best placed to benefit from the increase in steel capacity of India with the US and Mozambique following (Lu & Yi Le, 2018). Thus, by this scenario, we will examine the impact of the increased demand for imports of coal in India, on the freight rates.

In general, it is obvious that the coal will remain one of the key factors for the growth of the Indian economy, either by increasing the domestic production or by increasing the imports. But what about the impacts of combustion of coal on human health and environment? As stated in the introduction, through the energy generation in the coal-fired plants, pollutants like COx, SOx, NOx, particulate matter (PM) and heavy metals are gathered in air and water and cause serious health and environmental problem (Munawer, 2018). COx contributes to global warming and in severe diseases like malaria, chronic obstructive pulmonary disease and lung cancer. SOx is toxic and lead people to diseases such as destabilization of the heartbeat, skin cancer and asthma, while NOx emissions lead to persistent pulmonary hypertension of newborns (Munawer, 2018). Moreover, particulate matter impacts way too negatively on both human health and environment, whereas heavy metals cause diseases significant diseases. Researchers from the ETH Zurich in Switzerland point out that the coal power plants in India are the unhealthiest in the world (Economic Times, 2019). 1.2 million deaths in India were attributed to air pollution in 2017 and under the study reports of University of Chicago the air pollution scales down the life expectancy by 5.3 years in India and 12 years in Delhi, which is the worst globally (Pompeu, 2019). Furthermore, Greenpeace report indicates that air pollution from coal power plants result in 80-120,000 premature deaths per year and 20 million of new asthma cases per year (Vidal, 2013). As a result, Indians are more aware of the effects of the air pollution, created by coal power plants, and launched a couple of campaigns against them (Pompeu, 2019). Coal reserves in India and in global level are projected to last for hundreds of years, which means that the governments have to take measures to mitigate the negative effects. However, the political cost might be high enough, especially for the Indian government, as the economy depends highly from the coal power generation and a significant number of household's income depends on it. Ambitious policy incentives to increase the use of renewables, wind and solar, is essential for the Indian government, in order to diminish the negative externalities of coal power plants and a decent way to decrease the political cost. Thus in the third scenario, we assume a gradual decrease in coal use and simultaneously a significant increase in renewable energy sources, which will affect in a negative way the imports of coal.

2.2.4 Determinants of Indian demand for coal

The demand for coal trade is steadily increasing, especially for India, which is the second largest importer in the world. The main reasons for this are the continuous increased demand for electricity and steel, the easy and safe transportation of coal compared to oil and natural gas and the fact that the coal reserves are much larger than oil and natural gas reserves. Thus, the major factors that determine the demand for coal imports are the demand for electricity generation and steel production, of which both of them are based on coal, the domestic production, the Indian GDP, the price of coal and its substitutes.

1) Demand for electricity generation

India has a huge demand for power generation, in order to cover the needs of the steadily increased population, as there are still places that have not yet access to electricity. Per International Energy Agency, 310 million of Indians have no electricity, 760 million of Indians have no refrigeration and roughly 820 million of Indians are still cooking with wood. However, according to Central Electricity Authority, the power consumption had annual growth 4.8% in the last ten years, reaching 1,149 kWh per capita in 2018, compared to 717 kWh in 2008 (Figure 2).

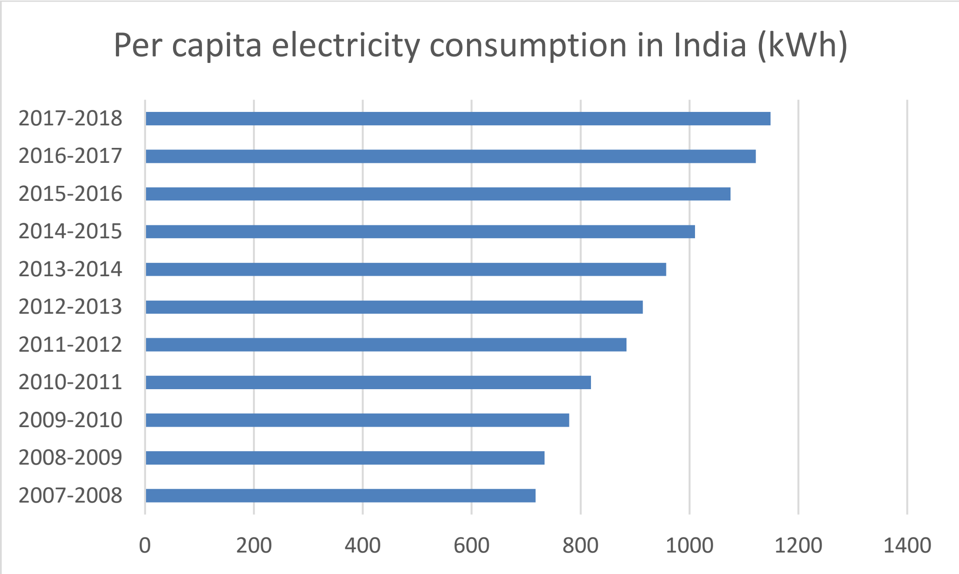

Figure 2: Per capita electricity consumption in India (kWh) (Source: Central Electricity Authority)

The country's objective to achieve a reliable and permanent supply of electricity for the whole country requires doubling of the Indian installed power generation capacity, with at least 50,000 – 60,000 megawatt of thermal power capacity (Mishra, 2019). In addition, a 5-6% growth in power production is projected for India during 2019-2020, in order to cover the household's needs (Behera, 2019).

Coal is the dominant source of electricity in global and the Indian coal-fired plants generate about 72% of the electricity (Seetharaman, 2019). This means that as the demand for power generation has an upward trend in India, it makes sense that the demand for coal imports is increased. Indeed, the following graph (Figure 3) indicates that the India's coal generation capacity is expected to double until 2035, as in 2011 it was 110 gigawatts, nowadays is almost 250 gigawatts and in 2035 is expected to reach at 450 gigawatts.

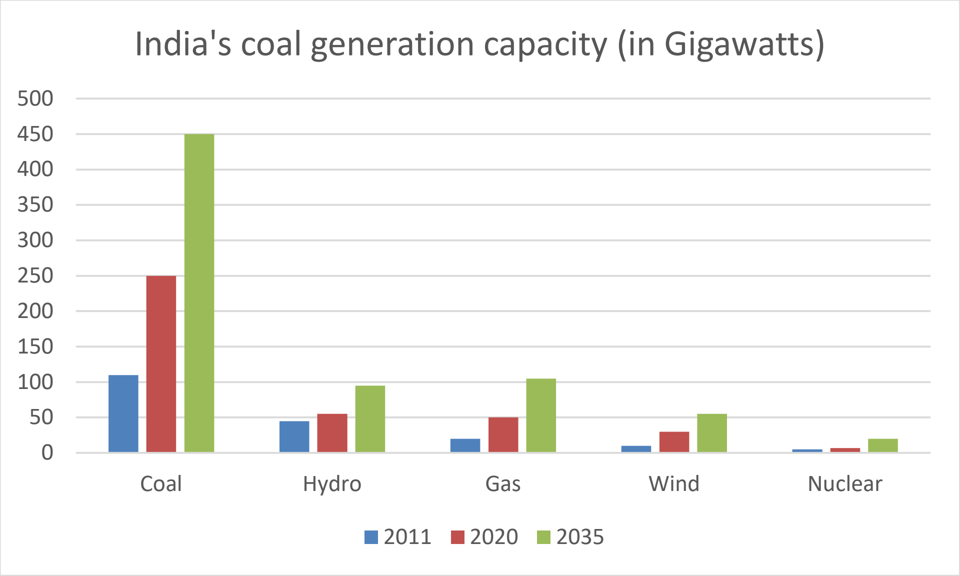

Figure 3: India's coal generation capacity (Source: IEA)

2) Demand for steel production

India is the second largest steel producer in the world, having produced 106.5 million tons in 2018 (India Brand Equity Foundation, 2019). The demand for steel production has an upward trend for India during the last 50 years (Figure 4).

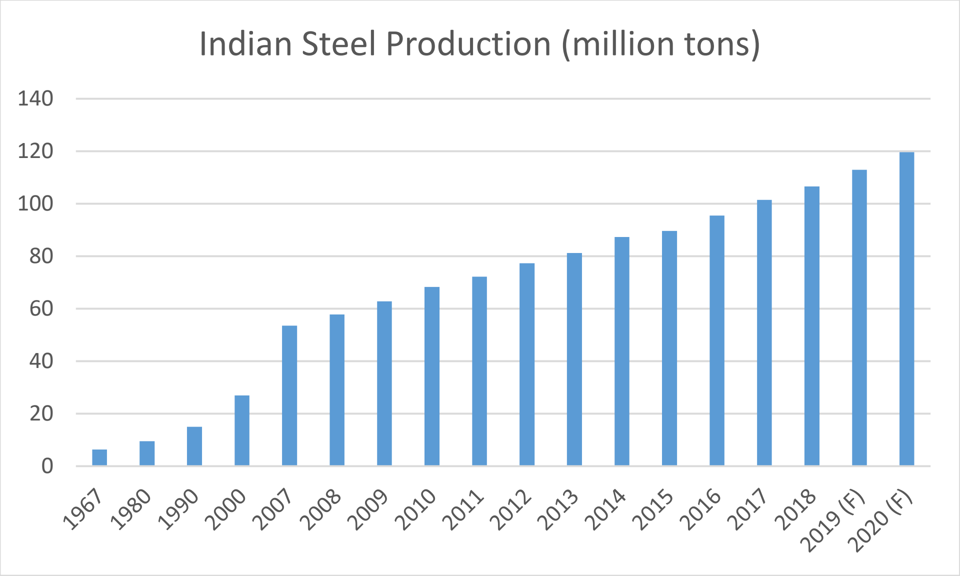

Figure 4: Indian Steel Production in million tons (Source: World Steel Association)

The demand for domestic production and demand are projected to increase by 6-7% in India, whereas in countries like China, Japan and EU the production and consumption will follow a downward trend (FE Bureau, 2019). The demand for steel in India, is mainly driven by the infrastructure sector and the automobile sector (20% of the total steel in India) (Ram, 2019). Moreover, the increased steel consumption per capita and the production capacity are in line with the National Steel Policy in India, which has set a goal of 300 million tons in 2031 (Ram, 2019).

The steel production is depending highly on coal and more specifically on metallurgical coal. Indian steel producers used 40 million tons of metallurgical coal in 2013 and as the steel capacity is expected to reach at 300 million tons by 2031, the imports could also grow to 110 million tons (Clemente, 2014). Thus, the demand for coal imports depends also from the demand for steel production.

3) Domestic Production of coal in India

According to the World Energy Outlook 2018 of International Energy Agency, India is expected to become the second largest coal producer in energy terms after China, in the early 2020s, overtaking Australia and the United States. This report also projects that India will produce 955 Megatonne of coal equivalent (Mtce), in comparison with 395 Mtce produced in 2017, with an annual growth rate of 3.9%. Despite every year there is a growth in coal production, the imports are also increasing. This is not only because of the increased demand for power generation or steel production, but also due to the fact that the Indian coal has low quality, which means that it can only produce steam coal, not coking coal. Thus, the imports of coking coal always increase, as the domestic resources do not have the require sufficiency to cover the demand of steel industry. The Indian domestic reserves of coking coal account for just 13% of the total reserves and plenty of them are not accessible, because are placed under communities or farm lands (Clemente, 2014). Even for the thermal coal, the imports are preferred in a higher degree, because the Indian coal has low Sulphur efficiency, which means less boiler efficiency, which leads more coal inputs to be used for the total output (Clemente, 2014).

For the aforementioned reasons, the structure of the domestic production of coal in India is such, that the demand for coal imports is affected positively.

4) Indian GDP

The economy of India is the sixth largest economy in the world in terms of nominal GDP and the third largest in terms of purchasing power parity. Figure 5 illustrates the Indian GDP from 1990 to 2018.

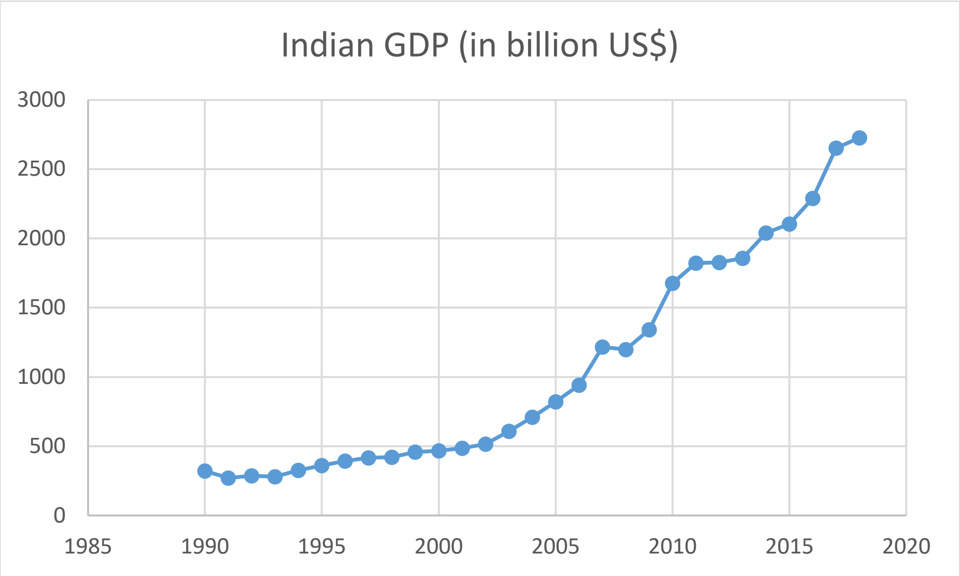

Figure 5: Indian GDP in billion US$ (Source: World Bank Group)

It is obvious that there is a sharp growth, especially after 2000. Actually, in 2014, India overtook China in terms of the fastest growing major economy and every year the growth is around 6-7%. As the population and GDP in India grow rapidly, the demand for power generation and steel production also grows. Therefore, we think that the GDP is another determinant of the demand for coal imports in India.

