Czech University of Life Sciences Prague

Faculty of Economics and Management

Department of Economics

Diploma Thesis

Foreign Trade of Brazil - Case study of raw centrifugal sugar export

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CZECH UNIVERSITY OF LIFE SCIENCES PRAGUE

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DIPLOMA THESIS ASSIGNMENT

Bc. Anežka Drašnarová

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Thesis title

Foreign Trade of Brazil – Case study of raw centrifugal sugar export

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Objectives of thesis

The main aim of thesis is to conduct the analysis of brazilian foreign trade with focus on export of raw centrifugal sugar commodity made from sugar cane. Analyzing trade balance of Brazil, identifiing determinants influencing Brazil export of raw centrifugal sugar and testing which factors have significant impact on brazilian sugar export are partial objectives of the thesis.

Methodology

The diploma thesis consists of two main parts (theoretical and analytical). First part is literature review which is processed on a basis of available books and scientific articles conected to sugar crops and its derivatives, sugar foreign trade and econometrics modelling. The content of analytical part of the thesis is connected with brazilian trade and construction of one-equation econometrics model in order to processed the quantitative analysis of brazil export of raw centrifugal sugar. For this purpose the secondary data are used from the database called Food and Agriculture Organization of the United Nations.There are used statistical techniques and softwares such as Gretl and MS Excel for testing, elaboration and to achieve set objectives.

The proposed extent of the thesis

40 – 60 pages

Keywords

Brazil, agriculture, raw centrifugal sugar, sugarcane, econometric model, foreign trade, export

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Recommended information sources

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Declaration

I declare that I have worked on my diploma thesis titled "Foreign Trade of Brazil - Case study of raw centrifugal sugar export" by myself and I have used only the sources mentioned at the end of the thesis. As the author of the diploma thesis, I declare that the thesis does not break copyrights of any their person.

In Prague on 25th March 2019 _____

Acknowledgement

I would like to thank Assoc. prof. Ing. Mansoor Maitah, Ph.D. et Ph.D. for his support, advice, and comments during my work on this diploma thesis. I would like to also thank my family and close friends for their support and patience.

Foreign Trade of Brazil - Case study of raw centrifugal sugar export

Abstract

The diploma thesis is focused on foreign trade of Brazil, particularly on raw centrifugal sugar export in the period from 1992 to 2016. The main aim of the thesis is to conduct analysis on foreign trade of Brazil with the intention of raw centrifugal sugar export. The thesis is divided into the theoretical and practical part. The first part, theoretical, deals with a world production and trade of sugar crops and its products, especially raw centrifugal sugar. Furthermore, the thesis describes sugar characteristics, major importers and exporters of raw centrifugal sugar, and econometric analysis and its methods. The second part, practical, initially deals with Brazil and its trade, Brazilian's sugar production and export, and analysis of chosen determinants. This is followed by analysis of the raw centrifugal sugar quantity exported from Brazil in the period from 1992 to 2016. There is a constructed one-equation econometric model, within the frame of the analysis through which it is determined which factors significantly influence the raw centrifugal sugar export volume from Brazil. Moreover, economic, statistical and econometric verification of model is processed. Subsequently, there are calculated elasticities of variables in the model, and prognoses of the endogenous variable for years 2017, 2018, 2019, and 2020.

Keywords: Brazil, agriculture, raw centrifugal sugar, sugarcane, econometric model, foreign trade, export

Zahraniční obchod Brazílie - případová studie vývozu surového cukru

Abstrakt

Diplomová práce je zaměřena na zahraniční obchod Brazílie, zejména na vývoz surového cukru v letech 1992 až 2016. Hlavním cílem této diplomové práce je provést analýzu zahraničního obchodu Brazílie se zaměřením na export surového cukru. Práce je rozdělena na teoretickou a praktickou část. První část, teoretická, se zabývá světovou produkcí a obchodem s cukernými plodinami a jejich produkty, zejména surovým cukrem. Dále práce popisuje vlastnosti cukru, hlavní dovozce a vývozce surového cukru a ekonometrickou analýzu a její metody. Druhá část, praktická, se nejprve zabývá Brazílií a jejím obchodem, brazilskou produkcí a exportem cukru a analýzou vybraných determinantů. Následuje analýza množství surového cukru vyvezeného z Brazílie v letech 1992 až 2016. V rámci analýzy je vytvořen jednoparametrový ekonometrický model, v jehož rámci je určeno, které faktory významně ovlivňují objem vývozu surového cukru z Brazílie. Dále je zpracováno ekonomické, statistické a ekonometrické ověření modelu. Následně jsou v modelu vypočteny pružnosti proměnných a prognózy endogenní proměnné pro roky 2017, 2018, 2019 a 2020.

Klíčová slova: Brazílie, zemědělství, surový cukr, cukrová třtina, ekonometrický model, zahraniční obchod, export

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List of abbreviations

ACP…….The African, Caribbean, and Pacific Group of States

CAP ……....The Common Agricultural Policy

CFD…….Contract for difference

EU……..The European Union

GATT……..The General Agreement on Tariffs and Trade

GDP……..…….Gross Domestic Product

ISO …….The International Sugar Organisation

MERCOSUR…….Mercado Común del Sur (Southern Common Market)

OEC..……..The Observatory of Economic Complexity

OLSM…….Ordinary Least Square method

PROEX……..The Export Financing Programme

SACU……The Southers African Customs Union

US……...The United States

USD…….United States Dollar

WTO ……..The World Trade Organization

1 Introduction

Sugar is commonly consumed all around the world as an ingredient in most food as a sweetener, and it is one of the essential commodities globally. Many industries are intimately connected with sugar such as food industry, beverage industry, the pharmaceutical industry, and other industries. The sugar is made by processing mainly two crops, sugar beet and sugar cane. These two crops have different growing regions. Sugar beet is grown mostly in North America, Europe, and Asia and sugar cane grows mainly in countries near the equator. Sugar from sugar cane is creating approximately 80% of world sugar production, and its biggest producer is Brazil. From the historical point of view, the sugar was an expensive commodity in Europe at very early times due to the difficulty of extraction sucrose from the plants. First notes of domestication of sugar cane came from Papua New Guinea and from that region spread through India to the world. In these destinations, the first forms of raw sugar were produced more than 2000 years ago. In the 16th century, Portuguese settlers in Brazil started cultivated sugarcane. The using of sugar beet for sugar production in Europe expand in 1747 due to the Napoleonic Wars.

There are many products from sugar cane and sugar beet such as molasses which is used for the production of alcohol, ethanol, feed and food, and last but not least a different types of sugar. Refined sugar is well known as a sweetener, but this diploma thesis focuses on raw centrifugal sugar, which is non-refined crystallized material, derived from the juices of sugar crops. This raw centrifugal sugar can be processed further to refined sugar or used for direct consumption or as an ingredient for industries. The by-products of sugar processing are beet pulp, bagasse, beet tops, and cane tops. These are used for animal feed, paper production, and biomass fuels.

Most the sugar is consumed in the countries of its origin, and only 20% of world production of raw centrifugal sugar is exported. In the year 2016, the significantly leading exporter of raw centrifugal sugar was Brazil with a volume of more than 23 million tonnes, and the leading world importer was Indonesia.

The practical part of this thesis examines the agriculture trade of Brazil, its main importers of raw centrifugal sugar, and exported quantity over the years. Furthermore, there is an analysis of the export quantity of raw centrifugal sugar from Brazil in the years 1992 – 2016 through econometric modeling. Besides, elasticities are compounded, and prognoses for 2017-2020 are derived.

2 Objectives and Methodology

2.1 Objectives

The primary objective of this diploma thesis is to conduct an analysis of Brazil foreign trade with a focus on export of raw centrifugal sugar during the time period from 1992 to 2016. One of the objectives is to examine global biggest producers of sugar crops, foreign trade of sugar crops as well as the raw centrifugal sugar trade. The main players will be listed. Analyzing the agricultural trade of Brazil, identifying determinants influencing Brazil export of raw centrifugal sugar and testing which factor has a significant impact on Brazilian raw centrifugal sugar export, are partial objectives of the thesis. Also, the prediction for the years 2017, 2018, 2019, and 2020 will be conducted at the application part of the econometric modeling of raw centrifugal sugar volume exported from Brazil.

Hypothesis:

- If the Brazilian raw centrifugal sugar export value increases, the Brazilian raw centrifugal sugar export quantity increases.
- If the total population of India increases, the Brazilian raw centrifugal sugar export quantity increases.
- If the Indian sugarcane production increases, the brazilian raw centrifugal sugar export quantity decreases.
- If the first differences of Brazilian sugarcane production increases, the brazilian raw centrifugal sugar export quantity increases.

2.2 Methodology

The theoretical part is based on information available in books and scientific articles connected to sugar, foreign trade, statistics, and econometric modeling. In this part is going to be an overview of sugar crops and sugar products and its global trade and also the biggest importers and exporters of raw centrifugal sugar.

At the beginning of the analytical part, Brazil and its agriculture trade are described. Selected determinants of raw centrifugal sugar export are introduced and their trend analysis within the period from 1992 to 2016 is performed. This time period was selected due to the last data availability. In the following part, the one-equation econometric model corresponding with economic theory is created and provided with data obtained from the statistic of the Food and Agriculture Organization of the United Nations (FAOSTAT). The Ordinary Least Square method is used for the estimation of the individual parameters. Verification of the one-equation model is performed via Gretl and MS Excel programmes. Tests for economic, statistical and econometric verification of the econometric model will be used. The conclusion of the analytical part consists of the computation of the model for calculations of elasticities and prognoses for the years 2017-2020. For the purposes of this thesis, an analysis of data obtained from secondary sources was conducted.

3 Literature Review

The theoretical background on sugar and its utilization, world sugar production and consumption as well as the importance of sugar to the economy is described and evaluated in this part. Furthermore, there is described world sugar market, major exporting and importing countries, determinants of sugar export, trade policies of selected countries, international organizations associated with sugar and development of price of sugar. The literature review of this diploma thesis used secondary data for the research on the basis of available articles, books, statistical bulletins, official documents, and reports.

3.1 Sugar characteristics

Generally, sugar is called sweet-tasting food. The liking of sweet taste is probably congenital to a human being, since from birth the baby gives preference to a sweet fluid, before non-sweet. A sweet taste can give you a sense of security. Sugar is chemically called sucrose, a non-reducing disaccharide composed of one molecule of glucose and one fructose molecule. Sucrose is in common language called sugar, sugar from sugar beet, sugar from sugarcane or table sugar. It is the most commonly used sweetener. In the pure state, sucrose is a white crystalline substance, well soluble in water. (Perušičová, et al., 2013; Edelsberger, 2009)

Sucrose has its most significant application in the food industry, where it provides the sweet taste, texture, structure, and consistency of food, thereby increasing the acceptability of food for the consumer. Other sugar functions include preservative effects in the production of fruit jellies, participation in browning processes in baking and is an essential raw material in fermentation processes. The less-favored sector for the use of sucrose is the pharmacy. Sugar contained in medication suppresses an unpleasant taste. The advantage of sucrose is its long-term shelf life and relatively low price. (Čepička, 1995)

3.1.1 Sugar History

From very early times, fruit (rich in fructose) and honey (rich in fructose and glucose) were valued for its sweetness. That was the reason why this form of sugar was an expensive commodity, especially in Europe. However, it was complicated to extract sucrose from plants in significant quantities. Sugarcane was first domesticated in Papua New Guinea, from where spread its cultivation to India and through the Pacific, as studies suggest. First crude

forms of sugar were produced more than 2000 years ago in mentioned destinations. The plant only thrives in tropical areas, and demand of sugar grew up and lucrative trade development. This leads Portuguese settlers in Brazil started the cultivation of sugarcane in the 16th century. (Cheesman, 2004)

In India, sugar cane began to produce sugar syrup. The technology consisted of pressing and cooking the juice, which was crystallized in the containers. These forms, which were formed by crystallization, were called "khandy". From the original Indian area, sugar cane growing expanded further into the world. In the 15th-century growing regions expanded for example to Cyprus, North Africa, Egypt, the Azores, and the Canary Islands. Since the second half of the 16th century that it began to be used for sweetening and confectionery itself. (Beranová, 2015)

In the 17th and 18th-century European colonial powers held a central position in the world economy through huge save-based sugarcane plantations in the Caribbean. Because of difficulties of transportation sugar for a long distance, sugarcane was imported to Europe as a raw material and refined locally. The massive expansion of sugar beet and its use for sugar production arose in 1747, which conditioned the Napoleonic Wars and the blockade of overseas ports and with that associated blockade of sugar imports into Europe and slave revolts on sugarcane plantations. Due to trade barriers, sugar beet became world-leading sugar crop at the beginning od 20th century. An international conference leads to release of trade restrictions and recovery of the predominance of the cane as a sugar source. (Cheesman, 2004)

3.1.2 **Sugar crops**

Sucrose is contained in many plants that produce it as a reserve of its energy. For human consumption, sucrose is extracted and refined from several different raw materials. The world's most important crop is sugar cane, which accounts for almost three-quarters of the world's total sugar production. The second place is sugar beet, whose importance is slowly declining, but still holds its position mainly in Europe. Other sugar crops can use such as maple juices, honey, dates, and sorghum. These crops create only a negligible percentage of global sugar production. (Dostálová, et al., 2014)

3.1.2.1 Sugarcane

Sugar cane (Saccharum officinarum) is a massive, long-lasting grass, which belongs to the reed family and matures for 12-16 months. Its stems, containing white sweet marrow, reach an average height of 3 to 4 meters. The leaves are found only in the higher part of the plant. For sugar cane growing, it is ideally a long, warm growing season with a high incidence of sunlight and adequate humidity, followed by a dry and relatively cold freeze-free period when the sugar cane matures and is harvested. The ideal temperature for growth and sugar production is in the range of 22 - 30 ˚C. (Food and Agriculture Organization of the United Nations, c2019)

Sugarcane is a tropical grass, a group of Saccharum species, which stores sucrose in its stem. Optimum periods for grooving and harvesting differ due to localities and availability of many different varieties (cultivars). With right conditions, the cane can re-grow from the old rootstock repeatedly for 6 or 7 years. Sugarcane usually ripens in the cooler and drier parts of a year, lack of water leads to accumulation of sucrose. (Cheesman, 2004)

Besides the production of sugar, sugarcane is used to produce rum, fuel, and sugar. Different usage of processing of sugarcane made Brazil the leading biofuel producer in the world. Together with the US, they produce 90% of global ethanol. The annual harvest of sugar cane in 2016 exceeded 1.3 billion tons. Worldwide, over 75% of world sugar production is produced from the cane. The largest producer is Brazil, with 338 million tonnes, which is the most critical market for a cane. In the last decade, cane production in Brazil rose twice. The second largest producer is India with 265 million tonnes and China's third place with 88 million tonnes. (Food and Agriculture Organization of the United Nations, c2019; Food and Agriculture Organization of the United Nations, c2018)

3.1.2.2 Sugar beet

Sugar beet (Beta vulgaris), is a two-year agricultural crop of the Amaranth family. It ranks among the rootstocks and grows for one year. The sugar beet reaches a height of 50-100 cm and has a massive root, which is called a buoy. It is the only crop grown in a temperate climate zone which is for sugar production. The most favorable temperatures for sugar production are 15-20 °C at night and 20-25 °C during the day. It is demanding for

cultivation, it requires quality and nutritious soil with plenty of water. (Food and Agriculture Organization of the United Nations, c2019)

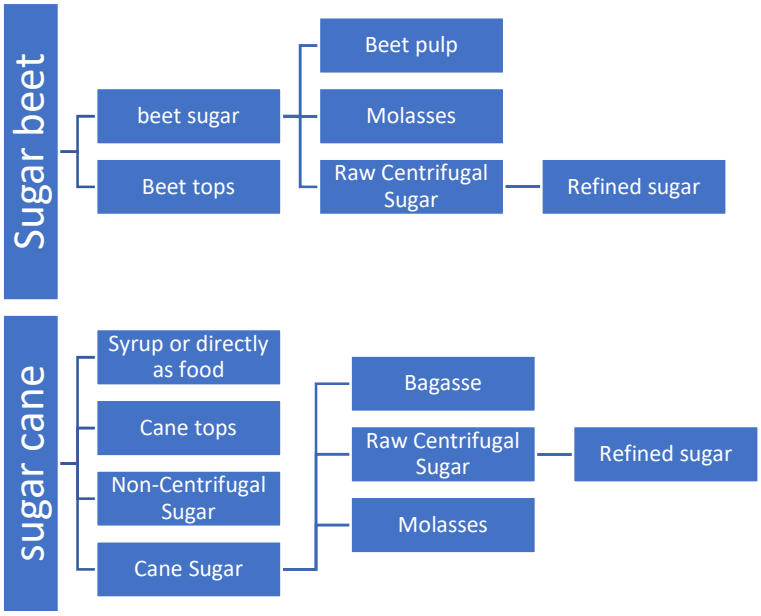
Sugar beet is a temperate, biennial root vegetable. This plant was domesticated as garden vegetables in the Mediterranean areas in ancient times. The beet stores sucrose in its bulbous root, in the first year of growth. Many different varieties of sugar beet are available, as with sugarcane. This crop is usually grown from seed and sown mostly in the spring and then harvested in the first autumn. (Cheesman, 2004)

Beet is grown for the production of several raw materials. Sugar beet is processed into alcohol, yeast, feed, beverages, and sugar. Sugar beet production is the most widespread in Europe, but its cultivation has recently receded. The last great harvest is the year 1990 when over 300 million tonnes of beet were harvested worldwide. At present, France is the largest producer of sugar beet with 31 million tonnes of sugar beet. The second place is the United States and Germany, whose production is between 25-30 million tons of sugar beet for 2016. (Food and Agriculture Organization of the United Nations, c2018; Food and Agriculture Organization of the United Nations, c2019)

3.1.3 **Products from sugar crops**

In this part, there are products from sugar crops divided into this diploma thesis according to Definition and classification of commodities from Faostat website. This distribution is based on the fact that most of the data in the practical part of this diploma thesis are acquired from statistics of Food an Agriculture Organization of the United Nations. Important to mention that sugar crops are not used only for sugar production but also for the production of alcohol and ethanol as well as juices and animal feed. There are many different types of crops which can be used for sugar products such as sugar palms, maple trees, sweet sorghum but this theoretical part of this thesis is focused only on two most common sugar crops namely sugarcane and sugar beet, which were described in the section above. (Food and Agriculture Organization of the United Nations, c1994a)

Figure 1: Products from sugar crops



Source: Own elaboration based on data from Faostat (2019)

From figure 1 is visible diversity of sugar crops use. To make it more explicit definitions of products follow:

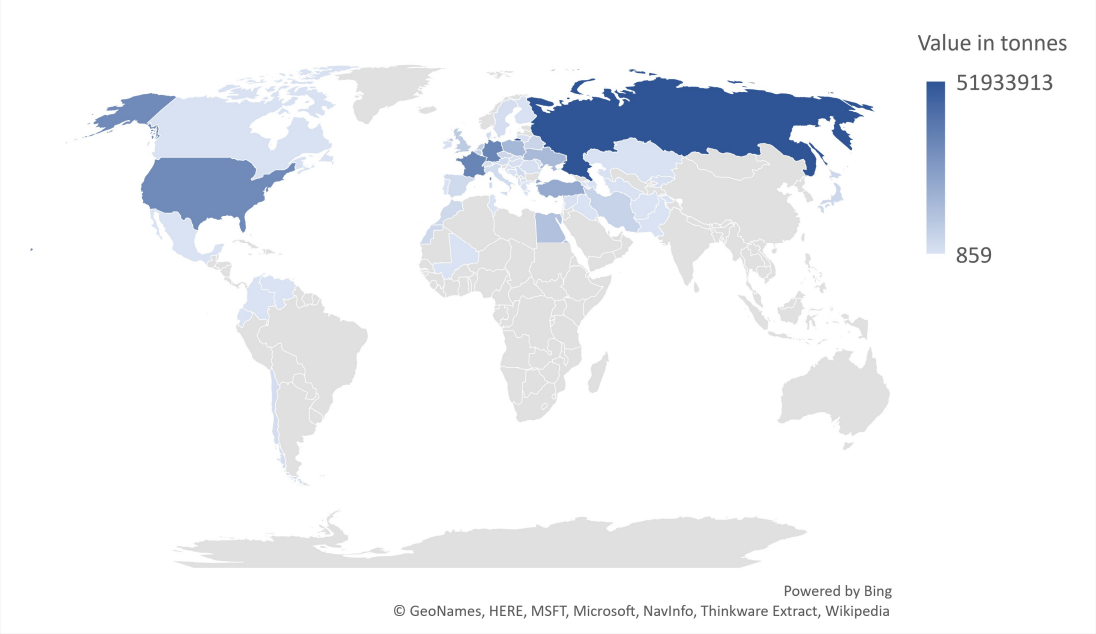
- **Beet Sugar** can be described as a non-refined, crystallized material. This material is derived from the juices extracted from sugar beet roots.
- **Cane Sugar** can be described as a non-refined, crystallized material derived from the juices of a sugar-cane stalk.
- **Non-centrifugal Sugar** is generally derived through traditional methods without centrifugation from sugar cane.
- **Raw Centrifugal Sugar** is the sum of beet sugar and cane sugar. Processed further to obtain refined sugar.
- **Refined sugar** is processed raw centrifugal sugar. To obtain refined sugar. Its production covers domestic production with the addition of imports and/or exports of raw centrifugal sugar in terms of refined sugar.
- **Molasses** can be described as a by-product of the refining or extraction of beet sugar or cane sugar or of the production of fructose from maize. It is mainly used for industrial alcohol, alcoholic beverages, ethanol, feed, and food. Degrees of sugar content in molasses may be different.

- **Beet Pulp** represents residue from the extraction of sugar from the root of sugar beets which is used for animal feed.
- **Bagasse** represents a residue of the fibrous portion of the sugar cane after the juice has been extracted. Used as a fuel in sugar mills, as an animal feed, and in paper production.
- **Beet Tops** are consisting of the leaves and upper part of the root, and they are used for feed.
- **Cane Tops** means the leaves and upper part of the stalks, which are used for feed. (Food and Agriculture Organization of the United Nations, c1994b; Food and Agriculture Organization of the United Nations, c1994a)

3.1.4 Sugar crops growing regions

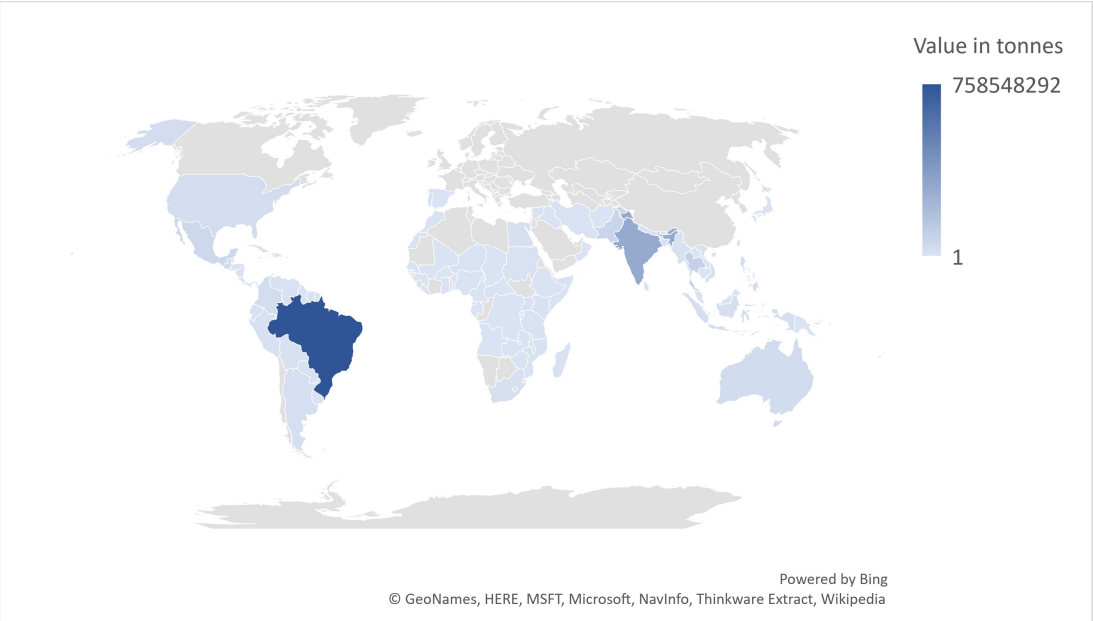
Over 120 countries produce sugar from either sugar cane or sugar beet. In fact, most of the sugar is produced from sugarcane (approximately 80%) and sugar beet sugar count the remaining 20%. For each of these two sources is required different climatic conditions and that is in connection with the need to use different growing regions throughout the world. (Canadian Sugar Institute, c2019)

Figure 2: Sugar beet production quantity in tonnes for the year 2017



Source: Own elaboration based on data from Faostat (2019)

Figure 3: Sugarcane production quantity in tonnes for the year 2017



Source: Own elaboration based on data from Faostat (2019)

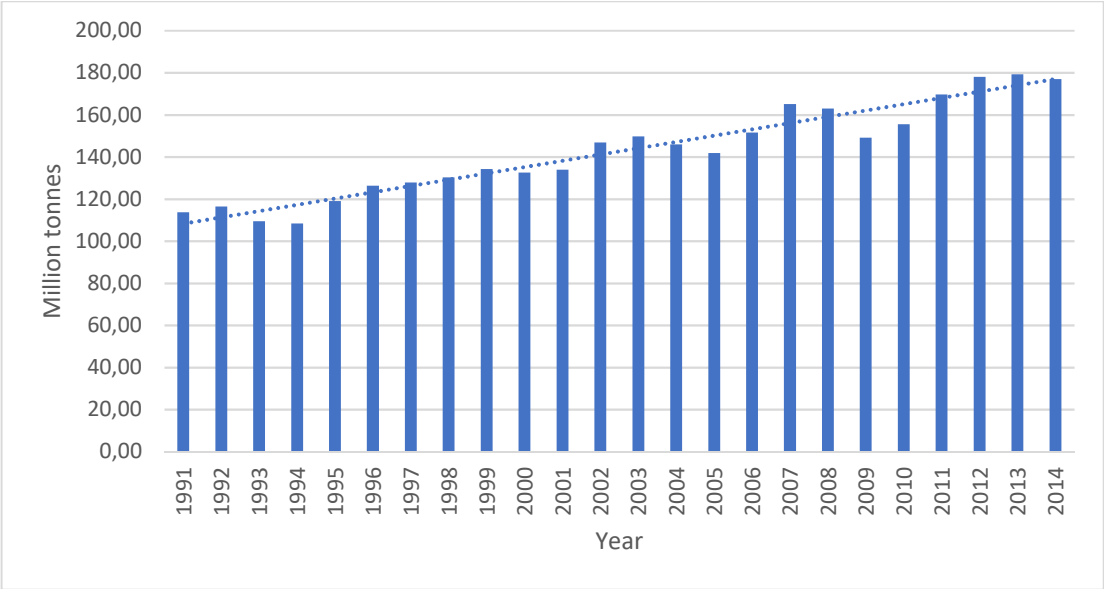
Figures 2 and 3 displayed the amount of production of sugar crops in countries around the world. From figure 2 which stands for sugar beet production quantity is visible that growing regions are related to North America, Europe, and Asia. On the other hand figure 3 shows that sugarcane grows mainly in countries near the equator. The dark blue color is evidence that the biggest producer of sugarcane was Brazil with the quantity of 758548292 tonnes and a most significant producer of sugar beet was Russian Federation with the quantity of 51933913 tonnes in the year 2017. If we compare the highest values from both maps (Figure 2 and 3), we obtain result 706614379 tonnes and this value represents the difference between production quantity of sugar crops in Brazil and Russian Federation which make Brazil leading country in the production of sugar crops.