5) Spot price of coal and its substitutes

Theoretically, a basic determinant of the demand is the price of the good and the price of its substitutes. From the law of demand, it is known that when the prices rise the demand drops and when the prices drop the demand grows, if the demand is elastic and the other factors are stable. If the demand is inelastic, then the prices do not affect so much the demanded quantity. The demand for coal imports in India seems to be inelastic, until now, for two reasons. Firstly, the economic growth and the rapid growth of the Indian population makes the coal crucial factor for electricity generation and steel production, which present an upward trend. Secondly, the power generation depends highly on coal and much less on renewables and natural gas. This has led to numerous investments on coal-fired plants and less to renewable based plants. However, this fact in the future might change. It depends mostly on the reliability of the substitutes, the costs for power generation and the spot prices. Coal will face a real challenge against the renewables, coal is getting much expensive compared to renewables like wind and solar, as they can be offered at less than 4 U.S. dollars per kWh (Russell, 2019). In addition to this, it is also important that the capital and operating costs for coal-fired plants are higher in comparison with renewables. Renewable energy costs have dropped by 50% and it is forecasted a further drop. Furthermore, 65% of the coal power generation of India is sold in higher prices than renewables and wind and solar, which are 20% cheaper than coal-fired power generation plants (Marcacci, 2018). Moreover, countries like the United States have declined the use of coal in the power system and use more natural gas. If this in the future will be proven a wise choice, which saves a lot of funds, then it will be an extra incentive for India to use less coal and more renewables and natural gas.

2.2.5 Determinants of coal price

The key factors that determine the price of coal are the price of other fuels, the law of supply and demand, the weather conditions and the governmental regulations.

1) Price of other fuels

A major factor that affects the price of coal is the price of the substitute fuels like oil, natural gas, solar etc. For example, if the price of oil or gas gets more expensive, the demand for coal would increase, which finally changes the price (Adeyanju, 2014). Actually, some people argue that whenever the price of oil or natural gas increases, then the price of coal also increases, but in fact this mainly happens when the rise in the price of oil changes the fundamentals of coal, mostly the demand (Adeyanju, 2014). This fact is depicted in Figures 6 and 7, which contain the thermal coal price and the oil price respectively.

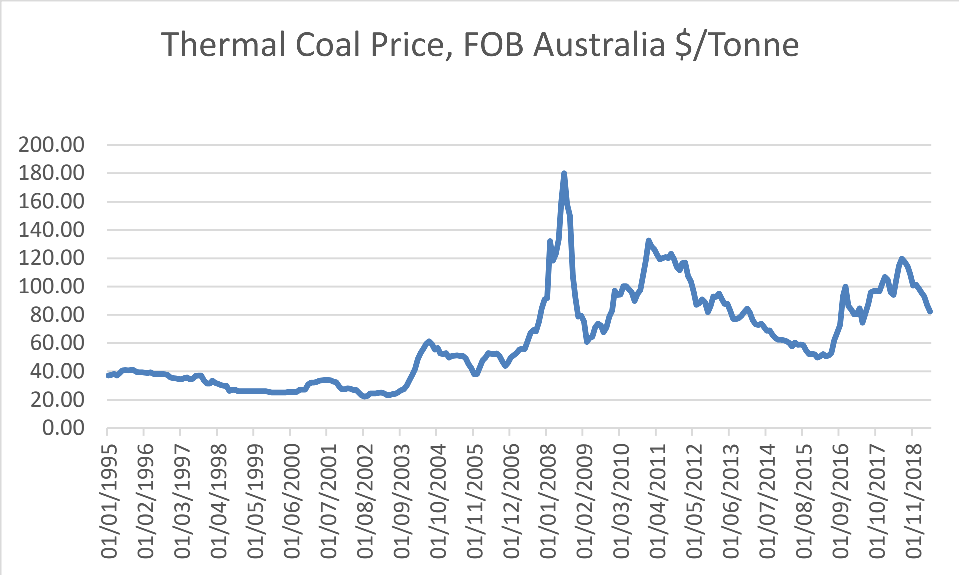

Figure 6: Price of Thermal Coal in Australia in US$/ton (Source: Clarksons)

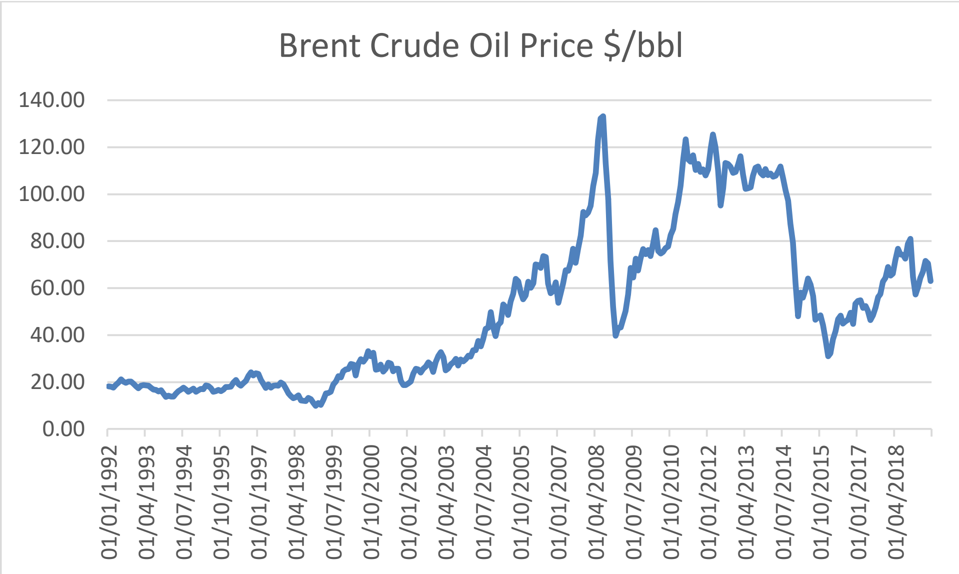

Figure 7: Price of Brent Crude Oil in US$/barrel (Source: Clarksons)

We observe that the price of coal follows the trend of oil's price. However, the natural gas price (Figure 8) seems to be more independent.

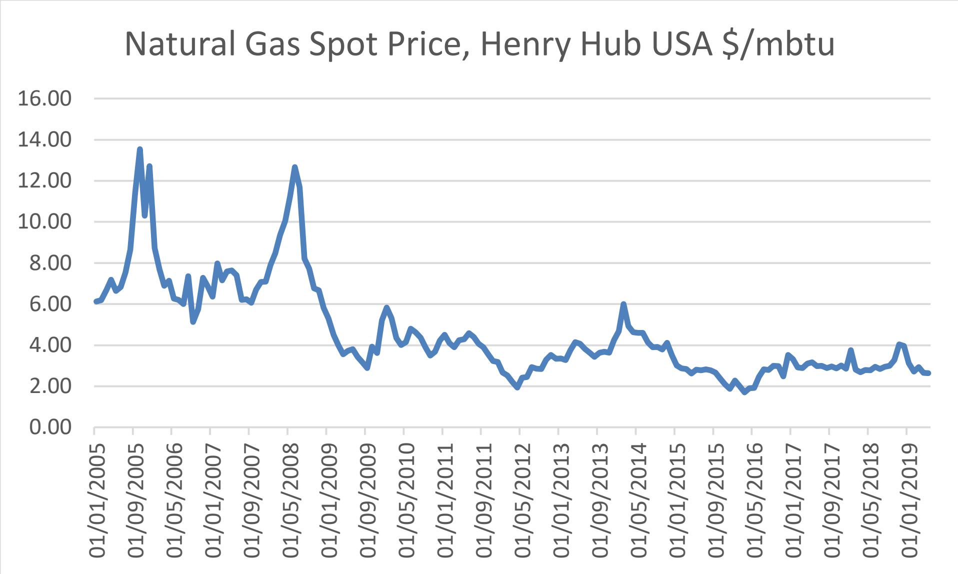

Figure 8: Price of Natural Gas US$/mbtu (Source: Clarksons)

2) Law of Supply and Demand

By this point, we mean that when the supply is higher than the demand of coal, a surplus is created, which makes the price of coal to drop, all the other factors unchanged. On the other hand, when the demand for coal is higher than the supply, a shortage is created, which makes the price of coal to grow.

The demand of coal depends highly on electricity industry. The electricity generation is growing sharply, as the upward trend of population, the economic growth of the developing countries and the higher standards of the developed countries. Until now, the electricity industry depends highly on coal and will do so at least until 2030 – 2040 according to various studies and projections. Coal will coexist with renewables, due to the fact that the global demand cannot be covered only with the renewables. However, plenty of countries in the world have already initiated national strategies for the removal of coal from power generation, promoting the use of renewables, in order to reduce the CO2 and other harmful emissions. The demand for coal also depends on the steel industry, because the steel production requires coal. The global need for steel grows, driven by the investments in infrastructure, especially in the developing countries in Asia and in Africa, and the demand for steel from the automobile industry.

The supply of coal depends on the mining industry. Technical disruptions or even weather conditions are able to affect the coal mining. Moreover, the production costs can also alter the supply. For example, when the coal is mined from the surface the cost is much lower than mining from deep and this can affect the price of coal. Furthermore, the supply of coal depends on the global reserves of coal (Figure 9).

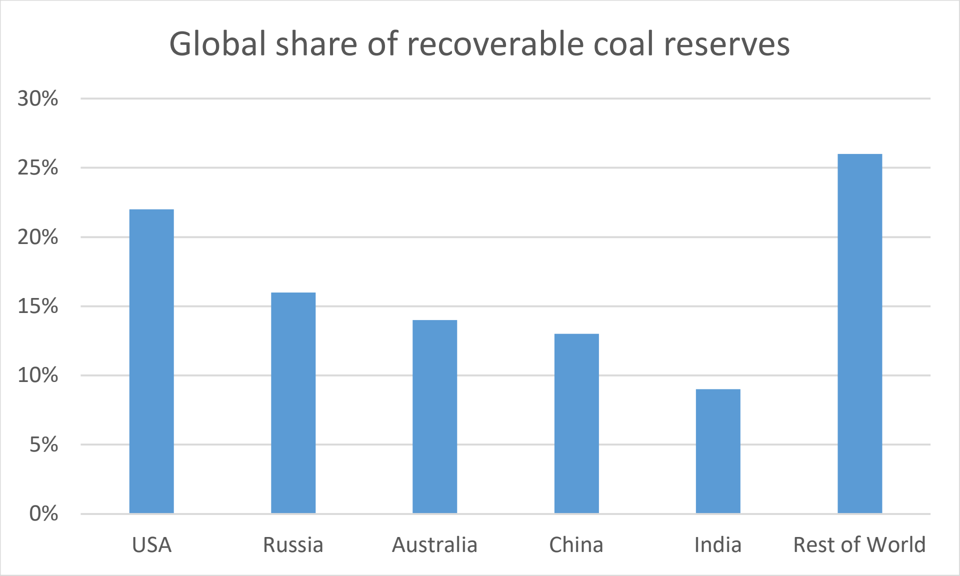

Figure 9: Global share of proved recoverable coal reserves (2015) (Source: U.S. Energy Information Administration)

The estimation of the global proved recoverable reserves of coal, from the U.S. Energy Information Administration, were almost 1.1 trillion short tons in 2015, which is a lot higher compared to natural gas reserves. Last but not least, the supply of coal is affected by the freight costs, as the majority of the produced coal is transported worldwide and thus they can affect the final price of coal.

3) Weather conditions

Coal price can also be affected by the weather conditions. In case of extreme weather conditions, the demand for electricity and therefore coal soars up and so does the price of coal. In extreme cold weather, people spend most of the time indoors, with electric heaters and lights switched on. In extreme hot summers, the demand for air conditioning in homes and buildings increases sharply, which results to increased demand for power generation. In cold winters, people also use heaters, which use oil or natural gas and thus the coal demand is not affected in the degree of a hot summer, when people use mostly air conditions, which use electricity.

4) Governmental regulations

As we have already mentioned beforehand, coal is dirty due to the fact that it contributes to the climate change, the air and water solution via increased CO2, SOx and NOx emissions, during its combustion. Some governments around the world have already enacted regulations for the restriction of use of coal. For example, in the United States former president Barrack Obama had launched the clean power plan in 2017, which focused on cutting the emissions from coal-fired plants and also on increasing the use of renewable energy. However, this plan was set aside by the current president of the United States Donald Trump, who enforced a new plan for the greenhouse gas emissions, which boosts the production of coal-fired plants. These key decisions affect the price of coal, as some of them increase the supply and others restrict it.

Another tool used by the governments to discourage the coal trade and the output of the coal-fired plants is the levy of taxes, like carbon tax. Most of the countries, who seek to restrict the greenhouse gas emissions and promote the renewables, have levied this kind of tax, the height of which depends on the degree the country is willing to restrict the use of coal.

On the other hand, some countries subsidize the coal-fired plants and by this they boost the use and the trade of coal, despite the immediate need to reduce the carbon emissions. Actually, G20 countries have tripled the subsidies to coal-burning power plants during the recent years, with China and India being the leaders, followed by Japan, South Africa, Indonesia and the United States (Carrington, 2019).

Thus the decisions of the governments, whether to keep or restrict the coal use, is a key factor for the coal price.

2.2.6 Determinants of freight rates

The freight rates are determined by supply and demand of the shipping market. The negotiations for the freight rates take place between the ship owners and the shippers and they usually agree on a freight rate, which depicts the balance of ships and cargoes, which are available in the market (Stopford, 2009). When there is overcapacity in the shipping market, which means that the ships are too many, the freight rates are low, because the shippers have increased negotiation power compared to the ship owners, who are willing to operate their vessels in lower rates to minimize the operational expenses. On the other hand, when the cargoes are more than the available ships, the freight rates are high, because the ship owners have more negotiation power in comparison with the shippers, who seek for a ship to transport their cargoes, even for higher rates. Thus this is the way the freight rate mechanism works. Last but not least, there are also some microeconomic factors that affect the freight rates, which will be presented in this chapter.

2.2.6.1 Determinants of demand for sea transportation

According to Martin Stopford, the factors which affect the demand for sea transportation are the world economy, the seaborne commodity trades, the average haul, the transport costs and the political events.

1) World economy

One of the most important factors that influence the demand for sea transportation is the world economy. The world economy creates the demand for trade and sea transport, as the demand from the manufacturers for raw materials and the demand from the consumers for finished goods are always high. World economy affects the demand for sea transport with two factors. First, the business cycles, which alter the rates of economic growth and thus the demand for seaborne trade. For example, the demand for seaborne trade and the freight rates were very high before the financial crisis of 2008, in contrast with the fact after this. Second, the economic shocks, which can affect the seaborne trade severely, for instance the 1930s depression in shipping after the Wall Street Crash in 1929. These economic shocks are unpredictable and do not follow the business cycles.

2) Seaborne commodity trades

In this case we need to distinguish the short-term and the long-term effects. A major reason for the short-term volatility is the seasonality of some trades. The harvest periods of some commodities like fruits, sugar, grains etc. create fluctuations in the seaborne trade. In this case the seaborne trade during the summer is not so active, as it is the harvest period, but from September to the December it booms. Another case is the oil business, of which the trade is very active in autumn and early winter and one more is the liner trade, which peaks during major holidays like Christmas and Chinese New Year.

Even more important are the long-term trends for some commodities in seaborne trade. First of all, the demand for a particular commodity may change the trade pattern, for instance the primary energy source changes from coal to oil. Second, the changes in the supply sources, for instance the new oil reserves in North Sea and Alaska in 1970s, abolished the requirement for deep sea imports. Third, the relocation of the processing of raw materials may also change the structure of the seaborne trade and fourth, the transport policy of the cargo owners like the oil producers, who controlled the sea transport of oil until the 1970s, whereas after this period they charter ships.

3) Average haul

The sea transport demand depends on the distance between the point of origin and destination. For example, a ton of coal may be transported from an origin to a destination ten times more than a ton of coal from another origin to another destination. This effect is the known “average haul”. The sea transport demand is usually measured in ton miles, which are equal to the volume of shipped cargo multiplied by the average travelled distance (Stopford, 2009). The average haul in commodities like oil and iron ore have an upward trend, compared to the past.

4) Transport costs

The transport costs also play a vital role for the demand of shipping services. During the recent years, the efficiency is increasing steadily and the transport costs are decreasing, as the vessels are getting larger and the service quality is increasing.

5) Political events

Political events can be wars, revolutions, government decisions and policies etc. Especially the political shocks, which are unpredictable, may have severe and sometimes indirect effect on the demand for shipping transportation. For example, during the Suez Crisis in 1956, when the canal closed, the ship demand for tankers increased sharply, because the tankers trading from Europe to Middle East and the opposite, were deflected round the Cape.

2.2.6.2 Determinants of supply for sea transportation

The supply of the shipping market responds slowly in the demand changes (Stopford, 2009). This is explained by the fact that vessels need at least one and sometimes even two or three years to be built. The life cycle of the ships is very long, almost 25-30 years, which means that when there is need for capacity to be removed from the market takes long time. The main decision makers for the supply in the shipping market are the ship owners, who order new ships and scrap the old ones and the banks, which finance the investments of the ship owners (Stopford, 2009). The key determinants of the supply for sea transportation are the merchant fleet, the fleet productivity, the shipbuilding production, the scraps and losses and freight revenues.

1) Merchant fleet

The development of the merchant fleet is rapid the last 50 years. The changes on the ships during these years are radical. First, the capacity has increased, due to economies of scale, in order the ship owners to lower the per unit costs of the transportation. Second, there are changes in the types of ships that are operated, for instance the general cargo vessels are not used so frequently as in the past, because in fact they are substituted by the container ships. Thus, the increased demand for transportation, due to the global industrialization, the increased population and the globalization, have led to this great growth of the global merchant fleet.

2) Fleet productivity

One way to measure the fleet productivity is in ton miles per deadweight (Stopford, 2009). The determinants the productivity of the fleet are the speed, the time that the vessel spends in ports, the deadweight utilization and the loaded days at sea (Stopford, 2009). The speed during the voyage depends on the situation in the market, for instance if the market booms the vessels usually travel even with the maximum speed, whereas when the market is in decline, slow-steaming is used. Moreover, if the carrier offers just-in-time services and focuses on quality, like the container ships in the liner shipping, the speeds are higher. Port times depend on the congestion in the ports and the quality of services that the terminals offer. Nowadays, the port times are decreasing, due to investments in infrastructures and automation in the ports. The deadweight utilization depends on the availability of cargoes and the right decisions of the chartering department in shipping companies. Last but not least, the length of the loaded days at sea depend on the idle days and the port times.

3) Shipbuilding production, the scraps and losses

These three elements are crucial for the supply of the shipping market. The shipbuilding production reach the peak, when the market booms and also in the early decline, as the delivery takes one to three years. On the other hand, the scrapping depends on the ship owner’s decisions, according to their future expectations. Whenever the market declines the scraps increase, whereas when the market booms scraps are very rare, as the ship owners make even old whips with low efficiency and high operating costs available for transport.

4) Freight revenues

This might be the most important factor for the supply of the shipping market. According to the freight revenues, the ship owners take key decisions about the shipbuilding and the scraps of the fleet. The freight revenues are high during booms periods and low in decline periods.

2.2.6.3 Microeconomic determinants of freight rates

Besides the macroeconomic variables that were analyzed before, there are some microeconomic factors that are able to affect the freight rates. First of all, the distance between the port of origin and the port of destination may affect the freight rates. In our case, we will include the average distance between the ports of India and the main exporters of coal to India. Second, size of the ships in deadweight can influence the freight rates. The trade of coal is carried out with capesizes bulk carriers, due to the large volumes that are transported. However, in the trade between India and other countries, the bulk carriers operated are mainly handysizes, supramaxes and panamaxes, due to the low-leveled port infrastructure in Indian ports. More specifically, geared handies and supramaxes are used in trade between India and Indonesia, and panamaxes between India and the other main exporters of coal like South Africa and the United States. Moreover, the age of the ships can play a role, as the newer ships may offer higher quality safety during the transportation, as well as the laycan period, which is the time limit for the cargo loading of the vessels and it depends on the agreed terms in the charterparty.

2.3 Conclusion overview

In the theoretical overview, we presented the main theory, crucial to understand the functions of coal, the trade patterns and apparently the determinants of price of coal, the demand for coal imports and the freight rates, either macro or microeconomic, which are taking into consideration for our model construction in the next chapters. In the next two sections we investigate the previous researches conducted within our research scope, in order to discover as a first step, if the theory applies to their models.

2.4 Final framework

Having analyzed the main theory, we are able to decide the final framework for our research. Our intention is to investigate if the Indian demand for coal imports is able to affect the freight rates and to predict the future freight rates in 2023, based on our scenarios.

In fact, the final framework remains the same as defined in Figure 1, where the initial framework was stated. The only difference is that, having composed the theory, we know exactly the variables that we will use in the three equations and the concepts of the three scenarios, that we built also in Chapter 2.

Thus, we begin with the determinants of the price of coal, which in our opinion and based on the theory, are the global coal trade, the global coal production, the price of oil, the price of natural gas and the average temperature of India. We proceed with the determinants of the Indian demand for coal imports, which are the Indian electricity generation, the Indian steel production, the Indian domestic coal production, the Indian GDP and the price of coal. Finally, for the determinants of freight rates, we use the total tonnage of the Panamax bulk carrier vessels, the Panamax fleet growth, the deliveries of Panamax bulk carrier vessels, the Panamax orderbook as a percentage of the total fleet, the sum of the demolitions and losses of Panamax vessels, the Indian GDP, the average age of Panamax vessels and the price of coal and the Indian demand for coal imports.

The next step is the scenario planning for the future of the coal in India. The first scenario that we use, is the increase in the Indian domestic coal production. The second one regards the increase in coking coal imports in India, vital for the steel production, while the third one assumes a regulation for the restriction of coal in India.

Using the aforementioned scenarios and taking into consideration the determinants of price of coal, the Indian demand for coal imports and the freight rates, we are able to calculate the freight rates in 2023, having three different results.

2.5 Theoretical review

In shipping industry, which is capital intensive, lots of investments take place every year. However, the ship owners and especially investors, of whom the shipping sector is not their main business, need to know and evaluate the micro and macroeconomic determinants of the freight rates, which in fact generate the profits and the returns of the investments, in order to avoid significant risks and secure their investments. Regarding the freight rates and their determinants, especially the macroeconomic, various researches have been conducted so far.

Everything begun with Tinbergen in 1934. Tinbergen was the first researcher who examined the sensitivity of freight rates to changes in demand and supply (Luo et.al, 2009). The author suggested that the determinants of supply were the world fleet size (K), the freight rates (FR) and the bunker prices (BP). From the perspective of demand (Q^D_t), Tinbergen proposed that shipping services demand was perfectly price inelastic. By creating the model in Equation (2.1), he concluded that supply, demand and bunker prices have great impact on freight rates.

$$lnFR_t = \alpha lnQ_t^D - \beta lnK_t + \gamma lnBP_t \qquad (2.1)$$

Few years after, in 1939, Koopmans separated the dry bulk market with the tanker market. This was not the only innovation, as Koopmans also distinguished the price elasticities of supply and demand in periods of booms and decline for the tanker sector, in order to make more accurate the forecasts about the tanker freight rates. He actually investigated the correlations and relationships between the market size, freight rates and shipbuilding sector (Luo et.al, 2009).

More recently, Kampa (2011) investigated sensitivity of the freight rates to the Chinese demand for iron ore and the global supply of vessels tonnage. For the quantitative analysis, the author uses a correlation analysis between the freight rates, the price of iron ore and the demand for imports with their determinants. After this Kampa uses the multiple regression method, in order to discover the relationships between the data and the dependent variables and forecasts the iron ore freight rates using a partial equilibrium model. The author concludes that the increase in Chinese demand for iron ore is not able to change the freight rates, as supply factors like shipbuilding industry have more power on this. In addition, the author used exclusively macroeconomic determinants of freight rates and thus in her future recommendations for further research suggests also microeconomic determinants to be taken into consideration.

Another research conducted by Kartsiouka (2011), investigated the impact of some factors on coal freight rates within the trade route Australia-China. In fact, for the quantitative analysis the author uses correlations between the main factors and the charter rates. The outcome was that the electrical power consumption, the electricity production from coal, the fossil fuel energy consumption and the Asian steel production are highly correlated, above 90%, with the freight rates.

Furthermore, a recent research conducted by Jugovic et.al (2015) indicates the importance of the supply, demand and prices of the shipping market, in a theoretical level. The interconnections created between these crucial factors either internal or external affect the formation of the freight rates and the structure of the shipping market.

Regarding the microeconomic factors that affect the freight rates, Cocconcelli (2017) investigated the microeconomic determinants of iron ore dry bulk freight rates. The author created two sets of variables, of which the first included the vessel age, laycan period, deadweight tons, cargo size, freight rate, distance and volatility, and the second focused on the characteristics of the iron ore terminals, including berth dimensions and number of berths. Conducting a two stage least square analysis, the conclusions were that the port and vessel characteristics affect the laycan period and the distance, cargo size, volatility and laycan period are the main factors that determine the freight rates in iron ore charter parties. Prior to this, Tamvakis (1995), Tamvakis & Thanopoulou (2000) and Alizadeh & Talley (2011) investigated the interrelationships between vessels characteristics, features of contracts and routes with the freight rates.

2.6 Conclusion review

Various research has been conducted about the determinants of freight rates during the last 100 years. Tinbergen and Koopmans were the first researchers during 1930s, investigating the sensitivity of the freight rates on demand and supply changes. The next researchers based their models and research methods on Tinbergen and Koopmans' models. It is remarkable to mention that most of the researches so far, investigate the macroeconomic determinants of freight rates and few researches have been conducted for the microeconomic determinants. In Table 5 we present the previous researches with the types of investigated determinants and the results, regarding the determinants of freight rates.

Table 5: Previous researches for the determinants of freight rates (Source: Own research)

Researcher(s)	Dependent variables	Independent variables	Determinants	Results
Tinbergen (1934)	Demand	No variables (inelastic demand)	Macroeconomic	Demand, supply, bunker prices
	Supply	Size of world fleet, bunker prices, freight rates		
Koopmans	Same as	Same as	Macroeconomic	Market size,

(1939)	Tinbergen, but only for tanker freight rates	Tinbergen, but only for tanker freight rates		shipbuilding sector
Kampa (2011)	Freight rates	Price of iron ore, newbuilding deliveries rate, Chinese demand for iron ore, scrap and losses rate, Logistics Performance Index, Capesize worldfleet, Chinese exports as percentage to the Chinese GDP	Macroeconomic	Shipbuilding sector, Price of commodity (iron ore), Logistics Performance Index
Kartsiouka (2011)	Charter rates	Electrical power consumption, electricity production from coal, fossil fuel energy consumption, Asian steel production	Macroeconomic	Electrical power consumption, electricity production from coal, fossil fuel energy consumption, Asian steel production
Jugovic (2015)	Demand for maritime transport	World economy, international maritime trade, average profit, political events, transport costs	Macroeconomic	Supply, demand and prices of the shipping market
	Maritime transport supply	Merchant fleet, productivity of the		

		merchant fleet, shipbuilding, shipbreaking and operative losses		
	Freight rates	Supply and demand factors		
Tamvakis (1995)	Freight rates	Age of vessels, double hull tankers	Microeconomic	Age and double hull in tankers do not affect freight rates
Tamvakis & Thanopoulou (2000)	Freight rates	Age of bulk carriers	Microeconomic	Age of bulk carriers do not affect freight rates
Alizadeh & Talley (2011)	Laycan period	Baltic Dirty Tanker Index, its volatility, vessel's hull type, age, routes, fixture deadweight utilization ratio	Microeconomic	Vessels characteristics and features of contracts and routes (Laycan period, vessel's hull type, age, routes, fixture deadweight utilization ratio)
	Tanker Freight rates	Laycan period, vessel's hull type, age, routes, fixture deadweight utilization ratio		
Cocconcelli (2017)	Laycan period	Freight rates for iron ore, volatility, berth length, depth, number of available berths, number of loaders, total hour productivity	Microeconomic	Distance, cargo size, volatility, laycan period
	Dry bulk	Size of the		

	freight rates	vessel, laycan period, age, distance, cargo size, volatility, iron ore price		

According to the table, the main determinants of freight rates, from the macroeconomic perspective seem to be the shipbuilding sector, the demand for trade and the prices of the commodities, while from the microeconomic perspective are the vessels characteristics, the features of contracts (agreed laycan period) and the distance between the port of origin and the port of destination.

2.7 Conclusion Theory

In this Chapter we developed the theoretical overview for the commodity of coal in India and the impact of the Indian demand on freight rates. Coal is an essential factor for electricity generation and steel production, the demand of which especially in India is steadily increasing, due to the upward trend in Indian population. However, the concerns about the negative externalities of the use of coal are continuously rising globally and plenty of countries have initiated strategies, in order to restrict the use of coal and increase the use of renewables.

The future of coal in India is not yet clear. In our point of view, there are three possible scenarios for the demand of coal in India. The first one is the domestic production to be increased and the Indian coal imports remain stable or at most slightly decrease, as the demand for coal would be covered from the increased domestic production. The second scenario regards the further increase in Indian coal imports, based on the projections for the raised future demand for steel production and the demand for electricity production. Finally, the third scenario regards the concerns of the negative externalities and assumes that Indian government or International Organizations take measures against coal, by restricting the use of it. This could lead to gradual decrease in Indian demand for coal imports.

Based on the theoretical review, the demand for coal in India is affected by the demand for electricity generation, the steel production, the domestic production, the GDP of India and the spot price of coal and its substitutes. The determinants of the price of coal are the price of other fuels like oil or natural gas, supply and demand, weather conditions and governmental regulations. According to Stopford, the determinants of freight rates are based on the determinants of supply and demand for sea transportation and we also added the determinants of freight rates from the microeconomic perspective, like the vessels' average age and size, the distance between the port of origin and port of destination and the laycan period.