3.2 World production and consumption of sugar

Worldwide, sugar consumption is rising. The ten largest consumers account for around 60% of global consumption. These are India, the European Union, China, Brazil, the United States, Indonesia, Russia, Pakistan, Mexico, and Egypt. An increase in demand in developing countries, particularly in Asia, due to population growth, rising incomes for these countries, and a change in dietary habits is expected. (International Sugar Organization, c2018a)

Sugar was once considered luxury goods, which served primarily for rich people, and the simple people replaced sugar with honey. Today the situation is completely different. Sugar is a commodity of daily consumption and its consumption is constantly growing. This growth is mainly related to the ever-growing population, rising living standards in Asian countries and the growth of purchasing power. For 2014, estimated sugar consumption for food purposes is about 175 million tonnes, while in 1961 it was only 49 million tonnes. Since 2000 sugar consumption has grown on average by more than 2% per year. (Smutka, et al., 2013)

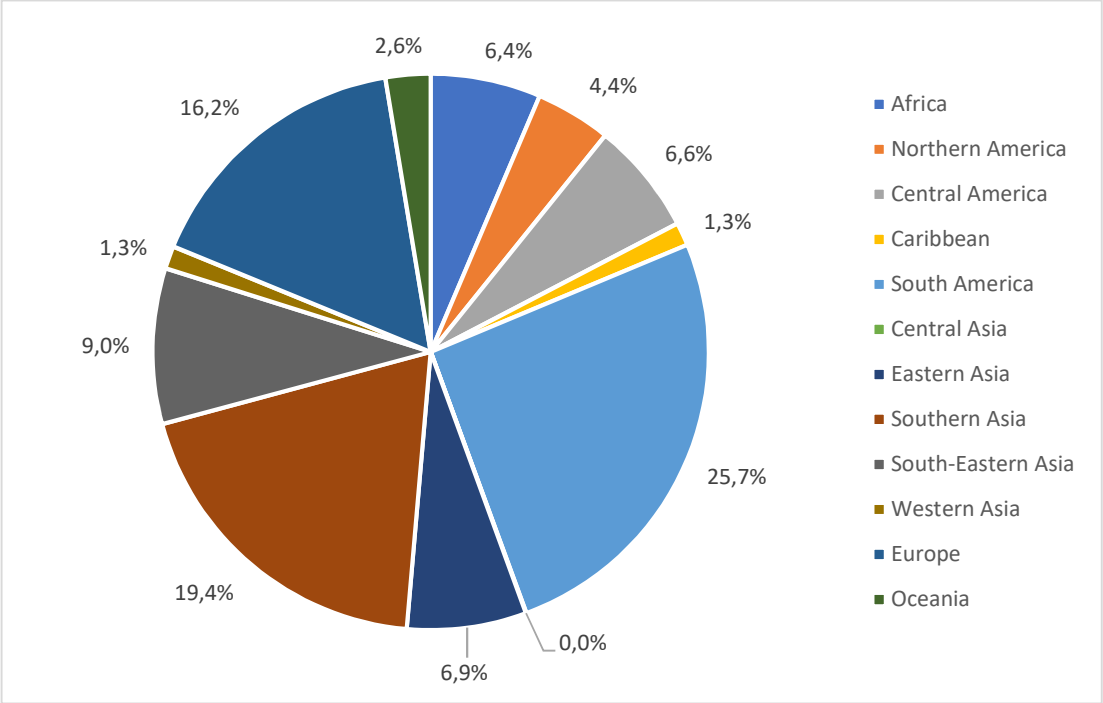
Figure 4: World production of sugar raw centrifugal from 1991 to 2014



Source: Own elaboration based on data from Faostat (2019)

From figure 4 is easy to see that the world production of raw centrifugal sugar has a moderate positive trend and figure below (figure 5) shows how this production is distributed by regions in percentage. The reason for distribution as it is is due to previous findings from chapter 3.1.4, where the highest values were found in the continent of Asia and America. Europe has not divided because the main producers there are members of the European Union. The year 2014 for figures 4 and 5 was set for the reason of non-availability of date for the years 2015 and 2016.

Figure 5: Share of producers of raw centrifugal sugar by region in 2014



Source: Own elaboration based on data from Faostat (2019)

South America is the biggest producer of raw centrifugal sugar with a share of 25.7% of whole world production. On the second position is Southern Asia with a share of 19.4% and the third most significant share belongs to Europe with 16.2% of total world production of raw centrifugal sugar. There is a need to highlight that the share of export can differ from a share of production because many countries consume and/or process sugar in their own country. The rate of growth in sugar consumption is lower than the growth rate of its production, thus constantly accumulation of sugar reserves.

3.3 World sugar market

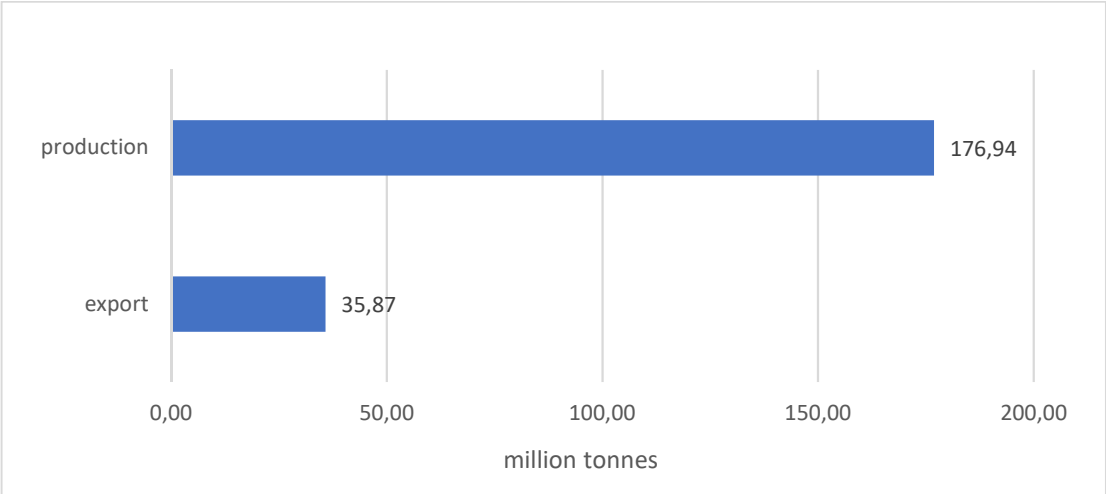
In economic theory, the market is the place where supply and demand collide, and the result of this collision is the price and traded volume (Macáková, 2010). The causes of foreign trade can be defined by the answer to the question of why the countries trade among themselves and what benefits they bring. The answer could be that, on the basis of the natural inequality of natural resources, the conditions of different countries and other factors, each country is able to produce other products and services that other countries can not and vice versa. This production is then the subject of foreign trade.

The reason for foreign trade may, therefore, be differences in production conditions. Each country is otherwise equipped with natural resources and other climatic and geographic conditions affecting the country's production and consumption potential. It can, therefore, happen that for the production of a particular product, home countries will not have a sufficient supply of raw material, which then becomes a component of imports. The second option is that the country is equipped with a raw material base, but on the contrary, it does not have the means to process it, and thus it will become an export component. (Carpenter, et al., 2012)

3.3.1 Sugar trade

Sugar is an essential commodity that is produced in more than 100 countries in the world. It also forms a large and irreplaceable part of the global food market. From the perspective of the history of commodity exchanges, sugar is one of the longest traded commodities at all. Despite this fact, however, less than half of global production is traded on the open market. The reason is that most countries that grow sugar cane or sugar beet use their sugar and export more than just surpluses. At around the world, about 70% of the sugar produced is consumed directly in the producer country, which means that even minimal changes in domestic consumption have a significant effect on the price of sugar. There are also numerous barriers to trade in the sugar market, such as import duties, quotas, and other state regulations. (Research by the Australian Bureau of Agricultural and Resource Economics and Sciences, c2017)

Figure 6: World production and export of raw centrifugal sugar in 2014



Source: Own elaboration based on data from Faostat (2019)

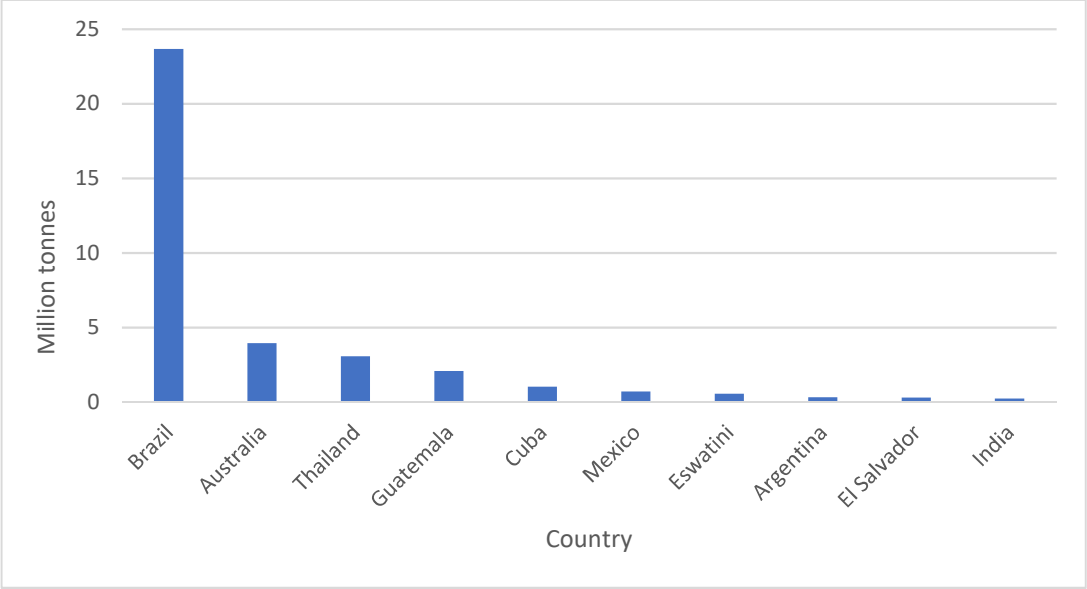
As previously mentioned, most sugar production is consumed in the county of its origin. Only a bit more than 20% of world sugar production in 2014 was exported from one to another country. The purpose of countries to use mainly sugar from their own production can be a result of achieving the greatest possible self-sufficiency.

3.3.2 Major exporters and importers of sugar

Export of raw centrifugal sugar

Export can be explained as goods produced in one country and sold to a customer in another country. Exports of money to the producer country; for this reason, many economists believe that the country's fair trade balance means that more exports are sold than buying imports. Exports can be challenging to sell in some countries because importers can take various protective measures such as import quotas and tariffs. Most governments seek export promotion, while they have different import positions. (Farlex Financial Dictionary, c2012a)

Figure 7: Top 10 exporters of raw centrifugal sugar in 2016



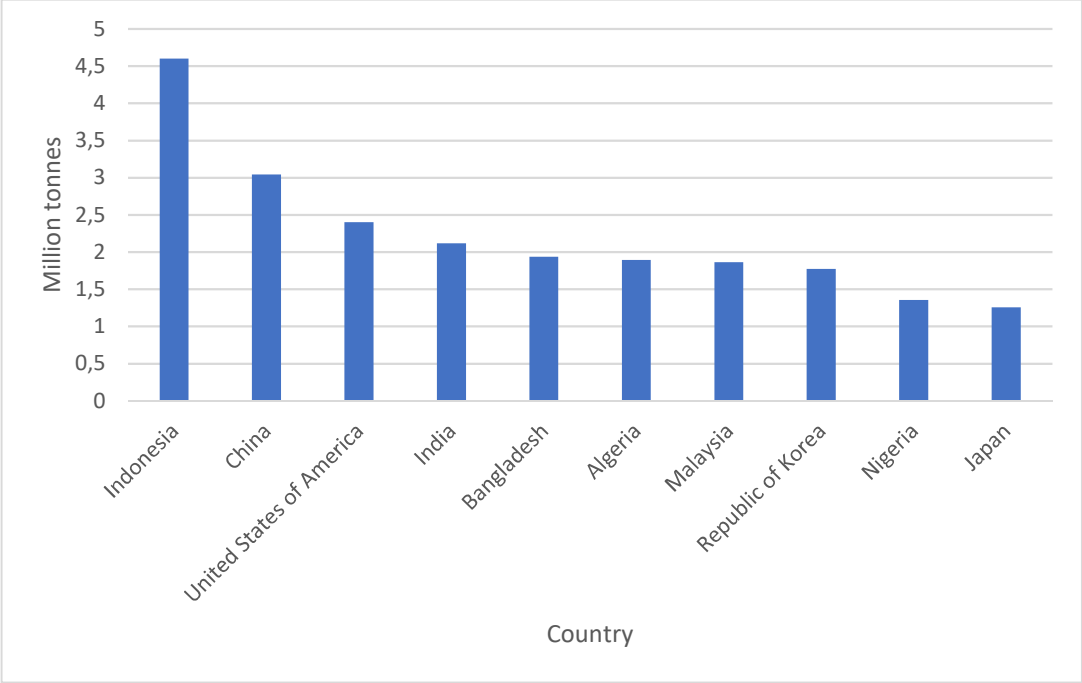
Source: Own elaboration based on data from Faostat (2019)

From the first look at figure 7 is visible that the majority of raw centrifugal sugar is exported from Brazil with a volume of more than 23 million tonnes in the year 2016. On the second and third position is Australia and Thailand, respectively. Leading export position of raw centrifugal sugar is for Brazil significant. Thus the difference between the first two world leaders is around 20 million tonnes.

Import of raw centrifugal sugar

Goods produced in a country other than that in which it is sold. Imports bring money to the producing country and can remove money from the country where the goods are sold. For this reason, many economists believe that the proper trade balance of a nation means that more exports are sold than buying imports. Some countries have created various barriers to trade against imports, in particular, import quotas and tariffs. Most governments seek export promotion while having different import positions. (Farlex Financial Dictionary, c2012b)

Figure 8: Top 10 importers of raw centrifugal sugar in 2016



Source: Own elaboration based on data from Faostat (2019)

Indonesia was the world biggest importer for the year 2016 with more than 4.5 millions tonnes of import raw centrifugal sugar as it is visible in Figure 8. On the next positions are China, United States of America, India, Bangladesh, respectively. In this figure, there are not as significant differences between importers as it was with exporters in Figure 7. Anyway, Indonesia's import is higher by 1.5 million tonnes than China's import in the year 2016.