In our research, we will combine both macro and microeconomic determinants, including as many microeconomic determinants of freight rates as possible, in order to investigate which determinants has higher significance. The reason about this, is that none of the previous researches have combined both macro and microeconomic determinants.

Thus, in the next chapters, using the multiple regression, we will practically investigate the effects of the Indian demand for coal on freight rates based on the aforementioned in theoretical review, mainly taking into consideration the determinants of freight rates. More specifically, we will construct three equations with the price of coal, Indian demand for coal imports, freight rates and their determinants, as stated in the theoretical overview. After this, we will use the three aforementioned scenarios and the three equations, in order to predict the future freight rates in 2023.

Our estimation about the result of our model, is that these three variables are strongly correlated with each other and more specifically that Indian demand for coal imports depends on price of coal and the freight rates are formed based on the price of coal and the demand for coal trade. We also think that especially the demand for coal imports in India is strong enough to affect the freight rates. This will be our null hypothesis. Therefore, the alternative hypothesis is that the Indian demand for coal imports do not affect the freight rates.

3. Methodology

In this chapter we present our methodology, which is essential to reach a result. Basically, in order to investigate the impact of Indian demand for coal on freight rates we use the correlations and multiple regression method with linking residuals. Thus, in fact, in this chapter we will interpret the way our model works in a theoretical level. Finally, we present our data collection and its sources. We remind that our null hypothesis is that the Indian demand for coal imports affects the freight rates, whereas the alternative hypothesis is that it does not affect the freight rates. If the null hypothesis is accepted, we proceed to the estimation of the freight rates in 2023, using the three scenarios built in Chapter 2.

3.1 Correlation analysis – Pearson correlation & p-values

Correlation is a bivariate analysis, which calculates the degree of association between to variables and the direction, either positive or negative (Statistics Solutions, n.d.). The coefficient of correlation is equal with the covariance divided by the variables' standard deviations (Equation 3.1) (Keller, 2018).

$$r = \frac{s_{xy}}{s_x s_y} \qquad (3.1)$$

The lower limit of this coefficient is -1, whereas the upper limit is equal to +1. In terms of the strength of the relationship between the two variables, values close to either +1 or -1, indicate strong relationship between the two variables, while values close to 0, indicate weak relationship between them. Regarding the direction of the relationship, it is positive when the sign is +, and negative when the sign is -. Table 6 indicates the guidelines for the interpretation of the coefficient r.

Table 6: Guidelines of interpretation of coefficient r (Source: J.D. Evans Straightforward Statistics for the Behavioral Sciences, 1996)

Strength of association	Positive	Negative
No relationship	0	0
Negligible	0.01 to 0.19	-0.01 to -0.19
Weak	0.2 to 0.39	-0.2 to -0.39
Moderate	0.4 to 0.59	-0.4 to -0.59
Strong	0.6 to 0.79	-0.6 to -0.79
Very strong	0.8 or higher	-0.8 or higher

The most widely used methods for the calculation of the correlation coefficient are the Pearson correlation, the Kendal rank correlation, the Spearman correlation, the Point-Biserial correlation and the Kendall's Tau. We will focus on the Pearson correlation, as we will use this method to calculate the correlations coefficients.

One typical research question that the Pearson correlation covers is for instance if there is a significant relationship between variable A and variable B. The formula (Equation 3.2) which calculates the Pearson correlation is the following:

$$\rho_{X,Y} = \frac{\sum(X_i - \bar{X})(Y_i - \bar{Y})}{\sqrt{\sum(X_i - \bar{X})^2 \sum(Y_i - \bar{Y})^2}} \qquad (3.2)$$

Actually, the Pearson correlation does not take into account if the variables are either dependent of independent. For example, if we want to examine if the performance in basketball is correlated with the height of the player, the outcome is that both the performance is determined by the height but also the height is determined by the performance in basketball, which in fact is not realistic. In other words, Pearson correlation is not able to point out the causation in the relationship between the variables. For this reason, the next stage for our research, is the multiple regression, where the dependent and independent variables are distinguished. Another characteristic of the Pearson correlation coefficient (r) is that it does not indicate the slope of the line of best fit, but the degree of variation between the data points and the line of best fit (Statistics Laerd, n.d.).

Besides that, we will find the p-values of each relationship between the variables, in order to check the significance of the relationships. In Table 7 we indicate the description of the p-values and the sign that we will use for each value, based on significance, in Chapter 4.

Table 7: Description of p-values (Source: Gerard Keller, Statistics for management and economics, 2018, pp. 701)

p-values	Relationship	Evidence	Sign
0-0.01	Highly significant	Overwhelming	***
0.01-0.05	Significant	Strong	**
0.05-0.1	Not significant	Weak	*
0.1-1	Not significant	None	No sign

Thus, we use this tool, as a first stage, in order to investigate the relationships between the variables, which will be used in the multiple regressions. In this stage, we will use Minitab and the results will be presented in Chapter 4.

3.2 Multiple regression with linking residuals

The second stage of our process is to conduct multiple regression. In general, multiple regression is a statistical tool that makes the researcher able to investigate how multiple independent variables are related to a dependent variable (Higgins, 2005). The following formula (Equation 3.3) indicates the multiple regression equation.

$$Y_i = \beta_0 + \beta_1 x_{1i} + \beta_2 x_{2i} + \ldots + \beta_p x_{pi} + \varepsilon \qquad (3.3)$$

Where:

Y_i is the dependent variable

β_0 is the constant term

β_1 to β_p are the coefficients of each independent variable

x_{1i} to x_{pi} are the values of the independent variables (i represents the observation row number)

ε is the error (residual)

In our case, we will conduct multiple regression with linking residuals. In fact, we use a simultaneous equation model with three equations, namely the demand for coal imports in India, the price of coal and the freight rates and their determinants. By this method, we regress the endogenous regressors on the exogenous regressors (Heij et.al., 2004). This means that we take into consideration the residuals from the first equation in the second one and both of them in the third one. Moreover, we select this method, because the method with two equations is a single equation method, which ignores the possible contemporaneous covariances between the errors, which means that this method is not asymptotically efficient (Heij et.al., 2004). On the other hand, the method with three equations, takes into consideration the covariances between the errors and thus it is asymptotically efficient.

Consequently, we will create three equations with three dependent variables. These will be the price of coal (Y_1) (Equation 3.4), the Indian demand for coal imports (Y_2) (Equation 3.5) and the freight rates (Y_3) (Equation 3.6). The independent variables of each equation will be selected, based on the theory that we developed in Chapter 2.

$$Y_1 = \alpha_0 + \alpha_1 GCT + \alpha_2 GCP + \alpha_3 PO + \alpha_4 PNG + \alpha_5 ATI + \varepsilon \qquad (3.4)$$

Where:

Y_1: Price of coal in US dollars per ton

GCT: Global coal trade in million metric tons

GCP: Global coal production in million metric tons

PO: Price of oil in US dollars per ton

PNG: Price of natural gas in US dollars per ton

ATI: Average temperature of India in Celsius

$$Y_2 = \beta_0 + \beta_1 IEG + \beta_2 ISP + \beta_3 DCP + \beta_4 IGDP + \beta_5 Y_1 + \beta_6 ResidY_1 + \varepsilon \qquad (3.5)$$

Where:

Y_2: Indian coal imports in million metric tons

IEG: Indian electricity generation in billion units

ISP: Indian steel production in million metric tons

DCP: Domestic coal production (India) in million metric tons

IGDP: Indian gross domestic product in million US dollars

Y_1: Price of coal in US dollars per ton

$$Y_3 = \gamma_0 + \gamma_1 PWF + \gamma_2 PFG + \gamma_3 DP + \gamma_4 POR + \gamma_5 PDL + \gamma_6 IGDP + \gamma_7 AAP + \gamma_8 Y_1 + \gamma_9 Y_2 + \gamma_{10} ResidY_1 + \gamma_{11} ResidY_2 + \varepsilon \qquad (3.6)$$

Where:

Y_3: Freight rates in US dollars per ton

PWF: Panamax world fleet in million DWT

PFG: Panamax fleet growth

DP: Deliveries of Panamax vessels in million DWT

POR: Panamax orderbook as percentage of fleet

PDL: Panamax demolition and losses in million DWT

IGDP: Indian gross domestic product in million US dollars

AAP: Average age of Panamax vessels

Y_1: Price of coal in US dollars per ton

Y_2: Indian coal imports in million metric tons

Using Minitab, we are able to calculate the coefficients of each independent variable. What is remarkable here, is that we use the residual from the Equation 3.4 in Equation 3.5, in order to link them and include the direct and indirect effects of the price of coal on the demand for coal imports in India. Similarly, in Equation 3.6, we use both the residuals of Equation 3.4 and Equation 3.5 for the same reason.

Until this stage, we have conducted correlation analysis for our variables and we have the full form of our equations for the multiple regression analysis. The next step is to evaluate the validity of our model. The dominant tools to examine the validity of our regressions are the coefficient of determination (R^2) (Equation 3.7) and the F-test.

$$R^2 = \frac{s_{xy}^2}{s_x^2 s_y^2} = 1 - \frac{SSE}{\sum(y_i - \bar{y})^2} = \frac{\sum(y_i - \bar{y})^2 - SSE}{\sum(y_i - \bar{y})^2} = \frac{Explained\ variation}{Variation\ in\ y} \qquad (3.7)$$

The coefficient of determination is in fact how well the amount of variation of the dependent variable is explained by the variation of the independent variables (Keller, 2018). The model fits better the data, when the value of R^2 is higher, therefore our goal is each of the three equations to have high R^2 close to 1, if possible.

Regarding the F-test, we first need to calculate the F-statistic (Equation 3.8). If its p-value is lower than 0.05, if the confidence interval is set to 95%, there is great evidence, that the model is valid (Keller, 2018).

$$F = \frac{MSR}{MSE} = \frac{\sum(y_i - \bar{y})^2 - SSE/k}{SSE/(n-k-1)} \qquad (3.8)$$

All things considered, in order to increase the validity of our model, each of the three equations need to have the highest possible R^2 and F-statistic with the lowest possible p-value (Table 8).

Table 8: Relationship between R2 and F-statistic for the assessment of model (Source: Gerard Keller, Statistics for management and economics, 2018, pp. 701)

R^2	F	Assessment of model
1	∞	Perfect
Close to 1	Large	Good
Close to 0	Small	Poor
0	0	Invalid

3.3 Sensitivity analysis and estimation of the future freight rates

After conducting the multiple regression analysis, we are one step closer to the final outcome. One crucial step before this, is to analyze the p-values of the coefficients of the independent variables especially in the third equation. By this, we will be able to investigate initially if the Indian demand for coal imports is strong enough to affect the freight rates, by checking the p-value of the coefficient. If the p-value is lower than 0.05, we are able to put in force our three scenarios for the future demand for coal imports in India and conduct the sensitivity analysis for the freight rates for the year 2023. Simultaneously, we will take into consideration all the other independent variables and we will estimate the future freight rates. More specifically, we will begin with the first equation and we will estimate the price of coal, depending on the projections of its determinants, then we will make the estimation of the Indian demand for coal imports based on the scenarios and we will use the two aforementioned variables in combination with the variables of the shipbuilding industry, to estimate the future freight rates.

It is remarkable to mention that we have two ways to follow for the estimation of the dependent variables. The first is to take into consideration only the significant variables in the estimation of the future freight rates, of which the p-value of the variable’s coefficient would be lower than 0.05, in case we set a 95% confidence level. The second is to include all of the independent variables of each equation, regardless of their significance. We select the second way, because if we eliminate the insignificant variables from our three equations, we actually put zero to their coefficients, even if the value of the coefficient is different (Heinze & Dunkler, 2016). This means that the estimation is not valid, as the coefficients of the significant variables have to be changed, if the insignificant variables are not included in our model. We have tested both methods, using our current data, and indeed the estimations were more accurate including both significant and insignificant variables in our equations. Therefore, in a predictive model, we include the variables that offer the best predictions and in our case we use all of the independent variables for the estimation of the dependent variables.

3.4 Data collection

To build our model and carry out multiple regression, using Minitab, we first need to collect time series data for each variable used in our three equations. We use monthly data between July 2009 and May 2019. Our intension was to use data from January 2005 to May 2019, in order to have larger sample and increase the validity of the model, though for some variables we did not have access to data prior to 2009. Therefore, as the length of the time series must be the same for every variable, we are using the monthly data for the past ten years.

Regarding the first equation, we collected data for the price of coal (Y_1) from Clarksons Shipping Intelligence Network (SIN). This particular data, concerns the spot price of thermal coal in Australia, expressed in US dollars per ton. Concerning the global coal trade (GCT), we collected the annual data from statista.com. In order to convert the annual data to monthly data, we divided each year's output into twelve equal parts for each month. We gathered the global coal production (GCP), measured in million metric tons, between 2009 and 2016 from the U.S. Energy Information Administration (EIA) and between 2016 and 2019 from bp.com. As the data was annual, again we divided into twelve equal parts. Moreover, the price of oil (PO) was collected from Clarksons SIN, expressed in US dollars per barrel. In this case, we converted the price to US dollars per ton, by dividing each observation by 0.1333 (Source: cmegroup.com). The spot price of natural gas (PNG) was gathered from Clarksons SIN, regarding the natural gas spot price in Henry Hub in the United States, expressed in US dollars per one million British Thermal Unit (mbtu). In this case, we converted the mbtus to tons by dividing each observation with 0.08333 (Source: translatorscafe.com). Last but not least, we gathered the average temperature of India by month, from Open Government Data Platform India, expressed in Celsius.

For the second equation, we gathered the data for the Indian coal imports (Y_2) from the UN Comtrade database, measured in million metric tons. From 2011 to 2019, the data is by month, whereas as between 2009 and 2010 the data is annual, we divide into twelve equal parts to calculate the monthly output. The same applies for the rest of the variables in this particular equation, except for the Indian steel production. Regarding the Indian electricity generation (IEG), we gathered data from the Indian Ministry of Power website, expressed in billion units. Furthermore, we collected data for the Indian steel production (ISP), expressed in million metric tons, from Clarksons SIN. Concerning the domestic coal production in India (DCP), we gather data from the provisional coal statistics reports published by the Indian Ministry of Coal, expressed in million metric tons. Finally, the Indian GDP (IGDP) was retrieved from World Bank's database, expressed in million US dollars.

Concerning the third equation, for the freight rates (Y_3) we used the data for a Panamax bulk carrier 70,000 DWT from Richards Bay (South Africa) to Mundra (India), from Clarksons (SIN), expressed in US dollars per ton. We think that this size of bulk carrier and route represents best our freight rate variable, as Panamax vessels are usually used for coal transportation to India. This is the reason for using data for Panamax bulk carriers in the rest of the variables in this particular equation. For the rest variables, Panamax world fleet in million DWT (PWF), Panamax fleet growth (PFG), Deliveries of Panamax bulk carriers in million DWT (DP), Panamax bulk carriers orderbook as percentage of fleet (POR), Panamax demolition and losses in million DWT (PDL) and Average age of Panamax bulk carriers (AAP), Clarksons (SIN) database was used.

In fact, we analyze our data in Chapter 4, conducting the correlation and the regression analysis.

3.5 Conclusion

In this chapter, we presented our methodology regarding the way that we will test the framework. As we had already determined the dependent and independent variables and built the scenarios, in this particular chapter we analyzed our data collection and our sources. We also examined the correlation analysis and the multiple regression in theoretical level, in order to apply them to our model. In order to reach the results for our main research question, we need to conduct a sensitivity analysis of the freight rates, according to the scenarios and we are able to make an estimation about the future freight rates.

In Figure 10, we graphically represent the general concept of our research, step by step in order to reach our result.

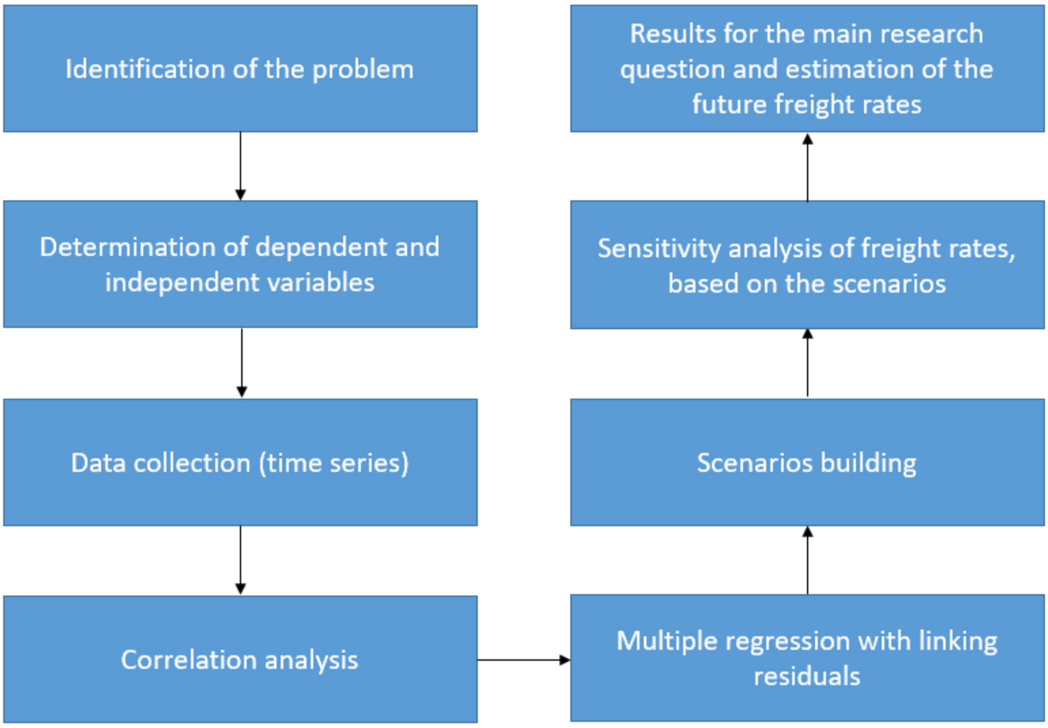

Figure 10: General concept of our research (Source: Own construction)

The results of each step are presented analytically in the next chapter (Chapter 4).

4. Empirical results and analysis

In this chapter we present and analyze the results of the correlation and multiple regression analysis. We also conduct the sensitivity analysis, based on the three scenarios and we estimate the future freight rates.

4.1 Correlation analysis results

In this section we will present and analyze the results of the correlation analysis. In Table 9, we begin with the results from the equation of the price of coal.

Table 9: Correlation between the determinants of price of coal (Source: Own calculations using Minitab)

	Y_1	GCT	GCP	PO	PNG	ATI
Y_1	1					
GCT	-0.16	1				
GCP	0.02	0.4	1			
PO	0.5	-0.14	0.66	1		
PNG	0.29	-0.32	0.09	0.47	1	
ATI	-0.11	0.09	-0.12	-0.09	-0.2	1

We notice that there are not very strong correlations between our variables. The only strong correlation that we can spot is between the price of oil and the global coal production, which are positively correlated. This can be explained by the fact that when the price of oil raises the global coal production also raises, as the coal is substitute of oil for the electricity generation. Thus, as the price of oil raises the consumers and mainly the electricity generators prefer to use coal, and this leads the coal production to be increased.

In Table 10, we present the correlation between the determinants of Indian coal imports.

Table 10: Correlations between the determinants of Indian coal imports (Source: Own calculations using Minitab)

	Y_2	IEG	ISP	DCP	IGDP	Y_1
Y_2	1					
IEG	0.88	1				
ISP	0.85	0.98	1			
DCP	0.81	0.95	0.93	1		
IGDP	0.79	0.96	0.96	0.95	1	
Y_1	-0.39	-0.23	-0.13	-0.1	-0.001	1

At first glance, we can spot various very strong and strong correlations between the variables used in our model’s second equation. The strongest correlation is between the Indian steel production and the Indian electricity generation, which are positively correlated. This means that if the Indian steel production increases, the Indian electricity generation also increases. In both cases, coal is a crucial determinant for steel production and electricity generation. Thus this can be explained by the fact that as during the last ten years the coal imports in India and the domestic production have an upward trend, it affects both of the variables and this is the reason for this increase in both variables, which leads to this very strong positive correlation.

We also notice that the electricity generation in India is very strongly and positively correlated with the Indian demand for coal imports. This makes sense, due to the fact that the more electricity generated the more coal is required and as the Indian domestic production is not enough to cover the demand for electricity generation, the demand for coal imports is raising. For the same reason the Indian steel production is very strongly and positively correlated with Indian demand for coal imports.

The Indian domestic coal production is very strongly and positively correlated with the demand for coal imports and the electricity generation and steel production in India. As we previously mentioned, the domestic production is not enough to cover the coal demand in India and thus the demand for coal imports increases. Regarding the other two correlations, as the domestic coal production increases, more coal from this production is used for the electricity generation and steel production.

Regarding the Indian GDP, it is positively and strongly correlated with the demand for coal imports in India. This can be explained by the fact that as the economy gets stronger, the demand for coal, which is used for the power generation and the steel production, raises. This also explain the very strong and positive correlations between Indian GDP and Indian electricity generation, Indian steel production and Indian domestic production of coal.

Finally, the price of coal is either weakly or very weakly and negatively correlated with the rest of the variables. This means, that coal is vital for India, and its price do not affect significantly the production of coal or the Indian demand for coal imports.

Table 11, illustrates the correlations between the determinants of freight rates.

Table 11: Correlations between the determinants of freight rates (Source: Own calculations using Minitab)

	Y_3	PWF	PFG	DP	POR	PDL	IGDP	AAP	Y_1	Y_2
Y_3	1									
PWF	-0.75	1								
PFG	0.69	-0.62	1							
DP	0.52	-0.48	0.91	1						
POR	0.74	-0.97	0.68	0.52	1					
PDL	-0.31	0.1	0.18	0.37	-0.08	1				
IGDP	-0.58	0.85	-0.65	-0.6	-0.79	-0.14	1			
AAP	0.72	-0.91	0.46	0.26	0.93	-0.28	-0.58	1		
Y_1	0.59	-0.36	0.46	0.34	0.47	-0.28	-0.001	0.54	1	
Y_2	-0.67	0.92	-0.6	-0.5	-0.88	0.07	0.79	-0.81	-0.39	1

To begin with, Panamax world fleet strongly and negatively correlated with the freight rates. This makes sense, as the overcapacity leads to lower freight rates, as the supply exceeds the demand.

The deliveries of Panamax vessels are very strongly and positively correlated with the Panamax fleet growth, which makes sense due to the fact that the increased deliveries, also increase the growth of the vessels.

What is remarkable for the Panamax orderbook as a percentage of the global fleet is that it is very strongly and negatively correlated with the Panamax world fleet.

Moreover, the Indian GDP is strongly and positively correlated with Panamax world fleet. In this case there is not significant explanation for this relationship and we assume that it happened as in the examined period both variables had an upward trend.

The average age of the Panamax vessels is very strongly and negatively correlated with Panamax world fleet. This occurs, because when the ships are getting older, over than 25-30 years old, are scrapped, which can cause a decrease in Panamax world fleet. Furthermore, the average age of Panamax bulk carriers, is very strongly and positively correlated with the Panamax ordebook as a percentage of world fleet. This is caused by the fact that as the Panamax vessels are getting older, the ship owners replace them with new ones and as a result, the Panamax ordebooks have an upward trend.

The price of coal is not strongly correlated with any of the variables of our model's third equation. On the other hand, the Indian demand for coal imports, are strongly and positively correlated with the Panamax world fleet. This means that as the Indian demand for coal imports create an increased demand for sea transportation, this in turn, creates a raised demand for available vessels, which in our case are the Panamax bulk carriers. Another remarkable correlation, is the very strong and positive correlation between the Indian demand for coal imports and the average age of the Panamax bulk carriers. This is explained by the fact that as the Indian demand for coal imports is steadily increasing, the ship owners use even their older vessels from their fleet, even if they have lower efficiency, especially in cases when the demand for sea transportation is higher than the supply of the vessels.

4.2 Multiple regression results

In this section, we present our multiple regression results, creating three tables, one for each equation, indicating the values of the coefficients and their significance, expressed in stars, based on their p-values in parenthesis.

Regarding the first equation, where the price of coal is the dependent variable we have the following results (Table 12).

Table 12: Multiple regression results for our model's first equation (Source: Own calculations using Minitab)

α_0	363.3***(0.000)
α_1	0.684***(0.000)
α_2	-0.5981***(0.000)

α_3	0.125***(0.000)
α_4	-0.203 (0.233)
α_5	-0.825**(0.024)
Residual	25,685.7
R^2	49.88%
F-value/p-value	22.49/0

Thus, the final equation for the price of coal is the following (Equation 4.1).

$$Y_1 = 363.3 + 0.684GCT - 0.5981GCP + 0.125PO - 0.203PNG - 0.825ATI \quad (4.1)$$

We notice that there is a positive relationship between the price of coal and the global coal trade volumes, which means that an increase in the global coal trade volumes, raises the price of coal. The p-value indicates that the relationship is highly significant. According to law of supply and demand, if the supply increases, in our case the global coal trade volumes, and the demand remains stable, the price of the product, the coal in our case, drops. In this case, it seems that the demand for coal is even higher than the supply, which causes an increase in price of coal, even if the supply increases.

On the other hand, there is a negative relationship between the price of coal and the global coal production, indicating that an increase in global coal production, causes a drop in coal's price. The relationship is highly significant, due to the fact that the p-value is almost zero. This result, can be explained by the fact that as the supply increases, the coal production in our case, the price of coal drops. In this case, the demand is not able to exceed the supply and thus the price of coal decreases.

The price of oil moves to the same direction with the price of coal. The p-value indicates that the relationship is highly significant. Actually, we indicated this relationship in the second chapter in the theoretical review in Figures 6 and 7 and by this result we confirm the theory. In the same chapter, we also mentioned the price of natural gas seems to be more independent, compared to the price of coal, as it followed a different pattern (Figure 8). According to our results, the theory is again confirmed, as the p-value indicates that there is no relationship between these two variables.

The average temperature of India has a negative coefficient, which means that an increase in the average temperature of India, causes a drop to the price of coal. The relationship between these two variables is significant, based on the p-value, which is equal to 0.024. In this case, we reject what we have stated in the theoretical review, as our initial hypothesis was that as the average temperature increase, the price of coal increases too.

This equation, as part of our model is not that good, as the R^2 and the F-value should have higher values, yet our intension is to quantify as more variables stated on the theory as possible, in order to either accept or reject the hypotheses in the theory. This is the reason for not using other variables, in order to increase both the R^2 value and the F-value.

In Table 13, we present the results of the second equation, where the Indian demand for coal imports is the dependent variable

Table 13: Multiple regression results for our model's second equation (Source: Own calculations using Minitab)

β_0	-13.24***(0.000)
β_1	0.293**(0.013)
β_2	1.665**(0.047)
β_3	0.101 (0.324)
β_4	-0.0706**(0.041)
β_5	-0.0361**(0.027)
β_6	-0.000001**(0.027)
Residual	511.57
R^2	82.66%
F-value/p-value	107.7/0.000

Thus, the final equation of the Indian demand for coal imports is the following (Equation 4.2).

$$Y_2 = -13.24 + 0.293IEG + 1.665ISP + 0.101DCP - 0.0706IGDP - 0.0361Y_1 - 0.000001ResidY_1 \quad (4.2)$$

The Indian electricity generation has a positive coefficient, which implies that an increase in the Indian electricity generation, causes an increase in the Indian demand for coal imports. The relationship between these two variables is significant, based on the p-value which is equal to 0.013. As we have already mentioned, the electricity generation depends highly on coal, and as a result the more electricity generated, the more volumes of coal are required. Exactly the same applies to the Indian steel production, which has a positive coefficient the relationship with the Indian demand for coal imports is significant. For the aforementioned reason, as the Indian steel production, increases, the Indian demand for coal imports increases too.

On the other hand, we observe that the Indian domestic coal production is not able to affect the Indian demand for coal imports. We have already pointed out in the theoretical review that the domestic coal production in India, is not able to cover the demand for coal and thus every year more and more volumes of coal are required to be imported. This is confirmed by the fact that there is no relationship between these two variables.

The Indian GDP's coefficient is negative, which means that an increase in India's GDP causes a decrease in Indian demand for coal imports. The relationship between the variables is significant, according to the p-value. Our expectation was the opposite to this result, as we estimated that an increase in GDP indicates economic development, which increases the demand for electricity and steel production, and thus for coal. On the other hand, this result can be explained by the fact that as the domestic coal production increases, the Indian GDP also increases and thus the production is high enough to reduce the imports of coal.

Moreover, the price of coal has both direct and indirect (Resid*Y_1) negative impact on the Indian demand for coal imports. The relationships are both significant, as the p-value is equal to 0.027. Even if coal is important for both power generation and steel production, which are important for India, if the price of coal is significantly high, less quantities of coal are imported, which means that the substitutes of coal are preferred.