3.3.3 **Development of price of sugar**

The current form of the world sugar market is mainly influenced by the liberalization of the agricultural commodity market. A significant proportion of world sugar production is consumed in domestic markets. The rest is traded in the world, mainly on the basis of long-term bilateral agreements or on preferential terms. Since only a small part of world production is freely tradable, small changes in production and country policies have a strong tendency to influence the global sugar market. As a result of this phenomenon, sugar prices on the world market are also unstable. (Taylor, 2016)

Unlike other essential agricultural commodities, current sugar prices are relatively high. Growing sugar production, in response to rising sugar prices, requires considerable investment in processing facilities. Sugar production does not significantly affect the price of sugar in the short term, but the price of sugar responds to changes in consumption. (Taylor, 2016)

The form of sugar trading is like most agricultural crops through future contracts, which are financial derivatives where the parties undertake to buy or sell a certain quantity of a given commodity at a certain date at a predetermined price or CFD's traded exclusively on organized markets. Commodity exchanges deal with two basic types of sugar - white and raw. The most important stock exchanges on which sugar is traded are located in London, New York, and Singapore. (Čermák, 2009)

3.3.4 **Trade policies and international organizations in world sugar market**

Based on international conventions and associations of states, the so-called international governmental organizations are formed, whose task is to fulfill the stated objectives and tasks under their own name and their authorities. Apart from governmental organizations, there are also non-governmental organizations that are associations of private individuals. The key role of international government institutions is the creation of institutional foundations, thanks to which international cooperation is established, using binding rules and codes. (Kučera, 2003)

The sugar market is currently one of the most politically deformed commodity markets. Sugar-producing countries strongly encourage and favor domestic producers and prevent an influx of cheap sugar by different import and production quotas, import duties or a minimum purchase price. These measures significantly distort competition on the world

sugar market, resulting in the fact that less than 50% of the world sugar trade is referred to as the free market. (Intercontinental Exchange, c2019)

The first international agreement to regulate the world sugar trade was signed in Brussels at the beginning of the 20th century and led in particular to the stabilization of world sugar prices. Followed by other important agreements, International Sugar Agreements, the first of which was signed in 1931. The further signing of international treaties continued after World War II. The aim of these contracts is to preserve world sugar prices at specified borders through export quotas. (Gudoshnikov, et al., 2004)

One of the important events in the sugar market regulation was the Uruguay Round of the GATT negotiations, which also made the most important player in world trade liberalization, the World Trade Organization (WTO). But with time, it is reported that the results of the Uruguay Round did not yield the desired results. Another important step was the WTO Doha Conference in Qatar in 2001. In particular, market access, domestic support, and export competition in the agricultural sector were discussed. The most important agreements are the agreement between the US, the EU, and ACP developing countries. This agreement allows access to products from developing countries to developed markets to promote their development. (Gudoshnikov, et al., 2004)

In the European Union, the sugar market is part of the Common Agricultural Policy (CAP). Long-term price support and the CAP trade restriction, first introduced in 1968, made the EU a net exporter of sugar beet sugar. European sugar prices are at a significantly higher level than the world sugar prices. These inequalities ended with the adoption of the new European Sugar Agreement, which should have been valid from 1 July 2006 to 30 September 2015. It aimed to reduce EU sugar exports, production and prices and also reduce import quotas. This EU regime was finally abolished on 1 September 2017. Since the beginning of October 2018, the European sugar market has been liberalized, meaning that each EU Member State can produce as much sugar as it thinks fit. (SITA, 2017)

The International Sugar Organization

The International Sugar Organization is a unique intergovernmental body dedicated to improving conditions on the world sugar market through debate, analysis, individual studies, transparent statistics, seminars, conferences, and workshops. The proactive attitude towards making ethanol from sugar crops helped promote the growing role of biofuels in the future

energy mix around the world. The ISO is based in London, the 87 member states of the ISO represent (based on data for 2017): 90% of world exports, 67% of world sugar consumption, 87% of world sugar production, and 41% of world imports. (International Sugar Organization, c2018b)

The European Association of Sugar Manufacturers

The European Association of Sugar Manufacturers through its activities aims to ensure and/or supporting sustainable sugar production for EU operators, growers, employees, and consumers, the proper functioning of the EU single market, a level playing field on the world stage. (CEFS, c2018)

3.4 Econometric analysis

Econometric analysis is a combination of econometric theory, mathematics, statistics, and also information technology for search, measurement and empirical verification. The methodology of the econometric analysis is based on a multistage abstraction based on the theory of qualitative analysis of the examined economic problem. The procedure is divided into four phases: specification, quantification, verification, and application. (Hušek, 2007)

3.4.1 Econometric model

An econometric model generally displays a real phenomenon whose object is the real system or process. The model explains, predicts and enables the management of a given real event. In econometrics, algebraic models are most often used to illustrate the real economic structure of the system of equations. (Tvrdoň, 2001)

Econometric models can consist of one or more than one equations, depending on the purpose of research. As mentioned there exist different types of models, such as single-equation models, multiple-equation models or simultaneous-equation models. (Gujarati, 2003)

The following steps show the principle of econometric model construction:

1. Economic model creation
2. Econometric model creation
3. Obtaining data and its verification
4. Parameter estimation of the econometric model
5. Model verification
6. Application or rejection of the econometric model (Gujarati, 2003)

3.4.1.1 Creation of economic model

It is important to formulate the economic model of the examined reality that captures relations between economic variables and serves to visualize economic theory in reality. (Gujarati, 2003)

The initial phase is the formulation of the economic model in which the object of the study is determined, the selection and the description of the variables used. The underlying hypothesis or assertion about the behavior of economic variables or social phenomena is defined. The output of this phase is an economic model that simplifies the reality of the problem being investigated. (Hančlová, 2012)

According to (Tvrdoň, 2001) there are three necessary steps when formulating the economic model:

1. To define the subject of research, which is expressed as an endogenous variable in the model
2. Selection of appropriate exogenous variables
3. Establishing a functional form of the model

Economic model has to fulfill specification assumption, such as the inclusion of relevant variables into the model, exclusion of irrelevant variables from the model, the selection of an appropriate functional form of the model, and no simultaneous relationship between the exogenous variables or between the endogenous and exogenous variables. Thus, a defined economic model is used for the confrontation of economic theory with reality. (Čechura, et al., 2017)

$$y = f(x_1, x_2, x_3, x_k) \quad (1)$$

where:

y … endogenous/explained/dependent variable

$x_{1\text{-}k}$ … exogenous/explanatory/independent variables

3.4.1.2 Creation of econometric model

At the end of the model formulation phase, an econometric model is created by introducing a random component ut, which will build hypotheses on the nature of the distribution of this disorder. Thus, the deterministic model becomes stochastic. (Hančlová, 2012)

The econometric model includes a random component that includes the effect of all other variables on dependent variables that are not included in the model. It also contains measurement errors and distortions resulting from the inappropriate type of function, referred to as the letter u. (Čechura, et al., 2017)

The econometric model has three fundamental differences from the economic model. The econometric model contains a stochastic variable as it was mentioned above, has specific functional form and contains parameters. (Hušek, 2007)

The econometric model can be mathematically expressed as following:

$$\beta_{11} y_{1t} = \gamma_{11} x_{1t} + \gamma_{12} x_{2t} + \cdots + \gamma_{1k} x_{kt} + u_{1t} \quad (2)$$

where:

β … parameter of endogenous variable

γ … parameter of exogenous variable

y_t … endogenous variable at time t

$x_{1t\text{-}kt}$ …exogenous variables at time t

u_t … random/stochastic component

The specification means the formulation and construction of the model. It is a combination of a theoretical model with available information from economic reality. When specifying a model, it is often necessary to use a variant specification and, on the basis of the model, experiment with selecting the most appropriate shape of the model. The essential

points of the specification are the right selection of the mathematical form of the model, classification and determination of all variables which are included in the econometric model, and appraisement of size and direction of estimated parameters of the econometric model. (Fiala, 2008)

1. **Right selection of mathematical form of the model**

Single-equation model has the character of a stochastic regression model, depicts one explained endogenous variable depending on one or more explanatory, exogenous or delayed endogenous variables and the random component (Hušek, 2007).¨

Multiple-equation model consists of more than one endogenous variables. Each endogenous variable on the model has its own equation and each equation can be examined as a single equation model (Hušek, 2007).

Simultaneous model, contains interrelationships between variables, can contain both stochastic and non-chaotic equations (Seddidhi, et al., 2000). This type of model is based on the fact that the endogenous variables that are not delayed appear in the individual equations of the model in a simultaneous role, both as explanatory and explanatory variables, and are intended to address all equations at one time (Hušek, 2007).

2. **Classification and determination of all variables which are included in the econometric model**

Endogenous variables, denoted by y, are explained by the model, so they are also called as explained variables. Their values are generated by the model. **Exogenous variables**, denoted by x, are those variables that explain endogenous variables, so they are also called explanatory variables. The external environment is gong to be described by the model and is characterized by considerable dynamics of relations between variables, so static models are usually not sufficient and the model needs to be dynamized. The model can be dynamized using delayed variables, both exogenous and endogenous. A set of exogenous variables, delayed exogenous variables, as well as delayed endogenous variables are called as **predetermined variables.** (Čechura, et al., 2017) **Random variables**, each equation contains only one random component. It is made up of three components that act at once and

can not be distinguished from each other. It is the action of all factors on endogenous transformation that were not included or neglected in the model, as well as the observational errors that arise when measuring the variables used, as well as the errors resulting from the simplification of the shape of the respective function. The random variable can be calculated as the deviation of the actual value of the endogenous variable from its theoretical value. (Hušek, 2007; Tvrdoň, 2001)

3. **Appraisement of size and direction of estimated parameters of the econometric model**

Economic theory determines the signs of parameters. Based on that, the decision of the sign of specific parameter can be determined as positive or negative. It is also possible to determine the interval of expected values of the estimated parameters. (Hušek, 2007)

3.4.1.3 Obtaining data and its verification

Model quantification is used to estimate numerical parameter values. This phase begins by gathering and editing statistical data. Data are typically the nature of quantitative statistical observations of the non-experimental nature. They are not explicitly generated for model estimation. They can be of a different kind, such as cross-sectional, panel or time series data that are most commonly used. Quality of the results of the econometric analysis affects not only the quality of the obtained data but also the specification and verification of the econometric model. These two phases require not only the knowledge of the relevant economic theory but also the knowledge and experience related to the functioning of the particular system being studied. (Hušek, 2007)

There are three types of data in econometrics, namely time series, cross-sectional data and panel data (Krkošková, et al., 2010):

Time series provides information about the numerical values of variables in consecutive periods of different lengths, most often the yearly data with which it is most commonly used (the value is recorded regularly every year). In addition, they are quarterly, monthly or daily data (Krkošková, et al., 2010; Hušek, 2007). The time index t is often used for marking, and the symbol T is used for the total number of observations (Cipra, 2008).

Cross-sectional data represent observations of variables in the same period, but in more subjects, cross-sectional data have the character of spatial data (Hušek, 2007). For cross-sectional data, it is not important to arrange them so that they can be sorted arbitrarily (Cipra, 2008).

Panel data is an important type of statistical data, which is generated by repeating a sample survey with a predefined set of questions for the same group of respondents in different periods (Hušek, 2007).

3.4.1.4 Estimation of parameters of the econometric model

When selecting a suitable method, it is necessary to take into account the purpose and character of the model, and the demands of the method on the quality and quantity of the data. The most well-known parameter estimation methods include (Fiala, 2008):

a) Ordinary Least Square method
b) Generalized Least Squares method
c) Two-stage Least Squares method

The most used is the Ordinary Least Square method (OLSM) which will be explained in more details in the chapter called Ordinary Least Square method.

3.4.1.5 Verification of the econometric model

If the model is estimated by using adequate econometric methods and techniques, its verification follows. Verification means verifying that the estimated parameters are in accordance with the initial theoretical assumptions using suitably chosen test criteria. The quality of the results of the econometric analysis influences both the data and the specification and verification of the econometric model, which require knowledge of the relevant economic theory (Hušek, 2007).

3.4.1.5.1 Mathematical verification

The mathematical verification serves to assess the correctness of the calculation of the parameters, which is verified by the fact that the average value of the explanatory variable is equal to the theoretical value obtained by fitting the average values of the explanatory model variables into the estimated equation. (Čechura, et al., 2017)

3.4.1.5.2 Economic verification

Economic verification is based on a priori economic criteria or constraint and is important for the economic interpretation and usability of quantification results. The accuracy of the signs and the numerical values of the estimated parameters are verified. If estimates are in line with assumptions about the signs and values of the individual parameters, they can be interpreted in accordance with the theoretical economic assumptions. The estimated econometric model thus becomes a corresponding, simplified representation of the economic problem or system under review. If the signs or values of the estimated parameters do not match the initial economic assumptions, it is necessary to specify the model or its individual equations in a different way. The reason is often the inadequate empirical data used to estimate the model, but the non-fulfillment of some assumptions required for the use of an econometric estimation method. (Hančlová, 2012; Hušek, 2007)

3.4.1.5.3 Statistical verification

Statistical verification is used to assess the statistical reality of the estimated parameters and the entire econometric model. Using statistical tests, the accuracy or significance of the quantification results obtained from one observation selection based on statistical induction is verified. (Hušek, 2007)

The most commonly used statistical verification criteria include standard errors of estimated parameters and multiple determinations. Furthermore, the statistical significance of the estimates at the level of significance is tested by means of the t-test and the F-test. Given the statistical criteria, a priori economic constraint is a priority. If the signs or the size of the estimated parameters are inconsistent with the theoretical economic criteria, we will deny them even if they are statistically significant and the model shows a significant degree of compliance with the observed data. (Hušek, 2007)

Testing the significance of the estimated parameters

The essential requirement is that the random vector u has a normal distribution with a zero mean vector and a scalar covariance matrix

$$u \sim N(0, \delta^2 I_n) \tag{3}$$

The t-test is used to examine the significance of the estimated parameters.

First, the root of the scatter estimates is expressed on the diagonal of the covariance matrix

$$s_{bj}^2 = s^2 x^{ij} \tag{4}$$

These values are also estimates for standard error estimates b_j and are valid for them

$sbj = s\sqrt{xij}$

$$s_{bj} = s\sqrt{x^{ij}} \tag{5}$$

Elements lying outside the diagonal express the estimated covariances of point estimates pairs:

$$cov(b_i b_j) = s^2 x^{ij} \tag{6}$$

The test criterion is then the ratio

$$t_j = \frac{b_j - \beta_j}{s_{bj}} \tag{6}$$

Where all j, so called Student t-distribution, have degrees of freedom. The test criterion is used especially for small selections ($n \leq 30$).

In addition, a 5% significance level is usually chosen, $\alpha = 0.05$, the assumed value of parameter β_j is assumed and for the estimates b_j and sbj the value t_j

If the rule applies:

$| t_j | > t^*_{\alpha/2}$, then we reject the zero hypothesis at a 5 percent level of significance in favor of an alternative hypothesis. If this is the case, the zero hypothesis is accepted. (Hušek, 2007)

Match the estimated model with the data

Using the smallest square method, the selective regression function can be determined to represent the maximum possible match with the observed data. Although the selective regression function selection criterion is the minimum sum of the squares of residues, it is advantageous to examine and measure the dispersion of empirical observations of the explained variable around the regression plurality. The smaller this scatter, the better the variation of the dependent variable due to changes in independent explanatory variables. The degree of compliance of the estimated linear model with empirical data is most often expressed by the multiplication factor, which reflects the magnitude of the explanation of the dispersion of the endogenous variable by all the independent variables of the model at the same time. (Hušek, 2007)

$$R^2 = 1 - \frac{s_u^2}{s_y^2} \tag{7}$$

Where:

s_u^2 … the residual variance, given by formula:

$$s_u^2 = \frac{\sum_{t=1}^{n}(y_t - \hat{y}_t)^2}{s_y^2} \tag{8}$$

Where:

s_y^2 … variance of endogenous variable, given by formula:

$$s_u^2 = \frac{\sum_{t=1}^{n}(y_t - \bar{y}_t)^2}{s_y^2} \tag{9}$$

Where:

y_t … real values of endogenous variable

$\hat{y}_t$ … theoretical values of endogenous variable

$\bar{y}_t$ … real values average of endogenous variable

n … length of time series

The R^2 value ranges from zero to one. If there is an extreme that all residues are zero, $R^2=1$ and the variables of dependent variables are 100% explained by changes in the variables independently. The opposite extreme is R2 = 0, where the model is not explained by explanatory variables. (Hušek, 2007)

Additionally, a Corrected Multiple Determination Coefficient (R^2 adjusted) is used, which is an impartial version of the R^2 estimate. It is obtained by correcting the number of degrees of freedom when comparing the explanatory capability of models having different numbers of observations or containing other sets of explanatory variables. The corrected multiplying factor can be expressed as:

$$\overline{R^2} = 1 - (1 - R^2)\frac{n-1}{n-k} \tag{10}$$

Where:

k…number of degrees of freedom

For large selection files, the $\overline{R^2}$ values and R^2 values are few. However, if the number of degrees of freedom is small, the corrected determinant is generally less than R^2 and may even have negative values. In this case, its value is interpreted as zero and R^2 is very close to zero. The statistical significance of the model as a whole can be tested using the F-test. If the F ratio is greater than the F* value, then the zero hypothesis about the statistical insignificance R^2 in the alternative hypothesis is rejected at the selected significance level with a certain number of degrees of freedom. Conformity of the estimated data model is therefore statistically significant. (Hušek, 2007)