In this equation, we notice that the R^2 value and the F-value are high enough to indicate a good model, with increased validity.

Last but not least, the results of the third equation, with freight rates as dependent variable, are available on Table 14.

Table 14: Multiple regression results for our model's third equation (Source: Own calculations using Minitab)

γ_0	22*(0.08)
γ_1	-0.1039**(0.043)
γ_2	46.6***(0.000)
γ_3	0.069 (0.942)
γ_4	-25.2***(0.000)
γ_5	-3.054***(0.000)
γ_6	-0.0445*(0.061)
γ_7	1.549*(0.092)
γ_8	0.0628***(0.000)
γ_9	0.1942**(0.036)
γ_{10}	0.000002***(0.000)
γ_{11}	0.000178**(0.036)
Residual	343.43
R^2	82.85%
F-value/p-value	58.49/0.000

According to the table, the final equation of the freight rates is the following (Equation 4.3).

$$Y_3 = 22 - 0.1039PWF + 46.6PFG + 0.069DP - 25.2POR - 3.054PDL - 0.0445IGDP + 1.549AAP + 0.0628Y_1 + 0.1942Y_2 + 0.000002ResidY_1 + 0.00038ResidY_2 \quad (4.3)$$

First of all, the coefficient of the Panamax bulk carrier's world fleet is negative, which indicates that an increase in Panamax fleet decreases the freight rates. The relationship between these two variables is significant. The result confirms the theory that the overcapacity leads to lower freight rates.

The Panamax fleet growth moves to the same with the freight rates as the coefficient is positive. The relationship between the variables is highly significant, as the p-value is almost zero. This was an unexpected result, as the fleet growth indicates additional tonnage in the market, and especially if the growth is high the theory states that the freight rates have downward trend.

The deliveries of Panamax bulk carriers do not affect the freight rates, as the p-value of the coefficient is very high, close to 1.

The Panamax orderbook as percentage of global fleet has a negative coefficient, which means that when this particular variable increases, the freight rates drop. The relationship between these two variables is highly significant. An increase in the tonnage of Panamax vessels makes sense to cause a decrease in freight rates, as the supply of vessels grows.

Furthermore, there is a negative relationship between the Panamax demolition and losses and the freight rates, which is highly significant, as the p-value is almost zero. This was also an unexpected result, as with the demolition and losses the tonnage decreases, which means that the supply decreases and the freight rates increase. However, it seems that the demolition and losses every year are not enough to exceed the new buildings, thus this could the reason for this result.

The Indian GDP has also a negative coefficient, which indicates that an increase in Indian GDP causes a decrease in freight rates. However, this relationship is not significant and thus it is not valid to take into consideration this hypothesis. Another variable with low significance is the average age of the Panamax vessels. In this case the coefficient is positive, which means that increased average age of Panamax vessels also increases the freight rates. From theory, this hypothesis does not make sense, and it is confirmed by the low p-value.

The price of coal has both direct and indirect (Resid*Y_1) positive impact on freight rates. The relationships between these variables are highly significant, as the p-values are almost zero. The positive relationships, indicate that an increase in price of coal, causes an increase in freight rates. This can be explained by the fact that when the market booms, the price of coal increases and so do the freight rates.

Finally, Indian demand for coal imports has both direct and indirect (Resid*Y_2) positive impact on freight rates. The p-values of these relationships are equal to 0.036, which indicates a significant relationship between the variables. When the Indian demand for coal imports increases, the freight rates also raise. This can be explained by the fact that the supply is not enough to cover the demand for coal imports and thus using the law of supply and demand, the freight rates increase.

The R^2 (82.85%) and the F-value (58.49) indicate that our model is good enough, in order to be considered as valid.

To sum up, we conclude that the Indian demand for coal imports has significant effect on freight rates, in a positive way. Thus, we accept the null hypothesis, which means that we are able to proceed with our estimation of freight rates in 2023, based on the three scenarios we constructed in Chapter 2.

4.3 Estimation of the dependent variables in 2023 based on the scenarios

In this section, we estimate the price of coal, the Indian demand for coal imports and the freight rates for the year 2023. We will divide the section into three sub-sections, as each dependent variable will have three different results based on the three scenarios that we constructed in Chapter 2. We remind that we take into consideration all the independent variables of our three equations.

4.3.1 First scenario's estimations

Having calculated each of the variable's coefficient, we use these three equations, in order to predict the future freight rates. We will predict the freight rates for the year 2023, based on projections for the independent variables. We remind that the first scenario regards the increase in domestic production. Theoretically, we could say that this would slightly decrease the imported volumes of coal in India, yet we need to investigate it practically.

The first step is to estimate the price of coal. In Table 15, we indicate our projections for each independent variable in 2023 and the sources we used.

Table 15: First scenario's estimations for the independent variables of the coal price and estimation of coal price in 2023 (Source: Own construction)

Variables	Estimation	Source
GCT	110 MT/month	International Energy Agency
GCP	675 MT/month	Global Data, Mining Intelligence Center
PO	612.975 $/ton	U.S. Energy Information Administration
PNG	36 $/ton	World Bank
ATI	26.5 Celsius	Own estimation
Coal price	**82.27 $/ton**	**Own estimation**

Based on International Energy Agency's projections, the global coal trade will remain stable until 2023. As in our data is indicated that the monthly global trade is 105.945 MT, we assume a very slight increase and thus we set it equal to 110 MT per month.

Regarding the global coal production, the combination of Global Data and Mining Intelligence Center data, led us to predict the rough volume of coal production in 2023. After the significant decrease of coal production until 2016, there is an upward trend, which is projected to reach to 675 MT per month in 2023. This volume roughly reaches the levels of 2014 and it might increase further until 2030. This significant increase is driven mainly by India, with annual growth rate of 10.9%, Indonesia, with annual growth rate of 3.9% and Australia, with annual growth rate of 2.3%, from 2018 to 2023. Apparently, this is also driven by the numerous potential coal projects, over than 300, which will be launched through this period.

Undoubtedly, the estimation of the future oil price is completely difficult, due to the fact that it depends on various factors and especially some unexpected events can either soar up the price of oil, or cause dramatic drop. Therefore, the risk is raised for our estimation, in case of unreliable projections. However, as we have to set a price, we use the projections of the U.S. Energy Information Administration, according to which, the price of oil will be equal to 612.975 U.S. dollars per ton. This price is higher than today's price, yet it does not reach the high levels of the period 2011-2014.

The same applies for the price of natural gas, as it traditionally fluctuates pretty much, yet the amplitude is not that high. In this case, we use the projections of World Bank, according to which the price of natural gas in Henry Hub, USA, will be equal to 36 U.S. dollars per ton. This price is within the levels of the last 4 years, based on our data.

Last but not least, we estimated ourselves the average temperature of India for the year 2023. The year 2016 was the hottest one in India, reaching 26.45 Celsius on average of the whole year. Normally the annual average temperature of India is around 24 Celsius, however in the last decade it has raised to at least 25 Celsius. This is driven by the greenhouse gases, which leads to global warming and taking into consideration this, we estimate that the average temperature in India for the year 2023 will be equal to 26.5 Celsius.

All things considered, we estimate that the price of coal will be equal to 82.27 U.S. dollars per ton in 2023. This means that the price will fall, compared to 2018 levels. World Bank, estimates that the price of coal will be equal to 83 U.S. dollars per ton in 2022 and 79.7 U.S. dollars per ton in 2023, which make our estimations very similar. However, in the next equations, we will use our exact estimation for the price of coal and not the World Bank's.

The second step of our process for estimating the future freight rates, is to estimate the Indian demand for coal imports in 2023. In Table 16, we present our projections for each independent variable of the second equation and the sources we used.

Table 16: First scenario's estimations for the independent variables of the Indian demand for coal imports and estimation of Indian demand for coal imports in 2023 (Source: Own construction)

Variables	Estimation	Source
IEG	150.788 BU/month	Institute for Energy Economics & Financial Analysis India
ISP	11.09 MT/month	Own estimation
DCP	98.725 MT/month	Global Data, Mining Intelligence Center
IGDP	313.4 Million dollars/month	Statista
Price of coal	82.27 $/ton	Own estimation
Indian demand for coal imports	**32.17 MT/month**	**Own estimation**

The Indian energy generation is projected to reach to 150.788 BU per month according to the Institute for Energy Economics & Financial Analysis in India. Throughout the whole of the examined period, it is obvious that the power generation has an upward trend, due to the increased population and standards.

Regarding the Indian steel production, we could not find any estimation for 2023. Thus, we took the average annual growth of our data, which was almost 5%. As a result, we estimate that the Indian steel production will be equal to 11.09 MT per month.

Moreover, the domestic coal production is projected to reach to 98.725 MT per month according to Global Data and Mining Intelligence Center. The annual growth of Indian coal production is expected to be 10.9% between 2018 and 2023. In that case, we calculated the average Indian coal production in 2018 and we added the 10.9% annual increase.

Based on Statista estimations, the Indian GDP is expected to reach to 314.3 million U.S. dollars per month. The annual growth rate of the Indian GDP is over than 7% each year, which indicates the potential of Indian economy.

Taking into consideration the aforementioned and our estimated price of coal and its residual from the first equation, we estimate that the Indian demand for coal imports will be equal to 32.17 MT/month in 2023. This volume is pretty much higher than the today's levels, due to the simultaneous upward trend in all of the independent variables. Our estimation is very close to the International Energy Agency's estimation, as it projects an annual 7.2% increase from 2017 to 2023, which is translated to 32.64 MT/month in 2023. In the next equation, we will again use our estimation.

The last step is to estimate the freight rates for the year 2023. In Table 17, we indicate our estimations for each independent variable of the third equation and the sources we used.

Table 17: First scenario's estimations for the independent variables of freight rates and estimation of freight rates in 2023 (Source: Own construction)

Variables	Estimation	Source
Panamax Worldfleet	224.4 million DWT	Own estimation
Panamax Fleet Growth	2%	Own estimation
Deliveries of Panamax	0.5 million DWT/month	Sea Europe Shipyard's & Maritime Equipment Association
Panamax Orderbook % Fleet	10%	Own estimation
Panamax Demolition & Losses	0.38 million DWT/month	Own estimation
Average Age of Panamax	10.59 years	Own estimation
Coal price	82.27 $/ton	Own estimation
Indian demand for coal imports	32.17 MT/month	Own estimation
Freight rates	**20.32 $/ton**	**Own estimation**

In this case, due to the fact that we did not have access to long term data of the ship building industry, we did almost all of the estimations on ourselves, based on the behavior of the ship owners during the last ten years.

The ship building activity during the last ten years is limited, due to the overcapacity. Taking into consideration this fact, the assumed a monthly growth of 2% for the Panamax vessels, which means that the Panamax Worldfleet's tonnage will be equal to 224.4 million DWT in 2023. Thus, in this case we preferred to use the scenario that the ship owners remain cautious in their decisions for adding new tonnage to the shipping market and we assumed that the crisis remains, which means that the ship owners do not order as much as in the boom periods, when the fleet growth exceeds the 20% monthly.

The only access we had for the projections that we are looking for, is for the deliveries of Panamax vessels, using the source of the Sea Europe Shipyard's & Maritime Equipment Association. Based on these projections, the deliveries of

Panamax vessels will reach to half million DWT per month in 2023. The situation will be similar to today's one and little bit increased.

Regarding the Panamax Orderbook as percentage of the existing Panamax fleet, we assume that it will be equal to 10% in 2023. Until the crisis of 2008 and almost 3-4 years after, until the vessels being delivered before the crisis, this indicator was reaching even the 60%, which indicates the high amount of tonnage entered the market during that period. After that, there was a downward trend and we estimate that it will remain in the today's levels, close to 10%. The overcapacity, led to decreased freight rates and apparently lower profits, which in turn led the ship owners to order less Panamax vessels or even none.

Another factor that is difficult to estimate in the long term is the demolitions and losses of Panamax vessels. As the situation in the market is not projected to change rapidly until 2023, we calculated the average of our data from 2009 to 2019, which is equal to 0.38 million DWT per month and we use this outcome for the estimation in 2023.

Similarly, for the average age of Panamax vessels, we calculated the average of our data which is equal to 10.59 years. The average age of Panamax vessels today is almost 9.5 years. As the shipbuilding sector will not be very active, we assume that the average age will increase in the next years. From another point of view, we could also assume the average age to decrease, because of the IMO 2020 regulation, which requires new technologies in order to lower the fuel harmful emissions. However, we think that due to the crisis, most of the ship owners, prefer to install scrubbers in the existing fleet and not invest in new vessels and this is the reason for assuming a slight increase in the average age of Panamax vessels.

Taking into consideration the aforementioned, the price of coal and the Indian demand for coal imports that we estimated and their residuals, we are able to calculate the estimated freight rates for the year 2023. The outcome is equal to 20.32 $/ton. This outcome is similar to the levels of 2010 and 2011 and much higher than the today's levels. This happens because we assumed that the ship building market will remain in low levels and simultaneously the demand for Indian coal imports increases. This is because of the fact that the demand for power generation and steel production steadily increases and the price of coal decreases, which makes it more competitive compared to the alternatives.

4.3.2 Second scenario's estimations

In this section we estimate the values of the dependent variables of our three equations, based on the second scenario. We remind that in the second scenario, we assume that the increased demand for steel production, increases further the imports of coking coal.

Regarding the first equation, the variable that we can increase, is the volume of the global coal trade, because of the further increase in demand for coking coal, which in fact affects the global coal trade.

Table 18: Second scenario's estimations for the independent variables of the coal price and estimation of coal price in 2023 (Source: Own construction)

Variables	Estimation	Source
GCT	115.5 MT/month	Own estimation
GCP	675 MT/month	Own estimation
PO	612.975 $/ton	U.S. Energy Information Administration
PNG	36 $/ton	World Bank
ATI	26.5 Celsius	Own estimation
Coal price	**86.04 $/ton**	**Own estimation**

In Table 18, we increased the global coal trade by 5%, compared to the estimation of the first scenario. In fact, this is a 1% annual further increase, compared to the first scenario, which is not high enough. The reason behind this decision, is that the coking coal is a small proportion of the coal trade, as the thermal coal is the leader and thus it cannot have a dramatic effect on coal trade, even if the demand for cocking coal soars up. Another reason, is that we are referring to India, which is just a part of the global coal trade. Therefore, the global coal trade is estimated to be equal to 115.5 MT per month. This slight increase in this variable, keeping the rest of the independent variables stable, slightly increases the price of coal to 86.04 $/ton.

In Table 19, we increase the Indian steel production again by 5%, compared to the estimation of the first equation. This is because of the fact that we have already increased fairly this particular variable from the first scenario. We keep all the other independent variables stable, as they are not affected by this scenario.

Table 19: Second scenario's estimations for the independent variables of the Indian demand for coal imports and estimation of Indian demand for coal imports in 2023 (Source: Own construction)

Variables	Estimation	Source
IEG	150.788 BU/month	Institute for Energy Economics & Financial Analysis India
ISP	11.65 MT/month	Own estimation
DCP	98.725 MT/month	Own estimation
IGDP	313.4 Million dollars/month	Statista
Price of coal	86.04 $/ton	Own estimation
Indian demand for coal imports	**32.87 MT/month**	**Own estimation**

Based on this scenario, the Indian steel production is equal to 11.65 MT per month. The result is equal to 32.87 MT per month, which is higher than the first scenario's estimation.

In the third equation, we only use the outcomes of the price of coal and Indian demand for coal imports and we keep stable all the other independent variables (Table 20).

Table 20: Second scenario's estimations for the independent variables of freight rates and estimation of freight rates in 2023 (Source: Own construction)

Variables	Estimation	Source
Panamax Worldfleet	224.4 million DWT	Own estimation
Panamax Fleet Growth	2%	Own estimation
Deliveries of Panamax	0.5 million DWT/month	Sea Europe Shipyard's & Maritime Equipment Association
Panamax Orderbook % Fleet	10%	Own estimation
Panamax Demolition & Losses	0.38 million DWT/month	Own estimation
Average Age of Panamax	10.59 years	Own estimation
Coal price	86.04 $/ton	Own estimation
Indian demand for coal imports	32.87 MT/month	Own estimation
Freight rates	**21.02 $/ton**	**Own estimation**

The freight rates are equal to 21.02 U.S. dollars per ton, which is higher than the outcome of the first scenario. This particular outcome makes sense, as we increase the demand for coal trade and particularly the Indian demand for coal, keeping the supply, the tonnage of the vessels, equal to the first scenario, where we assumed mild shipbuilding activity.

4.3.3 Third scenario's estimations

Throughout this section, we estimate the dependent variables' values of our three equations, based on the third scenario, according to which we assume a new regulation, which imposes the restriction of emissions caused by coal in India.

To begin with, in the first equation we decrease the values of the variables of the global coal trade and the global coal production and we keep stable the other independent variables, as they are not affected by this concept (Table 21).

Table 21: Third scenario's estimations for the independent variables of the coal price and estimation of coal price in 2023 (Source: Own construction)

Variables	Estimation	Source
GCT	104.5 MT/month	Own estimation
GCP	658.125 MT/month	Own estimation
PO	612.975 $/ton	U.S. Energy Information Administration
PNG	36 $/ton	World Bank
ATI	26.5 Celsius	Own estimation
Coal price	**88.6 $/ton**	**Own estimation**

Actually, we decreased the global coal trade by 1% annually until 2023, compared to the first scenario's estimation, reaching to 104.5 million tons per month. India is a significant part of the global coal trade, mainly through the imports, yet we decrease this variable's value by only 1% annually, as the trade of coal between the rest of the world countries, is projected to have stable increase. Moreover, we decreased the global coal production by 0.5% annually until 2023, compared to the first scenario. Again in this case, even if India is one of the major producers of coal, it does not have the power of China, which produces almost half of the coal worldwide. As India produces not more than 10% of the coal globally, we believe that this decrease is realistic, as the global coal production is expected to have an upward trend, especially for the major producers, until 2023. As a result, the coal price in this particular scenario reaches 88.6 U.S. dollars per ton, which is the highest price of our scenarios.

Proceeding to the second equation, the Indian energy generation, the Indian steel production and the domestic coal production are the variables that could be affected directly by this scenario (Table 22).

Table 22: Third scenario's estimations for the independent variables of the Indian demand for coal imports and estimation of Indian demand for coal imports in 2023 (Source: Own construction)

Variables	Estimation	Source
IEG	127.536 BU/month	Institute for Energy Economics & Financial Analysis India
ISP	9.98 MT/month	Own estimation
DCP	51.56 MT/month	Own estimation
IGDP	313.4 Million dollars/month	Statista
Price of coal	88.6 $/ton	Own estimation
Indian demand for coal imports	**18.35 MT/month**	**Own estimation**

In this case, we increased the value of the Indian electricity generation by 4.5% annually, from 2018 to 2023. Compared to the first scenario, where the annual increase reached almost 9%, in this case we decrease the annual growth on half, because India is not yet able to cover the decrease in the use of coal with the use of renewables. As we stated in the theory, both coal and renewables need to be combined, in order to cover the demand for power generation and the transition from coal to renewables will be slow. For this reason, we increase this particular variable by 4.5%, as more use of renewables, but much less quantities of coal used, will restrict the growth of Indian electricity generation. We also increased the Indian steel production by 2.5% per year, from 2018 to 2023, and not less, as there are already available technologies to replace coal in the steel production, like biomass or wood. Thus, we assume that India will use in any case these alternative solutions, as the demand for steel production is getting higher and higher. It is also obvious that we decreased the value of the Indian domestic coal production by 5% annually, from the data of 2018 to 2023, due to the assumed new regulation. We assume that the decrease in the coal production will be gradual, in order to reach the goal of the reduced emissions in a couple of years. As a result, the Indian demand for coal imports will reach to 18.35 million tons per month in 2023, and it is projected to decrease further in the following years, as the use of coal will be restricted through this regulation that we assume.

Last but not least, we use the results of the price of coal and the Indian demand for coal imports, generated by our third scenario's assumptions, in order to calculate the freight rates (Table 23). Again we keep the rest of the independent variables regarding the shipbuilding market stable.

Table 23: Third scenario's estimations for the independent variables of freight rates and estimation of freight rates in 2023 (Source: Own construction)

Variables	Estimation	Source
Panamax Worldfleet	224.4 million DWT	Own estimation
Panamax Fleet Growth	2%	Own estimation
Deliveries of Panamax	0.5 million DWT/month	Sea Europe Shipyard's & Maritime Equipment Association
Panamax Orderbook % Fleet	10%	Own estimation
Panamax Demolition & Losses	0.38 million DWT/month	Own estimation
Average Age of Panamax	10.59 years	Own estimation
Coal price	88.6 $/ton	Own estimation
Indian demand for coal imports	18.35 MT/month	Own estimation
Freight rates	**15.67 $/ton**	**Own estimation**

The freight rates in this scenario are equal to 15.67 U.S. dollars per ton. The difference with the first and the second scenario is large, because this scenario affects more independent variables, of which the coefficients' values are high and affect in a higher grade the outcome. The outcome of the freight rates is lower, in comparison with the other two scenarios, as we cause a decent decrease, through the assumed regulation, in the demand for coal seaborne trade and thus even if the shipbuilding activity is mild, it is not able to keep the freight rates in a higher level.

4.4 Empiric Conclusion

In this chapter we presented and analyzed our results from the correlation and regression analysis using Minitab. We also estimated the values of the coal price, the Indian demand for coal imports and the freight rates in 2023, based on the scenarios that we built in Chapter 2.

The correlation results indicated that in the equation of the coal price, there were not any very strong correlations between the variables. However, in the second equation, the Indian demand for coal imports was very strongly and positively correlated with the Indian electricity generation, the Indian steel production, the Indian domestic coal production and the Indian GDP. The same applies to the correlations between these particular independent variables. It is remarkable to mention that there are weak or very weak and negative correlations between the price of coal as an independent variables and the other variables in the second equation. Regarding the third equation, we do not have any very strong correlation between the freight rates, as dependent variable, and the independent variables, yet only a couple of very strong correlations between the independent variables.

As far as the multiple regression analysis concerns, using Minitab we found the coefficients of each independent variable for each of the three equations. Examining the p-values of each coefficient, we are able to find the significant coefficients for the dependent variables. In our case, most of the independent variables were either significant or very significant for the dependent variables. We also used the method of the linking residuals, in order to make our model more accurate, in case of predictions. Moreover, we used the R^2 and the F-test, in order to check the reliability of our equations. Except for the first equation, where we had average R^2 value and low F-value, the second and the third equation, indicated that they are reliable for accurate estimations of the dependent variables.

Furthermore, we estimated the future values of the price of coal, the Indian demand for coal imports and the freight rates in 2023, based on the three scenarios. In Table 24, we summarize our results.

Table 24: Summary of the results of the freight rates estimation in 2023

Scenario/Dependent variables	Price of coal	Indian demand for coal imports	Freight rates
Average values of 2018	106.98 $/ton	18.95 MT/month	13.53 $/ton
First scenario	82.27 $/ton	32.17 MT/month	20.32 $/ton
Second scenario	86.04 $/ton	32.87 MT/month	21.02 $/ton
Third scenario	88.6 $/ton	18.35 MT/month	15.67 $/ton

We remind that in the first scenario, we increase the Indian domestic coal production. The price of coal in this case, is the lowest one (82.07 $/ton), compared to the other scenarios, and simultaneously much lower than the average price of 2018. The Indian demand for coal imports is a lot higher than this of 2018. In addition, the freight rates seem to have an upward trend regardless the scenario. This might happen, if the global shipbuilding activity remains mild. In the second scenario, we increase further the demand for coal imports, due to the increased demand for steel production, which requires coking coal. In this case, the price of coal is higher than that of the first scenario, but again lower than the price of 2018. Apparently the Indian demand for coal imports in this case is the highest one, in comparison with the other scenarios and the volumes of 2018, reaching 32.87 million tons per month. The freight rates are also the highest one in the second scenario, compared to the other scenarios, reaching 21.02 US dollars per ton, as we increase further the demand and we keep more or less stable the shipbuilding activity. Last but not least, in the third scenario, we assumed an environmental regulation, which would restrict the use of coal. The price of coal reached to 88.6 US dollars per ton, which is the highest price, compared to the other two scenarios, but again not close to the price of 2018. The Indian demand for coal imports is the lowest one, even compared to the volumes of 2018, due to the restriction of coal. This seems to affect the freight rates, as they are equal to 15.67 US dollars per ton. This is explained by the fact that we restrict the trade volumes of coal, keeping the supply of the vessels more or less constant.

5. Conclusion

5.1 Conclusion

All things considered, we investigated the effect of the Indian demand for coal imports on freight rates and we predicted the future freight rates in 2023, based on the three scenarios, which we constructed.

In order to reach to our result, we created three equations, of which the dependent variables were the price of coal, the Indian demand for coal imports and the freight rates and based on the theory on Chapter 2, we determined the independent variables for each equation. Having collected the data for each variable for the last ten years, using Minitab, we run the correlations between the variables and the multiple regression analysis. Through this step, we are able to mention that the Indian demand for coal imports affects significantly and positively the freight rates, as the p-value of the coefficient is equal to 0.036. Setting the confidence level to 95%, the p-value is lower than 0.05 (0.036<0.05), thus there is a significant relationship between these two variables.

By this result, we were able to continue our research with the estimation of the freight rates in 2023, based on our scenarios, in order to investigate further the impact of the Indian demand for coal imports on freight rates. The first scenario regarded the increase in the Indian domestic coal production. Based on the projections of some reports and our assumptions, the Indian demand for coal imports will increase sharply for the next five years, and it will reach to 32.17 million tons per month in 2023, compared to 18.95 million tons per month in 2018. The freight rates are affected positively, as we keep the shipbuilding activity mild, and from 13.53 U.S. dollars per ton in 2018, reach 20.32 U.S. dollars per ton in 2023. The second scenario concerns the further increase in Indian demand for coal imports, due to the increased demand for coking coal, which is used for the steel production. In that case, we had a further increase in Indian demand for coal imports, which is projected to reach to 32.87 million tons per month in 2023, which leads the freight rates to reach to 21.02 U.S. dollars per ton. On the other hand, the third scenario has to do with an assumed regulation for the restriction of the use of coal for environmental reasons. In this case, the Indian demand for coal imports will be even lower than the today's data, in 2023, 18.35 million tons per month, and the freight rates will reach to 15.67 U.S. dollars per ton. Therefore, based on these results it is clear that the Indian demand for coal imports affects just significantly the freight rates. This is because of the fact that when we increase significantly the Indian demand for coal imports, the freight rates increase also sharply. However, decreasing the Indian demand for coal imports, we notice that the freight rates increase slightly, yet they do not decrease. This is explained by the fact that the other assumptions for the other variables, also affect in a decent degree the freight rates. Thus, our general conclusion is that the effect of the Indian demand for coal imports on freight rates is significant. In our point of view, it could not be more than this, as we focus on just one country and we take into consideration some other significant variables for the freight rates. On the other hand, it could also not be less than significant, as India is one of the major importers of coal worldwide, which means that the demand for coal of this country plays a vital role for the freight rates.

5.2 Limitations

Conducting this research, we faced some limitations. First of all, the limit of time prevented us to investigate the supply side, in order to have a clearer and more complete view about which side, either the demand or the supply, is more significant for the freight rates.

Secondly, in the beginning of our thesis, we mentioned that we will include some microeconomic variables in the freight rates equation, as independent variables. Actually, we did include only the average age of the Panamax bulk carrier vessels and due to the limited access to data for the last ten years, we did not include the laycan period and the average size of the vessels.

Another limitation that we faced, is that the time series of the freight rates that we selected, which concerned the voyage between Richards Bay in South Africa and Mundra in India for a Panamax vessel 70,000 DWT, were between 2009 and 2019. Our initial intension was to find data for the last 15-20 years, as we had access for this period for every other dependent and independent variable. In that way, we would have more accurate and reliable results in our regression analysis, yet we preferred to select this particular data for the freight rates, as it was the most representative one, compared to other data.

Moreover, for some variables the data were given annually. We faced this limitation by dividing the annual data into twelve equal parts, as our data was monthly. However, it would be better if we had the exact data for every month, as by dividing into twelve equal parts, we dismiss some possible fluctuations, which would lead to slightly different results in correlation and regression analysis.

Furthermore, the low R^2 in the equation of the price of coal, results in slightly less accurate results of the future price of coal in 2023, which also affects the Indian demand for coal imports and definitely the freight rates.

Last but not least, we had a very limited access to the shipbuilding activity for five years later, which makes sense, as the data for this sector is available for at most two or three years later.

5.3 Recommendations for future research

For the future researchers, we recommend to include more microeconomic determinants, along with the macroeconomic ones, such as the laycan period, the utilization rates of the cargo capacity, the size of the vessels etc.

It would be also interesting to conduct similar research for a different commodity, like grain, for one of the major importers worldwide, like Indonesia.

Another recommendation would be to continue the research for coal for a different country, like China, with different independent variables, different size of vessels and different scenarios for the future of this commodity.

References

Adeyanju C. (2014). *The Top Factors that Move the Price of Coal.* [online] Available at: http://www.futuresknowledge.com/news-and-analysis/energy/the-top-factors-that-move-the-price-of-coal/ [Accessed July 10, 2019].