3.4.1.5.4 Econometrics verification

The econometric verification of the model is based on the verification of the conditions that are necessary for the successful application of econometric methods, tests, and other techniques. Using econometric criteria, we investigate the validity or authorization of the use of statistical criteria, especially in the case of a small range of observation selection. If the assumptions needed to apply a particular procedure or test are not met, then the parameter estimates do not have some of the required features, or the power of statistical tests drops to give unrealistic results. (Hušek, 2007)

Econometric criteria include, for example, autocorrelation tests for random components, multichanneliness criteria for explanatory variables, or conditions for the identifiability of the structural equations of a simultaneous model. On the basis of the above, it is clear that determining the reality of the estimated model is an important part of the econometric analysis. Practically, only the results of the quantification of the econometric model that meet all the criteria mentioned at the same time can be used. (Hušek, 2007)

Heteroskedasticity

The requirement of a classical linear regression model is the final and constant dispersion of random constituents, which is referred to as homoskedasticity. If this is the case, the term "heteroskedasticity" is used. This phenomenon usually occurs in the model from cross-sectional data where there are large changes in the values of explanatory variables. (Seddidhi, et al., 2000)

Causes and consequences of heteroskedasticity:

1. Incorrect model specification - omission of a substantive explanatory variable
2. Microeconomic cross-sectional data with large differences in values
3. Accumulation of errors with a growing explanatory variable
4. Estimation of model parameters based on group averages (Hušek, 2007)

When examining the presence of heteroskedasticity, it usually begins with graphical analysis. Depending on the development of the functional dependence of varying residual scatter, an adequate test, eg White Generalized Test, Goldfeld-Quandt Test, and others is used. (Hančlová, 2012)

Autocorrelation

Autocorrelation is a phenomenon when there is a dependence between the sequence of values of one variable, arranged in time or space. (Hušek, 2007)

$$E(u_t u_s) \neq 0\,; \quad t \neq s \tag{10}$$

This phenomenon occurs by the fact that the residual component ε_t is correlated with its delayed and future values ε_{t+k} ($k \neq 0$). Correlation over time is quite common for time-based variables, and the prefix "auto" means that this correlation occurs in one time series. (Cipra, 2008)

Causes of autocorrelation:

1. The inertia of macroeconomic time series
2. Incorrect model specification – the omission of an important exogenous variable or inappropriately chosen functional form of model
3. Measurement errors
4. Incorrectly set delay for explanatory variables
5. Incorrectly modified observed data

The presence of the autocorrelation of the residual component results in the properties of the estimates obtained inconsistent and impartial estimates or/and estimates do not have minimal scattering or/and estimates are not asymptotically robust. (Gujarati, 2003)

The estimated variance of the random component and the regression parameter is then deflected, and the hypothesis testing using the confidence interval is not accurate and disappears. (Hančlová, 2012)

Mostly, Durbin-Watson statistics are used to test the autocorrelation of first-order residues. Using the table values for a given number of degrees of freedom (so-called upper and lower limits) and calculated Durbin-Watson statistics, the interval <0; 4> is divided into 5 parts - negative autocorrelation, gray zone, auto-correlation, gray zone, and positive autocorrelation. Higher order autocorrelation can be tested, for example, using the Breusch-Godfrey test. (Hušek, 2007)

Multicollinearity

The term multicollinearity refers to the presence of more than one relationship of linear dependence between explanatory variables. It is shown that selective observations of some explanatory variables reflect small changes or differences. The existence of this dependence between the explanatory variables emerges in matrix X as a multi-collinearity. In an econometric analysis, it is essential to determine the intensity of dependence between two or more explanatory variables and not only to identify whether or not it is present. (Hušek, 2007)

The presence of high multicollinearity can be identified by quantifying a correlation matrix that contains the pair correlation coefficients of each explanatory variable (Čechura, et al., 2017).

Multicollinearity is determined by assessing pairwise correlation coefficients of the explanatory variables that take values <-1; 1>. If one of the pair correlation coefficients reaches an absolute value of greater than 0.8, there is a high multi-collinearity and needs to be eliminated appropriately. (Hušek, 2007)

The causes of multicollinearity:

1. The same trend of economic time series
2. Inappropriate selection of delayed explanatory variables
3. Unsuitable established artificial variables (zero-unit explanatory variables)
4. Non-experimental type of available data in a cross-sectional analysis

The presence of multicollinearity then causes adverse consequences such as the large variance and covariance of the estimated parameters, the influence of the individual explanatory variables on the explained variable cannot be excluded, thus can not interpret the parameters (Hančlová, 2012).

Best practices for removing multicollinearity:

- Ignoring multi-collinearity
- The omission of exogenous variables resulting in multicollinearity
- Transformation of some exogenous variables
- Use a larger data file
- Use of a priori information
- Application of the main component method. (Cipra, 2008)

3.4.1.6 Application or rejection of econometric model

If the model is validated and its practical use is decided, the model can be used in the area for which it was derived. There are many ways to apply econometric models that can be divided into three groups. The first group represents the prognostic use of the econometric

model, the second group is the area of structural analysis, and the last group of the model is the simulation of effects and results of various scenarios. (Čechura, et al., 2017)

When applying the model, the elasticity coefficients are the most commonly used in practice. Flexibility is the relative expression of the effect of the explanatory variable on the explained transformation. The elasticity is calculated according to the following formula (Čechura, et al., 2017):

$$E = \frac{\delta y_i}{\delta x_i} \times \frac{x_i}{\hat{y}_i} \tag{11}$$

Prognosis of econometric models is done in two stages. In the first stage, expected values of predetermined variables are determined in the predicted period by extrapolating trending functions. It is only in the second stage that the estimated predicted values of endogenous variables are calculated according to the equation. (Tvrdoň, 2001)

3.4.2 **Linear regression model**

A setting of propositions about some aspect of the economy is the beginning of an econometric study. The linear regression model is the most useful tool in the econometrics as it is used to study the relationship between a dependent variable and one or more than one independent variables. (Greene, 2003)

3.4.2.1 Assumptions of linear regression model

To estimate the linear regression model parameters, the most common least squares method is used for its simplicity. This method provides the best, impartial and consistent estimates of model parameters when the following assumptions are met:

- Specifying:
  - a substantive explanatory variable,
  - deleting irrelevant explanatory variables,
  - choosing the correct functional form of the model,
  - stable estimated parameters,
  - time invariance,
  - respecting the simultaneity of relations between variables
- Zero average random component u_t

- Homoskedasticity
- The absence of autocorrelation of residues
- Independent variables are non-linear and fixed in repeating files
- The lack of perfect multi-collinearity
- Normal distribution of the random component (Čechura, et al., 2017)

3.4.2.2 Ordinary Least Square method

The most commonly used method for estimating linear regression model parameters is the ordinary least squares method (Cipra, 2008). This method provides the best, impartial and consistent parameter estimates, assuming the assumptions mentioned in the previous chapter are met (Gujarati, 2003).

The essence of the ordinary least square method is to find parameters that minimize the sum of squares of the deviations of the theoretical values of the variable to its actual values, expressed by the formula:

$$min \sum_{t=1}^{n} (y_t - \hat{y}_t)^2 \tag{12}$$

If a partial derivative of formula (12) is made according to estimated parameters and set to zero the model parameters will be found. The search parameters will be determined by solving the obtained system of equations. By generating the "k" explanatory variables, the relationship will have the form (Gujarati, et al., 2009):

$$\gamma = (X^T X)^{-1} X^T y \tag{13}$$

Where:

γ … vector of estimated parameters with size of (k x 1)

X … matrix of observed values of exogenous variables with size of (n x k)

y … vector of observed values of endogenous variable with size of (n x 1)

4 Practical Part

The diploma thesis is going to focus on sugar from sugarcane mainly because Theoretical part of the diploma thesis described that sugarcane as the essential commodity for sugar production in Brazil.

4.1 Brazil overview

The Brazilian Federative Republic is the largest country in South America, both in population and in geographic size. The country occupies approximately 40% of the entire continent, making it the 5th largest country in the world. The official language is Portuguese and the capital is Brasilia. This city is located in a federal dungeon in the middle of the country and was officially inaugurated in 1960. (Braz, 2018)

Brazil may be classified as "a large middle-income country". Because the status of being a "big country" is an important dividing factor that focuses on the implications of socio-economic models, international relations and institutional capacities. A country is usually considered large if it has a large population. (Maluf, et al., 2007)

From the economic point of view, this factor is expressed in the size of the domestic market, which increases the possibility of diversification of the production base. In addition to the population, it is necessary to take into account the geographic extent, as the extent can be the result of problems related not only to the spatial distribution of people and infrastructure but also to the impacts on the availability of natural resources of regional diversity and decentralized strategies. (Maluf, et al., 2007)

Here, the "middle income" classification is distinguished economically from countries grouped under the "developing countries" euphemism, where the level of income clearly shows the mediating situation between the developed countries and other peoples that form the periphery of the global economic system. It can be assumed that large middle-income countries have significant institutional capacity across different areas of public activity. (Maluf, et al., 2007)

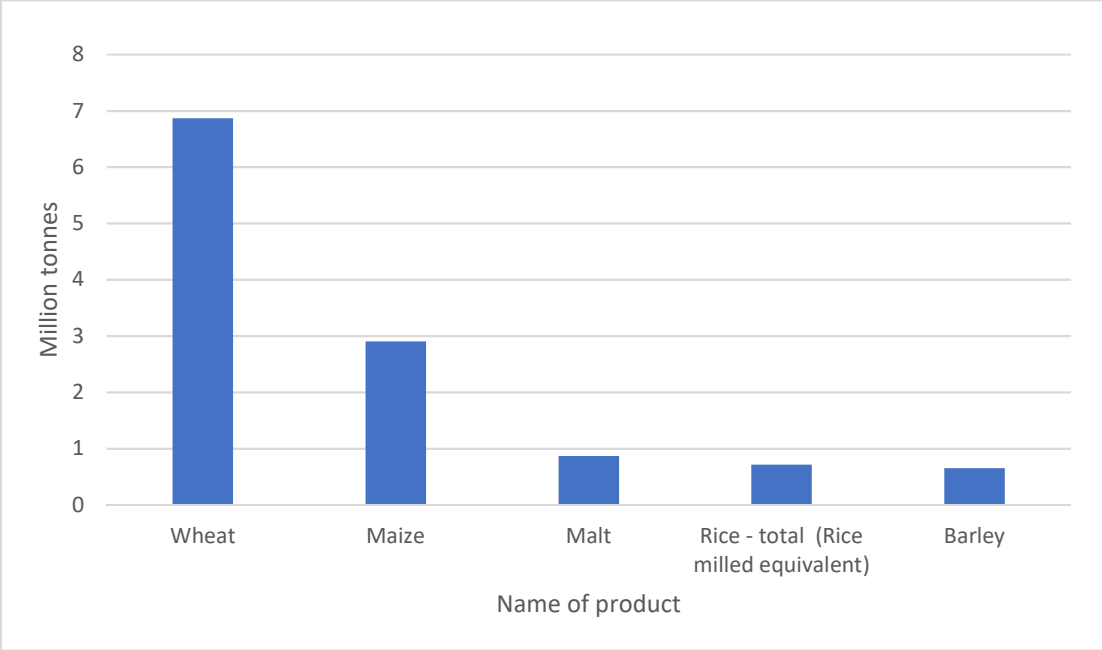
4.2 Trade balance of Brazil

Brazil is the 21st largest export economy in the world. In 2016 Brazil exported $ 182 billion and invested $ 135 million, leading to a positive trade balance. The most exported raw materials include soy, raw sugar, oil, and poultry. The country's three largest export targets are China, where Brazil exports each year at the expense of exports to the European Union, which is still second, but its share is falling sharply and the third place is the USA where Brazilian exports are at a constant level. (OEC, c2018)

Brazil exports and imports were less than a quarter of GDP, which means that its economy is significantly less integrated into international trade than other emerging market economies of similar size. The main reason for this is decades of internal-oriented politics, for which reason Brazil is on the side of global value chains and has only one trade relationship with neighboring Argentina. This situation reflects a high degree of protectionism in the country. Average import rates are almost twice as high as in Colombia and eight times higher than in Mexico or Chile. While high trade barriers protect domestic producers, they also prevent Brazil from benefiting from the many benefits of an increasingly integrated world economy. (OECD, c2019)

Two following figures show Brazil trade of crops and livestock products in the year 2016. This year is the base year in the whole thesis and the reason is mostly, that it is the latest year with available data and to get consistency this year is used as latest through the whole diploma thesis.

Figure 9: Top 5 Brazil imported agricultural products in 2016

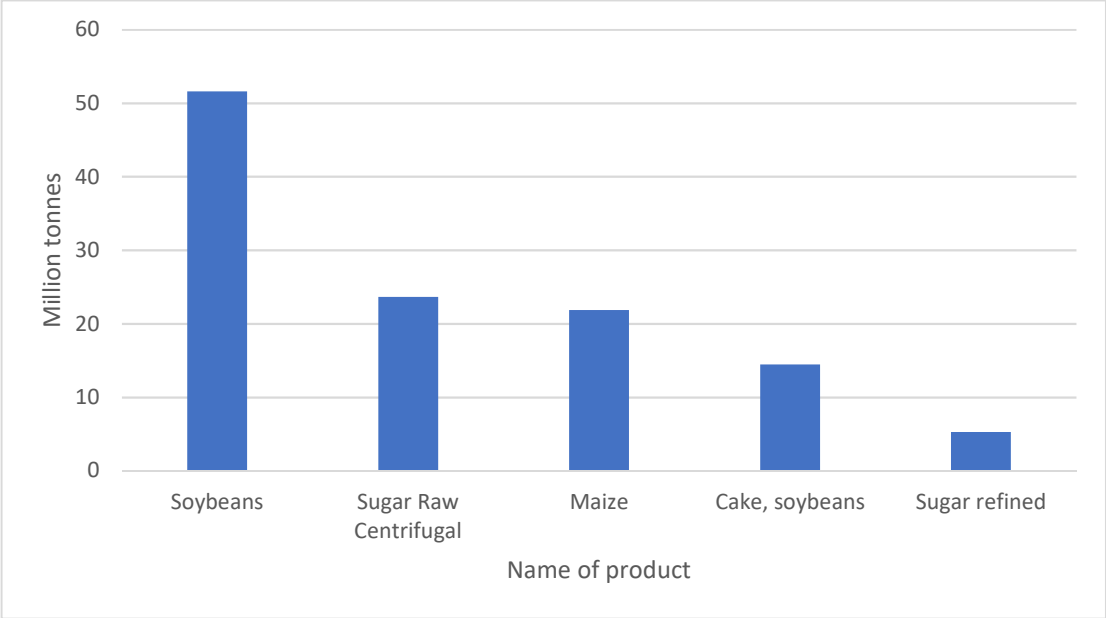


Source: Own elaboration based on data from Faostat (2019)

Wheat created the largest agriculture item imported to Brazil for the year 2016 with the quantity of almost 7 million tonnes. The second position belongs to maize with a quantity of less than half of the imported quantity of wheat. The imported quantity of malt, rice in total, and barely follows respectively. It is visible that crops are leading item in the imports while livestock and products from livestock are not represented in the top 5 Brazil imported agricultural products in the year 2016.

Figure 10 is explaining the opposite as figure 9, in the means of export of Brazil export of crops and livestock products in the year 2016. Leading position belongs to soybeans with the amount of more than 51 million tonnes. The second position in export quantity ranking is represented by raw centrifugal sugar with the amount of more than 23 million tonnes. Maize soybeans cake and sugar refined are on the next three positions respectively.

Figure 10: Top 5 Brazil exported agricultural products in 2016



Source: Own elaboration based on data from Faostat (2019)

Brazil export is higher than Brazil import in term of five most traded agricultural products in the year 2016. Raw centrifugal sugar is examined product in this thesis and its traded quantity is significant. Also, it is possible to say that sugar raw centrifugal is a valuable commodity for Brazil agriculture export.

4.3 Brazilian's sugar production and export

The hardest period of the sugar industry in Brazil came after the fall of the New York Stock Exchange in 1929. The surplus of sugar, which was not where to store, began to accumulate unexpectedly on the domestic market. At that time, the sugar industry moved from the northeast to the south and to the center of the country. Thus, due to the crisis, new solutions have been sought that would lead to the efficient use of excess sugar. Thus began the interest in the development of fuels that originate in today's sugar cane ethanol. (Hinčica, 2013)

In the 1940s and 1950s, the sugar industry in Brazil was difficult. Changing market regulation, problems in the innovation sector, and in particular, the shift of government support to the oil industry, have stagnated the sugar industry. The situation improved only after the revolution in Cuba, which had one of the most important positions in the sugar market. This opened the North American market to Brazil and extensive modernization took

place in the sector until the early 1970s. The 1970s were difficult for Brazil. After the first oil crisis in 1973, oil prices increased by more than 200% and the country dependent on oil did not know how to face its shortage. The Brazilian government has started to focus more on ethanol and has supported the entire industry with financial injections from the state budget. Thus, in 1975, the "PROETCOOL" (National Proethanol Program) was created, replacing or limiting the share of gasoline through alternative fuels, such as sugar cane ethanol, as its main goal. Proálcool endeavored to add 4.5% ethanol to gasoline. This program was not only about Brazil's self-sufficiency but also about the balance of payments, whose huge oil imports did not thrive. On the other hand, oil shocks did not affect the size of cane fields or sugar production. (Hinčica, 2013)

However, after this auspicious period of development of alternative fuels, oil prices have fallen and government support has slowly turned to the oil industry, reducing support for the ethanol industry. This situation resulted in 1990 when the IAA was suspended. The sugar cane surplus, which had previously been used for ethanol production, enabled increased sugar export growth. (Brazilian Sugarcane Industry Association, 2018a)

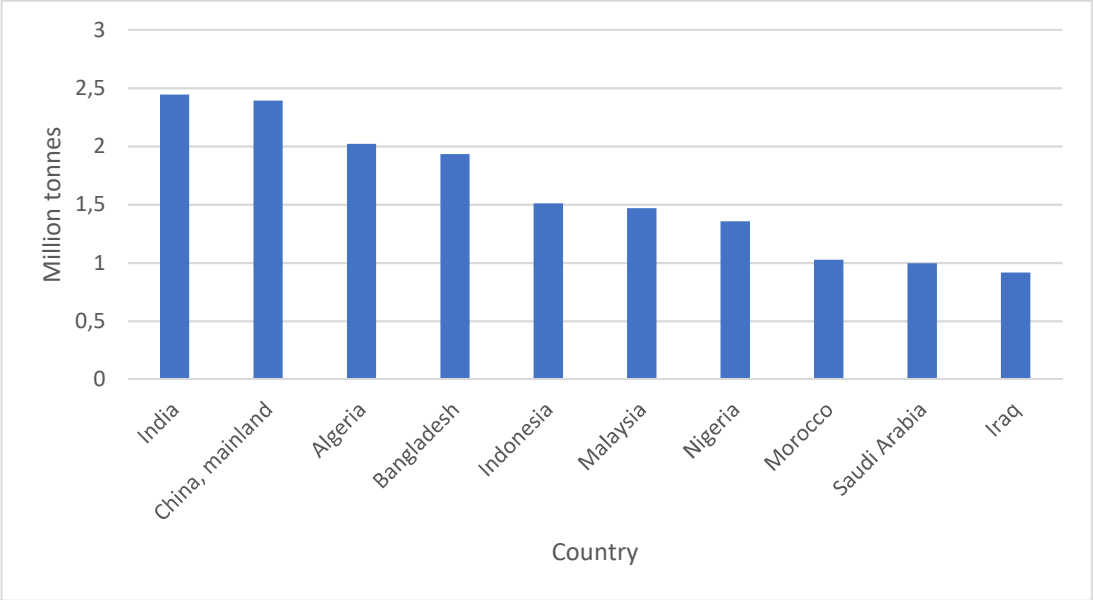
Since 1990, with a small exception at the turn of the century, the sugar industry has done well. Sugar cane was produced more every year, and after 2000 there was a rebound in ethanol production from sugar cane, again due to rising oil prices and increased use of ethanol as a fuel additive in other countries around the world. The revolution in the Brazilian car market in 2003 introduced the type of flex-fuel, which can be powered by both ethanol and petrol or any mixture of these two fuels. In 2007, São Paulo's total ethanol consumption was 34% higher than gasoline consumption. This figure reflects the national trend when ethanol production increased by 265% between 2004 and 2009. (Brazilian Sugarcane Industry Association, 2018a)

As mentioned in this work, Brazil is the world's largest sugar producer. Today, sugar cane is grown in almost every state of Brazil, with the predominance of São Paulo, where 60% of the country's production is concentrated. The country's sugar cane production in 2016 amounted to nearly 770 million tons of the total collection area of more than 10 million hectares. Sugar cane production in Brazil is divided between sugar stocks, 72% of which is exported and ethanol for domestic use. (OECD/FAO, 2017)

Approximately two-thirds of the sugar produced in Brazil is destined for foreign markets. More than 100 countries in the world depend on sugar from Brazil. These countries

include the Russian Federation, India, Iran, and the United Arab Emirates. Virtually all Brazilian exports are traded in a free market environment. Several developed countries offer preferential import quotas to Brazil, but these are small compared to Brazil's total exported sugar. (UNICA and ApexBrasil, c2017)

Figure 11: Top 10 importers of Brazilian sugar raw centrifugal in 2016



Source: Own elaboration based on data from Faostat (2019)

India, according to figure 11 is in the leading position of importing sugar raw centrifugal from Brazil in 2016 with the export value of 2.4 million tonnes. India is the top importer of Brazilian raw centrifugal sugar even though the world biggest importer of sugar raw centrifugal is Indonesia as it is displayed in figure 8. China is the number two in importing Brazilian raw centrifugal sugar with the quantity of 2.3 million tonnes which is really close to India's import.

4.4 Brazilian's sugar policies and regulations

According to the data, Brazil has about 70,000 independent farmers who produce 40% of sugar processing. To ensure a fair relationship between suppliers and processors, a sugar payment system was introduced in 1999. A non-profit organization called Consecana ensures this relationship between sugar and ethanol production in São Paulo. There are no

mutual rights and obligations between the members. (Brazilian Sugarcane Industry Association, 2018b)

In order to adapt to market developments, the rules are adjusted every five years. The price paid to sugar producers is proportional to their share of industrial income, which means that, if sugar production represents 60% of the total sugar and ethanol production costs, the sugar producer obtains 60% of the agro-industrial income. Growers get even more for sugar with a higher sugar content, which is determined by total raw sugar. The money it receives also depends on the prices of sugar and ethanol trading on the domestic and foreign markets. The Market Research Market Survey for Brazil provides a Center for Advanced Studies in Applied Economics. (Brazilian Sugarcane Industry Association, 2018b)

4.5 Analysis of chosen variables

For conduction of an econometric analysis of Brazil sugar raw centrifugal export, there were following variables included:

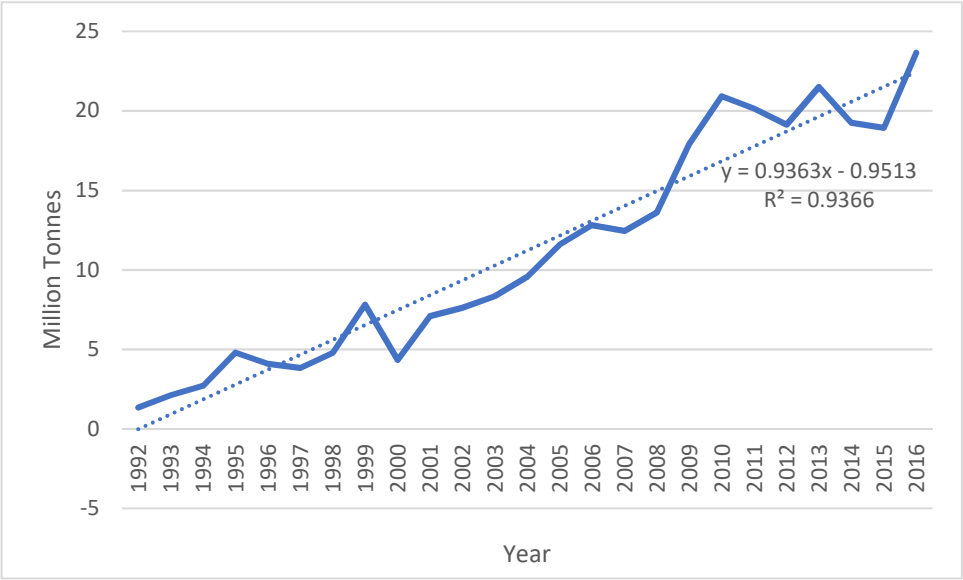
- Brazilian sugar raw centrifugal export quantity
- Brazilian sugar raw centrifugal export value
- India total population
- Indian sugarcane production
- Brazilian sugarcane production (first differences)

All variables are analyzed through data set of time series in the period from 1991 to 2016, but the size of observed values decreased by one observation due to dynamization of one variable and that caused that observed period is from 1992 to 2016.

4.5.1 Brazilian Sugar Raw Centrifugal export quantity

Figure 12 illustartrates the development of Brazilian sugar raw centrifugal export quantity during the period from 1992 to 2016.

Figure 12: Brazilian sugar raw centrifugal export quantity, 1992 - 2016



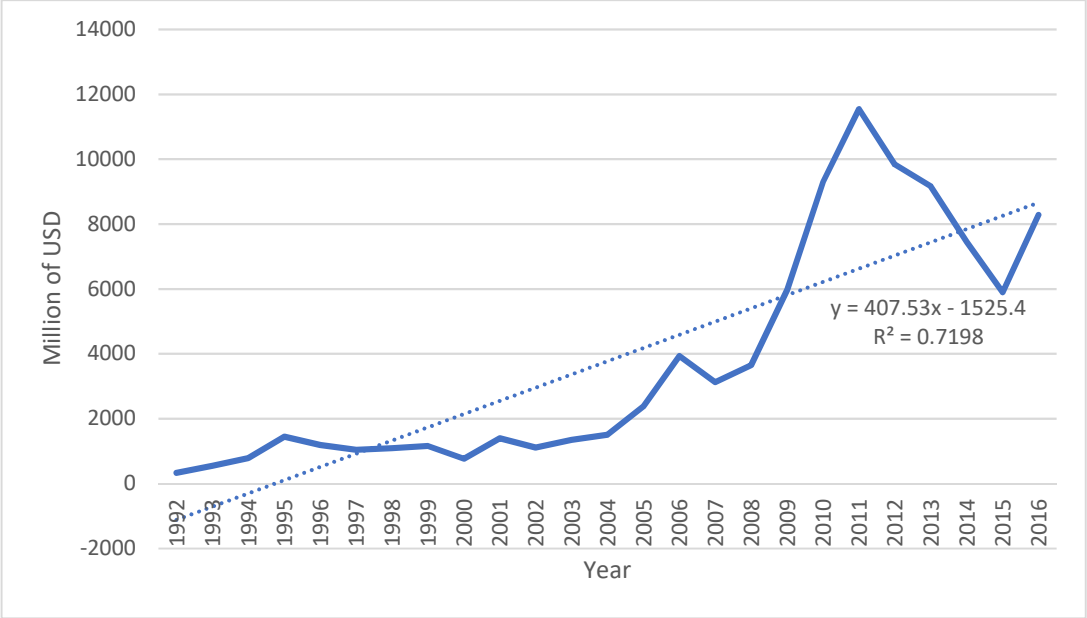
Source: Own elaboration based on data from Faostat (2019)

As it is evident from the chart, during the selected period, the export quantity of raw centrifugal sugar from Brazil indicates an increasing trend. The average annual quantity of Brazil export of raw centrifugal sugar in 11.2208798 million tonnes. In the last decade, the exported quantity rise significantly is in comparison with previous years. The lowest value is located at the beginning of the observed period with the value of 1.3 million tonnes and through the observed period, the value increased with moderate fluctuation and the final year of observed period hold the highest value (almost 23.67 million tonnes) of exported quantity. So in other words, the Brazilian sugar raw centrifugal export quantity increased during the observed period more than 17.5 times. Based on the linear trend function is possible to expect that the quantity of the Brazilian sugar raw centrifugal export with the reliability of 93.6% will increase in the following years.

4.5.2 **Brazilian Sugar Raw Centrifugal export value**

Another variable which was selected for estimation of the econometric model is Brazilian sugar raw centrifugal export value. This variable reflects the value of Brazilian sugar raw centrifugal in currency, specifically in millions of USD.