Afework B. et al. (2018). *Bituminous coal.* [online] Available at: https://energyeducation.ca/encyclopedia/Bituminous_coal [Accessed June 1, 2019].

Afework B. et al. (2018). *Lignite.* [online] Available at: https://energyeducation.ca/encyclopedia/Lignite [Accessed May 31, 2019].

Afework B. et al. (2018). *Sub-bituminous coal.* [online] Available at: https://energyeducation.ca/encyclopedia/Sub-bituminous_coal [Accessed June 1, 2019].

Alizadeh A.H. & Talley W.K. (2011). *Vessel and voyage determinants of tanker freight rates and contract times.* Transport Policy. Volume 18. Issue 5. pp. 665-675.

Ayres C. (2016). *14 advantages and disadvantages of coal.* [online] Available at: https://vittana.org/14-advantages-and-disadvantages-of-coal [Accessed May 1, 2019].

Behera N. (2019). *India's power production to grow 5-6% in FY20 on new household demand.* [online] Available at: https://www.business-standard.com/article/economy-policy/india-s-power-production-to-grow-5-6-in-fy20-on-new-household-demand-119052801088_1.html [Accessed July 9, 2019].

Bouchentouf A. (n.d.) *Coal in the commodities market.* [online] Available at: https://www.dummies.com/personal-finance/investing/commodities/coal-in-the-commodities-market/ [Accessed May 31, 2019].

Business Today. (2018). *India to become the largest cocking coal importer by 2022.* [online] Available at: https://www.businesstoday.in/top-story/india-to-become-largest-coking-coal-importer-by-2022/story/295174.html [Accessed July 7, 2019].

Business Today. (2019). *Indian economy projected to grow at 7.1% in FY20: UN report.* [online] Available at: https://www.businesstoday.in/current/economy-politics/indian-economy-projected-to-grow-at-7-percent-in-fy20-un-report/story/348889.html [Accessed June 24, 2019].

Carrington D. (2019). *G20 countries triple coal power subsidies despite climate crisis.* [online] Available at: https://www.theguardian.com/environment/2019/jun/25/g20-nations-triple-coal-power-subsidies-climate-crisis [Accessed July 11, 2019].

Clemente J. (2014). *India Will Be Using and Importing More Coal.* [online] Available at: https://www.forbes.com/sites/judeclemente/2014/11/09/india-will-be-using-and-importing-more-coal/#37cbb8b269c4 [Accessed July 9, 2019].

Cocconcelli L. (2017). *Manage Speculation Risks in the Dry Bulk Industry.* Phd thesis. UCL. London.

Economic Times. (2019). *India's coal power plants 'unhealthiest' in world: Study.* [online] Available at: https://economictimes.indiatimes.com/news/environment/pollution/indias-coal-power-plants-unhealthiest-in-world-study/articleshow/68092635.cms [Accessed July 7, 2019].

FE Bureau. (2019). *India steel production, demand may grow at 7 per cent.* [online] Available at: https://www.financialexpress.com/industry/india-steel-production-demand-may-grow-at-7-per-cent/1574988/ [Accessed July 9, 2019].

Giziakis C., Papadopoulos A., Plomaritou E. (2010). *Chartering.* 3rd Edition Athens, Greece: Stamoulis S.A., pp. 141-144.

Gross S. (2019). *Coal is king in India and will likely remain so.* [online] Available at: https://www.brookings.edu/blog/planetpolicy/2019/03/08/coal-is-king-in-india-and-will-likely-remain-so/ [Accessed May 4, 2019].

Gross S. & Tongia R. (2019). *Coal in India: Adjusting to transition.* [online] Available at: https://www.brookings.edu/research/coal-in-india/ [Accessed May 4, 2019].

Gyan B. (2016). *Importance of coal in Indian economy.* [online] Available at: https://www.importantindia.com/21958/importance-of-coal-in-indian-economy/ [Accessed June 24, 2019].

Heij C., de Boer P., Hans Franses P., Kloek T., van Dijk H.K. (2004). *Econometric methods with applications in business and economics.* Oxford University Press. pp. 705-706.

Heinze G. & Dunkler D. (2016). *Five myths about variable selection.* [online] Available at: https://onlinelibrary.wiley.com/doi/pdf/10.1111/tri.12895 [Accessed August 9, 2019].

Higgins J. (2005). *The radical statistician.* Sacramento, United States: The Higgins Group, LLC. pp. 230.

India Brand Equity Foundation. (2019). *Indian economy overview.* [online] Available at: https://www.ibef.org/economy/indian-economy-overview [Accessed April 30, 2019].

India Brand Equity Foundation. (2019). *Iron & Steel Industry in India.* [online] Available at: https://www.ibef.org/industry/steel.aspx [Accessed July 9, 2019].

Jugovic A., Komadina N., Peric Hadzic A. (2015). *Factors influencing the formation of freight rates on maritime shipping markets.* [online] Available at: https://www.researchgate.net/publication/284170614_Factors_influencing_the_formation_of_freight_rates_on_maritime_shipping_markets [Accessed July 20, 2019].

Kampa E.M. (2011). *The Chinese demand for iron ore and its effect on freight rates.* MSc thesis, Erasmus University, Rotterdam.

Kartsiouka E. (2011). *Factors that affect the Freight Rates of Coal Trade between Australia and China for Panamax Vessels.* MSc thesis, Erasmus University, Rotterdam.

Kay A. (2019). *The 4 coal types and their uses.* [online] Available at: https://investingnews.com/daily/resource-investing/industrial-metals-investing/coal-investing/types-of-coal/ [Accessed May 31, 2019].

Keller G. (2018). *Statistics for management and economics.* 11e Edition Boston, United States: Cengage Learning pp. 112, 653, 700.

Koopmans, T.C. (1939). *Tanker Freight Rates and Tankship Building: An Analysis of Cyclical Fluctuations.* De Erven F. Bohn N.V., Haarlem.

Kopp O.C. (n.d.) *Bituminous coal.* [online] Available at: https://www.britannica.com/science/bituminous-coal [Accessed June 1, 2019].

Kopp O.C. (n.d.) *Subbituminous coal.* [online] Available at: https://www.britannica.com/science/subbituminous-coal [Accessed June 1, 2019].

Lu J. & Yi Le W. (2018). *India's metallurgical coal demand through 2020 on the rise.* [online] Available at: https://blogs.platts.com/2018/08/29/india-metallurgical-coal-demand-2020-rise/ [Accessed July 7, 2019].

Luo M., Fan L., Liu L. (2009). *A dynamic-economic model for container freight market.* [online] Available at: https://pdfs.semanticscholar.org/c473/21bb94f9a0484f52ccb5391b66b232664596.pdf [Accessed July 13, 2019].

Lyons Sunshine W. (2018). *All about anthracite coal.* [online] Available at: https://www.thebalance.com/what-is-anthracite-coal-1182544 [Accessed June 1, 2019].

Lyons Sunshine W. (2019). *Bituminous coal.* [online] Available at: https://www.thebalance.com/bituminous-coal-characteristics-applications-1182545 [Accessed June 1, 2019].

Lyons Sunshine W. (2019). *Sub-bituminous coal characteristics and uses.* [online] Available at: https://www.thebalance.com/sub-bituminous-coal-characteristics-and-uses-1182548 [Accessed June 1, 2019].

Lyons Sunshine W. (2018). *What is lignite.* [online] Available at: https://www.thebalance.com/what-is-lignite-1182547 [Accessed May 31, 2019].

Marcacci S. (2018). *India Coal Power Is About to Crash: 65% Of Existing Coal Costs More Than New Wind and Solar.* [online] Available at: https://www.forbes.com/sites/energyinnovation/2018/01/30/india-coal-power-is-about-to-crash-65-of-existing-coal-costs-more-than-new-wind-and-solar/#33ad176a4c0f [Accessed July 10, 2019].

Mishra T. (2019). *India needs to double its installed power-generation capacity.* [online] Available at: https://www.thehindubusinessline.com/economy/india-needs-to-double-its-installed-power-generation-capacity-official/article27266372.ece [Accessed July 9, 2019].

Munawer M.E. (2018). *Human health and environmental impacts of coal combustion and post-combustion wastes.* [online] Available at:

https://www.sciencedirect.com/science/article/pii/S2300396017300551 [Accessed July 7, 2019].

Page V. (2018). *The fundamentals of how India makes its money.* [online] Available at: https://www.investopedia.com/articles/investing/043015/fundamentals-how-india-makes-its-money.asp [Accessed June 24, 2019].

Panda R.K. (2019). *Coal production is expanding in India.* [online] Available at: https://www.climatescorecard.org/2019/05/coal-production-is-expanding-in-india/ [Accessed July 7, 2019].

Penney K. & Cronshaw I. (2015). *Coal in India.* [online] Available at: https://www.industry.gov.au/sites/g/files/net3906/f/June%202018/document/pdf/coal-in-india.pdf [Accessed June 23, 2019].

Pines L. (n.d.) *How to trade coal: All the facts in one place.* [online] Available at: https://commodity.com/energy/coal/ [Accessed May 31, 2019].

Pompeu N.B. (2019). *Air pollution and the health cost of coal.* [online] Available at: https://www.iisd.org/gsi/subsidy-watch-blog/air-pollution-and-health-cost-coal [Accessed July 7, 2019].

Ram R.S. (2019). *India steel demand is holding up well against a sluggish global growth.* [online] Available at: https://www.livemint.com/market/mark-to-market/india-steel-demand-is-holding-up-well-against-a-sluggish-global-growth-1555031079470.html [Accessed July 9, 2019].

Reuters. (2018). *Opinion: India boosts purchases of Indonesian coal as prices drop.* [online] Available at: https://energy.economictimes.indiatimes.com/news/coal/opinion-india-boosts-purchases-of-indonesian-coal-as-prices-drop/65707411 [Accessed June 25, 2019].

Russell C. (2019). *Coal going from winner to loser in India's energy future: Russell.* [online] Available at: https://www.reuters.com/article/us-column-russell-coal-india/coal-going-from-winner-to-loser-in-indias-energy-future-russell-idUSKCN1Q90OP [Accessed July 10, 2019].

Satija A. (2019). *Why coal reforms are so important for the Indian economy?* [online] Available at: https://www.alphainvesco.com/blog/future-of-coal-in-india-panel-discussion/ [Accessed May 1, 2019].

Seetharaman G. (2019). *Coal here to stay despite India's ambitious goals for renewable energy.* [online] Available at: https://economictimes.indiatimes.com/industry/energy/power/india-will-not-be-able-to-achieve-its-renewable-energy-targets-anytime-soon/articleshow/69286279.cms [Accessed July 9, 2019].

Silver C. (2019). *Top 20 economies in the world.* [online] Available at: https://www.investopedia.com/insights/worlds-top-economies/ [Accessed June 24, 2019].

Statistics Laerd (n.d.). *Pearson Product-Moment Correlation.* [online] Available at: https://statistics.laerd.com/statistical-guides/pearson-correlation-coefficient-statistical-guide.php [Accessed July 20, 2019].

Statistics Solutions (n.d.). *Correlation (Pearson, Kendall, Spearman).* [online] Available at: https://www.statisticssolutions.com/correlation-pearson-kendall-spearman/ [Accessed July 20, 2019].

Stopford M. (2009). *Maritime Economics.* 3rd Edition New York, United States: Routledge pp. 450.

Szewczyk A. (2019). *India to significantly boost demand for steel.* [online] Available at: https://www.worldsteel.org/media-centre/blog/2019/india-boost-demand-for-steel.html [Accessed July 7, 2019].

Tamvakis M.N. (1995). *An investigation into the existence of a two-tier spot freight market for crude oil tankers.* Maritime Policy Management. Volume 22. Issue 1. pp. 81-90.

Tamvakis M.N. & Thanopoulou H.A. (2000). *Does quality pay? The case of the dry bulk market.* Transportation research. Part E. Logistics and Transportation Review. 36(4), pp. 297-307.

Tinbergen J. (1934). *Scheepsruimte en Vrachten.* De Nederlandsche Conjunctuur, pp. 23-35

Tongia R. & Gross S. (2019). *Coal in India: Adjusting to transition.* [online] Available at: https://www.brookings.edu/wp-content/uploads/2019/03/Tongia_and_Gross_2019_Coal_In_India_Adjusting_To_Transition.pdf [Accessed June 23, 2019].

Trade Map (2019). *List of importers of coal.* [online] Available at: https://trademap.org/Country_SelProduct_TS.aspx?nvpm=1%7c%7c%7c%7c%7c2701%7c%7c%7c4%7c1%7c1%7c1%7c2%7c1%7c2%7c2%7c1 [Accessed May 1, 2019].

Tsedu T. (2016). *South Africa's coal mines to process low-grade coal to produce quality products.* [online] Available at: https://www.csir.co.za/south-africas-coal-mines-process-low-grade-coal-produce-quality-products [Accessed June 25, 2019].

UNCTAD. (2018). *Review of maritime transport 2018.* [online] Available at: https://unctad.org/en/PublicationsLibrary/rmt2018_en.pdf [Accessed June 17, 2019].

Varadhan S. (2019). *Canada, U.S. gain as India cuts dependence on Australian coking coal.* [online] Available at: https://www.reuters.com/article/us-india-coal-imports/canada-u-s-gain-as-india-cuts-dependence-on-australian-coking-coal-idUSKCN1TQ234 [Accessed June 25, 2019].

Vidal J. (2013). *Indian coal power plants kill 120,000 people a year, says Greenpeace.* [online] Available at: https://www.theguardian.com/world/2013/mar/10/india-coal-plants-emissions-greenpeace [Accessed July 7, 2019].

Workman D. (2019). *Coal exports by country.* [online] Available at: http://www.worldstopexports.com/coal-exports-country/ [Accessed June 22, 2019].

Workman D. (2019). *Coal imports by country.* [online] Available at: http://www.worldstopexports.com/coal-imports-by-country/ [Accessed June 22, 2019].

World Coal Association. (2019). *Basic coal facts.* [online] Available at: https://www.worldcoal.org/file_validate.php?file=WCA_Basic%20Coal%20Facts_0.pdf [Accessed May 31, 2019].

World Coal Association. (2019). *The role of coal in India's energy ambitions.* [online] Available at: https://www.worldcoal.org/role-coal-india%E2%80%99s-energy-ambitions [Accessed June 24, 2019].

World Coal Association. (2019). *What is coal.* [online] Available at: https://www.worldcoal.org/coal/what-coal [Accessed May 31, 2019].

World Population. (2019). *Current world population.* [online] Available at: https://www.worldometers.info/world-population/ [Accessed April 30, 2019].