Figure 13: Brazilian sugar raw centrifugal export value, 1992-2016



Source: Own elaboration based on data from Faostat (2019)

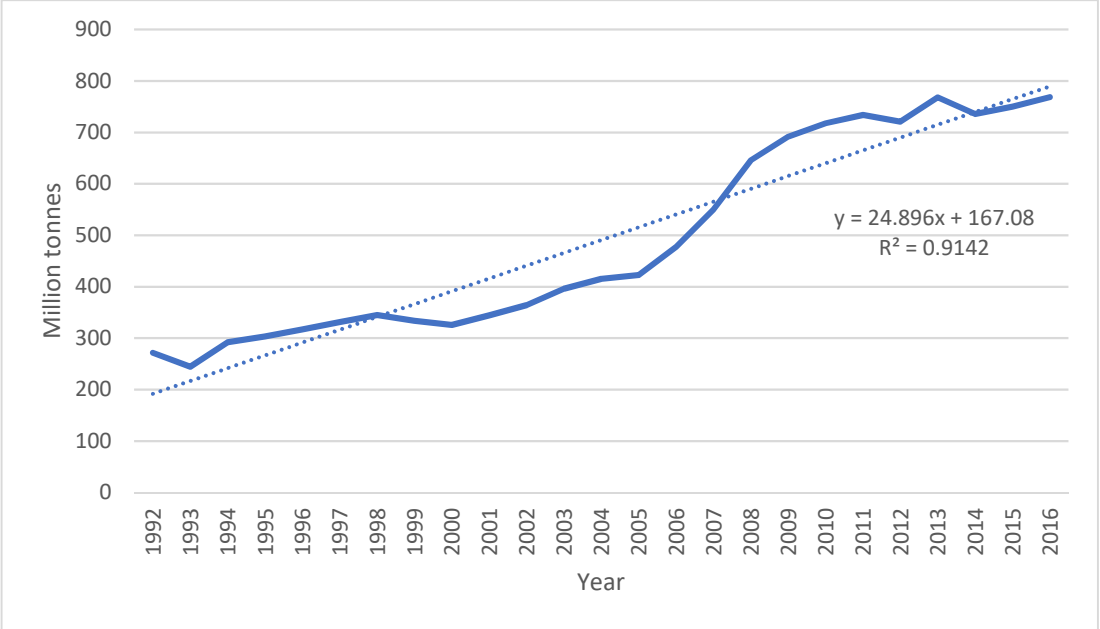
As might be seen, the export value of Brazilian sugar raw centrifugal during the selected period had been moving between the values of 330.255 – 11548.786 million USD. The average annual value of this variable is 3772.46368 million USD. The linear trend function determines the increasing trend of Brazilian sugar raw centrifugal export value in the following years with the 71.9% reliability.

In figure 13, fluctuation of values is also visible and the maximum value belongs to the year 2011. The reason can be caused by agricultural export promotion policy and signing of new preferential trade agreements, such as MERCOSUR agreements with India (2009) and Israel (2011), and three other agreements were signed with the Southern Africa Customs Union (SACU) (2008), Egypt (2010) and Palestine (2011). In 2009, was created to support micro, small and medium exporting enterprises the Export Financing Programme (PROEX). (Food and Agriculture Policy Decision Analysis, 2014)

4.5.3 **Brazilian sugarcane production**

As it was mentioned previously in this diploma thesis, Brazil is a leader in sugar cane production and according to economic theory, Brazilian sugarcane production belongs to determinants of export.

Figure 14: Brazilian sugarcane production, 1992-2016

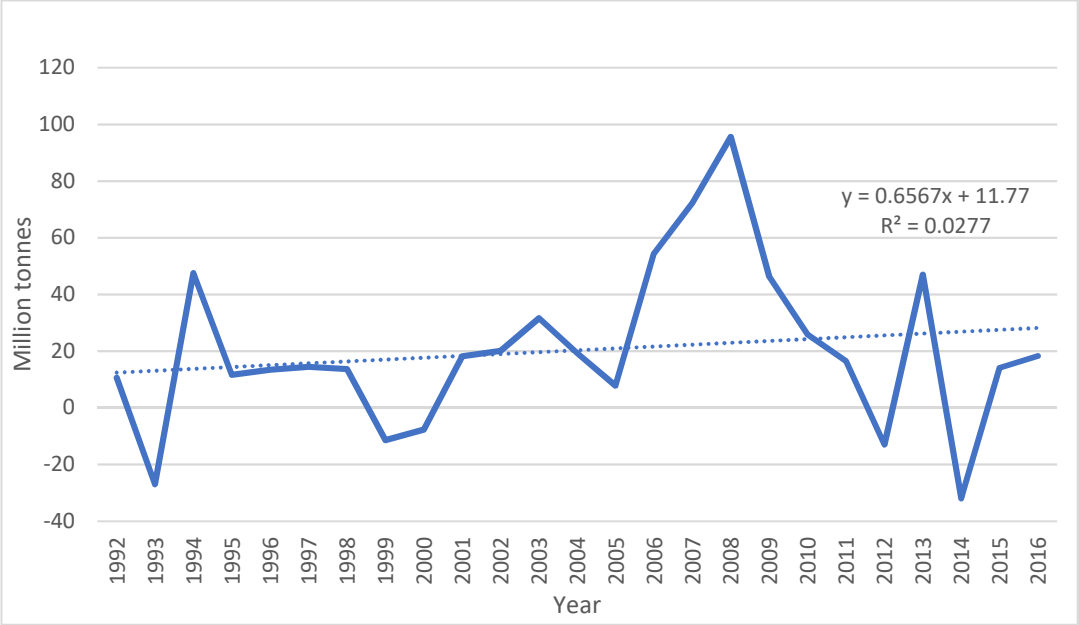


Source: Own elaboration based on data from Faostat (2019)

From figure 14 is readable that there is increasing trend and mild fluctuation of sugar cane production in Brazil during the observed period and based on trend line there will be a growth of sugar cane production in Brazil with 91% of reliability. The average value for this observed period is 490.729225 million tonnes, the maximum volume of sugar cane production was in the year 2016 with the value of 768.563715 million tonnes, and the minimum volume of sugar cane production was in the year 1993.

Figure 15 shows the first differences of sugar cane production in Brazil during the period from 1992 to 2016. These values were computed in order to model dynamization. The first difference describes the changes from one period to the next.

Figure 15: Brazilian sugarcane production (fisrt differences)



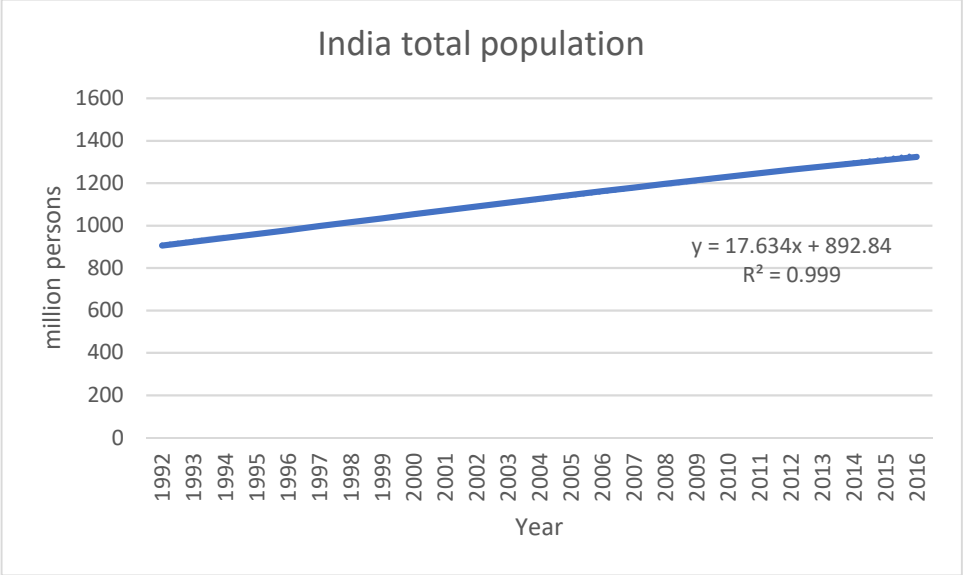
Source: Own elaboration based on data from Faostat (2019)

From the figure above is evident the size of fluctuation in Brazilian sugar cane production during the observed period within the range of values from -31.981957 to 95.592868 million tonnes and that create the difference of 127.574825 million tonnes. The average of values from figure 15 is 20.30703288 million tonnes change. The reliability of the increasing trend is only 2.7% for linear trend function. It is also visible that the positive values are higher and more frequent than negative values.

4.5.4 India total population

India total population over the period 1992 - 2016 is also one of the variables. The reason is simple, in the world raw centrifugal sugar market is not the biggest importer, but it is the biggest importer of Brazilian raw centrifugal sugar. In the same time is India in the top 10 exporters of mentioned product for the year 2016.

Figure 16:Total population of India



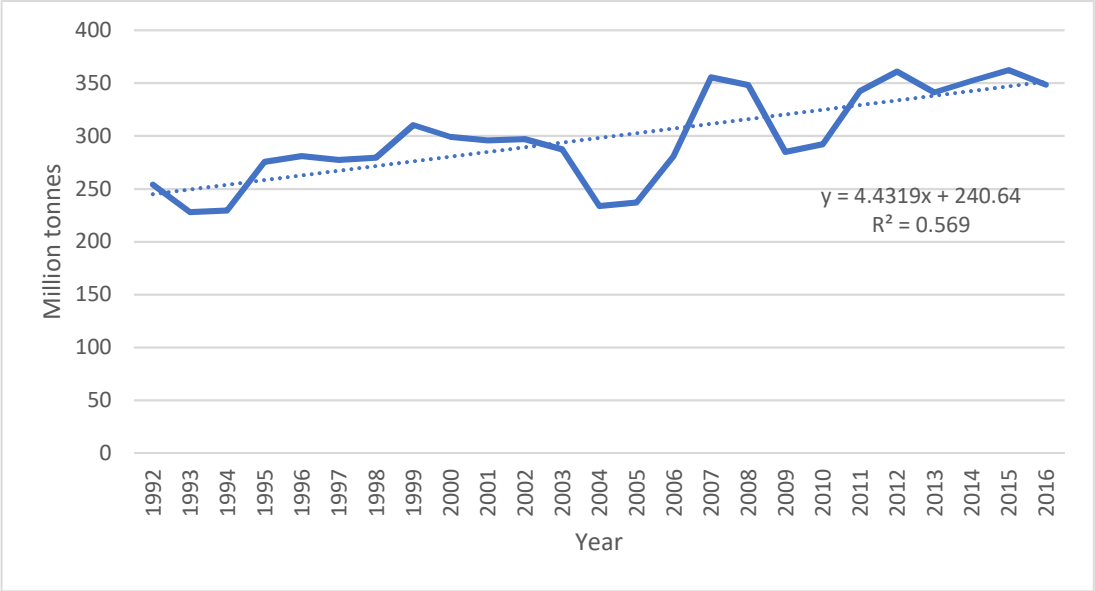
Source: Own elaboration based on data from Faostat (2019)

During the selected period the population of India increased from 906.021106 million persons to 1324.171354 million persons with an average of 1122.088054 million persons. This data was obtained from Faostat but were estimated, so the reliability of trend function is not correct. Anyway we can say that there were the growth of 418.150248 million persons during the fifteen years in the period from 1992 to 2016.

4.5.5 Indian sugarcane production

As it was mentioned, India belongs to the biggest importers of Brazilian raw centrifugal sugar. The sugar cane production in India is tight with the negative relationship of Brazilian raw centrifugal sugar export because if India produce more sugar cane than they do not need to import such a quantity of product from sugar crops.

Figure 17: Indian sugarcane production, 1992-2016



Source: Own elaboration based on data from Faostat (2019)

As it is evident from the chart, the linear trend function determines the increasing trend of Indian sugar cane production in the following years with 56.9% of reliability. The fluctuation of the values during the observed period is in the range of values from 228.03 to 362.333 million tonnes, and its average is 298.2539101 million tonnes.

4.6 Linear regression model

For modeling the relationships between the variables, the linear regression is employed. For this purpose, Gretl software has been used because this programme offers comprehensive tools for data analyzing. Annual data are used for interpretation of the time series with 25 observations from 1992 to 2016. Model construction is distributed into several steps which are mentioned in the literature review.

4.6.1 **Construction of economic model**

An economic model of Brazilian sugar raw centrifugal export quantity was constructed on the basis of economic theories and aspects of economic theories and economic reality. The economic model used in this thesis has been compiled as shown in the following formula.

$$y_{1t} = f(x_{0t}, x_{1t}, \Delta x_{2t}, x_{3t}, x_{4t})$$

Where:

y_{1t} … Brazilian sugar raw centrifugal export quantity (million tonnes)

x_{0t} … Unitary vector (constant)

x_{1t} … Brazilian sugar raw centrifugal export value (million USD)

x_{3t} … India total population (million persons)

x_{4t} … Indian sugarcane production (million tonnes)

Δx_{2t} …First differences of brazilian sugarcane production (million tonnes)

The main assumption of the economic model is the dependency of Brazilian sugar raw centrifugal export quantity as an endogenous variable on the exogenous variables. In accordance with economic theory, the relationships among variables are assumed as:

- If the Brazilian sugar raw centrifugal export value increases, the Brazilian sugar raw centrifugal export quantity increases.
- If the India total population increases, the Brazilian sugar raw centrifugal export quantity increases.
- If the Indian sugarcane production increases, the Brazilian sugar raw centrifugal export quantity decreases.
- If the first differences of Brazilian sugarcane production increases, the Brazilian sugar raw centrifugal export quantity increases.

4.6.2 **Construction of econometric model**

For the purpose of construction of the econometric model in this thesis, the one-equation econometric model is used and includes one endogenous variable (y1t) at the time t, five exogenous variables (x0t – x4t), and one stochastic variable (random component or

error) u1t. The functional form of the one-equation econometric model used in this diploma thesis is linear and expressed by the following equation:

$$y_{1t} = \gamma_0 x_{0t} + \gamma_1 x_{1t} + \gamma_3 x_{3t} + \gamma_4 x_{4t} + \gamma_2^* \Delta x_{2t} + u_{1t}$$

4.6.3 Data set

The following table contains all the gathered data for parameter estimation in the period from 1992 to 2016.

Table 1: Data set of selected variables, 1992-2016

year	Sugar Raw Centrifugal export quantity Brazil (million tonnes)	Brazilian Sugar Raw Centrifugal export value (million USD)	India total population (million persons)	Indian sugarcane production (million tonnes)	First differences of brazilian sugarcane production (million tonnes)
	y	x1	x3	x4	Δx2
1992	1.345871	330.255	906.0211	254	330.255
1993	2.132976	550.059	924.0578	228.03	219.804
1994	2.716975	787.861	942.2042	229.67	237.802
1995	4.800099	1450.653	960.4828	275.54	662.792
1996	4.090398	1190.736	978.8932	281.1	-259.917
1997	3.844224	1045.395	997.4053	277.56	-145.341
1998	4.788981	1094.687	1015.974	279.5415	49.292
1999	7.826984	1162.307	1034.539	310.3328	67.62
2000	4.346076	761.792	1053.051	299.3239	-400.515
2001	7.089873	1400.827	1071.478	295.956	639.035
2002	7.630323	1111.343	1089.807	297.2078	-289.484
2003	8.353676	1350.039	1108.028	287.3832	238.696
2004	9.565749	1510.983	1126.136	233.8618	160.944
2005	11.578985	2382.147	1144.119	237.0884	871.164
2006	12.80693	3935.802	1161.978	281.1718	1553.655
2007	12.443222	3129.809	1179.681	355.5197	-805.993
2008	13.624578	3649.553	1197.147	348.1879	519.744
2009	17.925542	5978.587	1214.27	285.0293	2329.034
2010	20.938703	9306.851	1230.981	292.3016	3328.264
2011	20.152914	11548.786	1247.236	342.382	2241.935
2012	19.147138	9836.041	1263.066	361.037	-1712.745
2013	21.521892	9163.702	1278.562	341.2	-672.339
2014	19.261113	7450.093	1293.859	352.142	-1713.609
2015	18.927791	5901.116	1309.054	362.333	-1548.977
2016	23.660982	8282.168	1324.171	348.448	2381.052

Source: Own elaboration based on data from Faostat (2019)

The correlation matrix consists of paired correlation coefficients of the selected parameters which are used to determine the presence of multicollinearity. Correlation matrix uncovers the high dependency among exogenous variables. Multicollinearity occurs when the extent of correlation coefficients is equal or higher than |0.85| in absolute value. (Allen, 2004)

Table 2: Correlation matrix of selected exogenous variables

x1	x3	x4	Δx2	
1.0000	0.8445	0.6612	0.0370	**x1**
	1.0000	0.7497	0.1798	**x3**
		1.0000	0.1364	**x4**
			1.0000	**Δx2**

Source: Own elaboration based on Gretl software and data from Faostat (2019)

Based on the output from Gretl software, there is no multicollinearity among selected variables from the data set, even though some values are close to the boundary, all values are still less than |0.85| thus the linear regression analysis can be conducted.

4.6.4 Estimation of parameters using Ordinary Least Square method

The parameters were estimated by using the ordinary least square method through elaboration through Gretl software. Table 3 describes the values that resulted from this estimation of parameters, and original Gretl output is located at the end of this diploma thesis as Appendix 1.

Table 3: Estimated parameters of selected variables

Parameters	Value
γ_0 – Unitary vector	−29.3914
γ_1 - Brazilian Sugar Raw Centrifugal export value	0.000835747
γ_3 - India total population	0.0367114
γ_4 - Indian sugarcane production	−0.0130309
γ_2^* - First differences of brazilian sugarcane production	0.00750985

Source: Own elaboration based on Gretl software and data from Faostat (2019)

Next step is to interface obtained values of estimated parameters with the econometric model. The final one-equation econometric model can be compiled as follows:

$$y_{1t} = -29.3914 + 0.000835747x_{1t} + 0.0367114x_{3t} - 0.0130309x_{4t} + 0.00750985\Delta x_{2t} + u_{1t}$$

4.7 Economic verification

The economic verification evaluates the direction and intensity of influence of exogenous variables on the endogenous variable. Furthermore, economic verification evaluates if the estimated parameters are consistent with economic theory with ceteris paribus conditions are assumed:

- If all the exogenous variables are equal to zero, the value of the Brazilian sugar raw centrifugal export quantity is −29.3914 million tonnes.
- If the Brazilian sugar raw centrifugal export value increases by one million USD, the Brazilian sugar raw centrifugal export quantity increases by 0.000835747 million tonnes, ceteris paribus.
- If the India total population increases by one million persons, the Brazilian sugar raw centrifugal export quantity increases by 0.0367114 million tonnes, ceteris paribus.
- If the Indian sugarcane production increases by one million tonnes, the Brazilian sugar raw centrifugal export quantity decreases by 0.0130309 million tonnes, ceteris paribus.
- If the first differences of Brazilian sugarcane production increase by one million tonnes, the Brazilian sugar raw centrifugal export quantity increases by 0.00750985 million tonnes, ceteris paribus.

All of the assumptions mentioned above are consistent with the economic theory expressed above. In other words, all variables are economically significant.

4.8 Statistical verification

The statistical verification verifies the significance of estimated parameters and model as a whole. The evaluation is made by comparison of calculated p-values with the significance level (α) in case of statistical verification of estimated parameters and by coefficients of determination in case of statistical verification of the whole model.

4.8.1 Statistical verification of the whole model

The coefficient of determination (R^2) is a measure which indicates how well the data are fitted with the regression line. In the case of the model, which was introduced in this diploma thesis, the value of the coefficient of determination is 0.981506 was obtained from the output of Gretl software (see Appendix 1). This value can be interpreted as the changes in the explained variable are explained by explanatory variables by 98.15%. The output also reports adjusted coefficient of determination ($\overline{R^2}$) with the value 0.977807 and this value represent the same as the coefficient of determination, but there is taken into account the number of terms in the model. So, interpretation of this value can be expressed as a variation of the dependent variable is by 97.78% explained by changes in the independent variables.

4.8.2 Statistical verification of estimated parameters

Parameters statistical significance is determined by the t-test, and these values are compared with table values. The output from Gretl software also shows p-values for each parameter, which contains information about the significance level at which a null hypothesis is rejected. These values can be found in the Appendix 1. The null hypothesis states that the parameter is not statistically significant at the level of significance which is chosen. In the case that p-value is is lower than the chosen level of significance, then the null hypothesis is rejected.

Table 4: P-values of selected variables

Parameter	P-value
γ_1 - Brazilian sugar raw centrifugal export value	<0.0001
γ_3 - India total population	<0.0001
γ_4 - Indian sugarcane production	0.1015
γ_2^* - First differences of brazilian sugarcane production	0.3456

Source: Own elaboration based on Gretl software and data from Faostat (2019)

At the significance level $\alpha = 0.01$, the variables Brazilian sugar raw centrifugal export value and India total population are statistically significant. It means that the relationships among the variables are caused by something else than by random occurrence.

The parameter Indian sugarcane production is significant on the level $\alpha = 0.11$ and first differences of Brazilian sugarcane production is not statistically significant.

4.9 Econometric verification

Econometric verification serves as a tool for checking out the conditions necessary for the application of the econometric model, and if it meets the assumptions of the linear regression model.

Table 5: Results of econometric verification

Test	P-value	sign	α	decision
Autocorrelation				
Breusch-Godfrey test				
H_0: no autocorrelation	0.232	>	0.05	The H_0 cannot be rejected => there is no autocorrelation in the model
H_1: autocorrelation				
Heteroscedasticity				
White test				
H_0: No heteroscedasticity	0.25113	>	0.05	The H_0 cannot be rejected => there is no heteroscedastcity in the model (there is homoscedasticity in the model)
H_1: Heteroscedasticity				
Breush-Pagan test				
H_0: No heteroscedasticity	0.273369	>	0.05	The H_0 cannot be rejected => there is no heteroscedastcity in the model (there is homoscedasticity in the model)
H_1: Heteroscedasticity				
Normailty				
Jarque-Bera test				
H_0: Normal distribution of residuals	0.2914	>	0.05	The H_0 cannot be rejected => the residuals are normally distributed
H_1: Not normal distribution of residuals				

Source: Own elaboration based on Gretl software and data from Faostat (2019)

Within the econometric verification scope, there are used tests of autocorrelation, heteroscedasticity as well as the test of normality. There are the overview of results from econometric testing obtained from Gretl software in table 5.

4.9.1 **Autocorrelation**

Test of autocorrelation reveals if the errors are correlated. To test this phenomenon the Durbin-Watson test is applied. The range of Durbin-Watson statistic is always between values 0 and 4. In this diploma thesis, the value of Durbin-Watson statistic of the econometric model is 2.143754. According to table values for the Durbin-Watson statistic, the lower limit is 1.04, and the upper limit is 1.77. The calculated test statistic is in the interval <1.77; 2.23> where it is possible to say that the is no significant autocorrelation in the econometric model.

Breusch-Godfrey test was run for verifying the autocorrelation of residuals of second order. The p-value according to the test is 0.232. This result can be expressed as there is not present autocorrelation of second order in the model, because the calculated p-value is higher than the significance level of α (α=0.05) and the null hypothesis is not rejected.

4.9.2 **Heteroscedasticity**

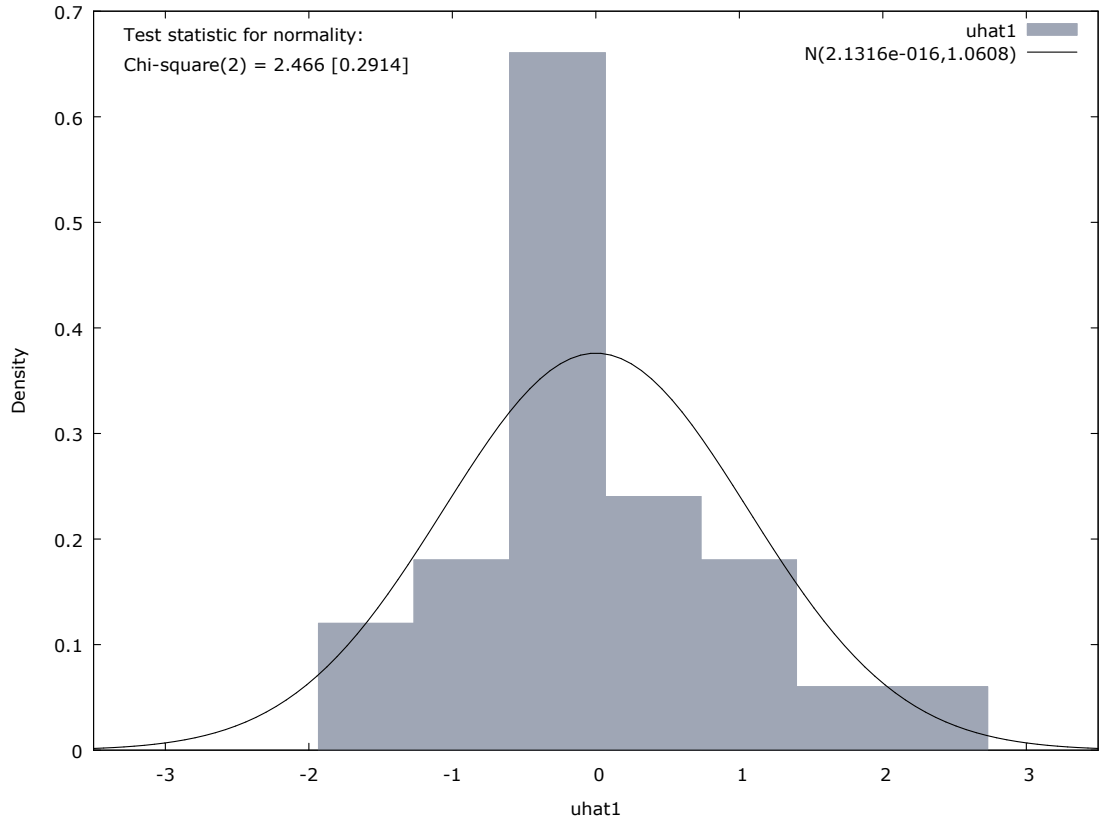
Heteroscedasticity or in other words absence of homoscedasticity is a major issue in the econometric verification. This phenomenon indicates that modeling errors are no longer independently and identically distributed. To test heteroscedasticity in the model the White test has been used. If the test statistic has the p-value lower than the significance level of α (α=0.05), then the null hypothesis is rejected and heteroscedasticity is assumed to be present in the econometric model. The White test for the model used in this thesis tas p-value with the value of 0.25113. So, this p-value is higher than the chosen significance level of α and therefore the null hypothesis can not be rejected, or the result can be also expressed as there is homoscedasticity in the model.

Based on Breush-Pagan test, which can be used for testing heteroscedasticity as well, the p-value is 0.273369. And again the p-value is higher than 0.05, which is stands for the level of significance α. Both tests demonstrated that the homoscedasticity is present in the model, the residuals have a constant scattering.

4.9.3 **Normality**

Normal distribution of residuals is one of the assumptions for linear regression analysis. Otherwise, the results of linear regression is not trustful because they are not reliable and it is the reason why the examination of residuals is a key part of all statistical modeling. For testing of normality in this diploma thesis, the Jarque-Bera test has been used. The test's null hypothesis states that residuals have a normal distribution. The calculated p-value which was obtained from the output from Gretl software (see Figure 18) and its value is 0.2914. If the obtained p-value is compared with the significance level of α (0.05) than the result is that p-value is greater and thus the null hypothesis can not be rejected. It refers that there is the normal distribution of residuals as it is also evident from the following figure.

Figure 18: The normal distribution of the residuals



Source: Output from Gretl software and data from Faostat (2019)

4.10 Application of the model

One of the econometric modeling main goals and also last step is the application of the model. In the framework of the application, there are computed and interpret elasticities of individual exogenous variables. In addition, prognoses of the endogenous variables and all explanatory variables are derived.

4.10.1 Elasticities

Elasticity is a measure which expresses a variable's sensitivity to a change in another variable. The following tables display the data set for the computation of elasticities of exogenous variables and their results respectively.

Table 6: Data set for computation of elasticities

Variable	Mean value	Theoretical value of endogenous variable	Value of parameter
x1	3637.2	11.22088	0.000835747
x3	1113.1	11.22088	0.0367114
x4	296.05	11.22088	-0.0130309
Δx2	20.307	11.22088	0.00750985

Source: Own elaboration based on Gretl software and data from Faostat (2019)

For computation of elasticities, the values from Table 6 were used. These values were obtained from Summary statistics as well as from estimated model output from Gretl software, and its outputs can be found in the Appendix 1 and 2. In the following table number 7, the results can be found.

Table 7: Calculated elasticities of exogenous variables

Variable	Elasticity result
x1	0.270903796
x3	3.641733923
x4	-0.343805294
Δx2	0.013590959

Source: Own elaboration based on MS Excel software and data from Faostat (2019)

Based on calculated elasticities, the total population of India has the most significant influence on the export quantity of Brazilian raw centrifugal sugar from all chosen explanatory variables. Interpretation of the elasticities for each exogenous variable follows:

- If the Brazilian sugar raw centrifugal export value increases by 1%, the Brazilian sugar raw centrifugal export quantity increases by 0.27% per year, ceteris paribus.
- If the India total population increases by 1%, the brazilian sugar raw centrifugal export quantity increases by 3.64% per year, ceteris paribus.
- If the Indian sugarcane production increases by 1%, the Brazilian sugar raw centrifugal export quantity decreases by 0.34% per year, ceteris paribus.
- If the first differences of Brazilian sugarcane production increases by 1%, the Brazilian sugar raw centrifugal export quantity increases by 0.01% per year, ceteris paribus.

4.10.2 **Prognoses**

To derive prognosis of the Brazilian sugar raw centrifugal export quantity for the years 2017, 2018, 2019 and 2020, the estimated equation of the linear regression model is used. The purpose is to estimate values of explanatory variables for the observations which are outside of the observed period. The first step is the process prognoses for all exogenous variables is chosen years. The second step is to the substitution of calculated prognoses into the model. This process was done by using Gretl programme tools for forecasting. The output is possible to find in Appendix 3. In a table below are values of predicted values in the next four years.

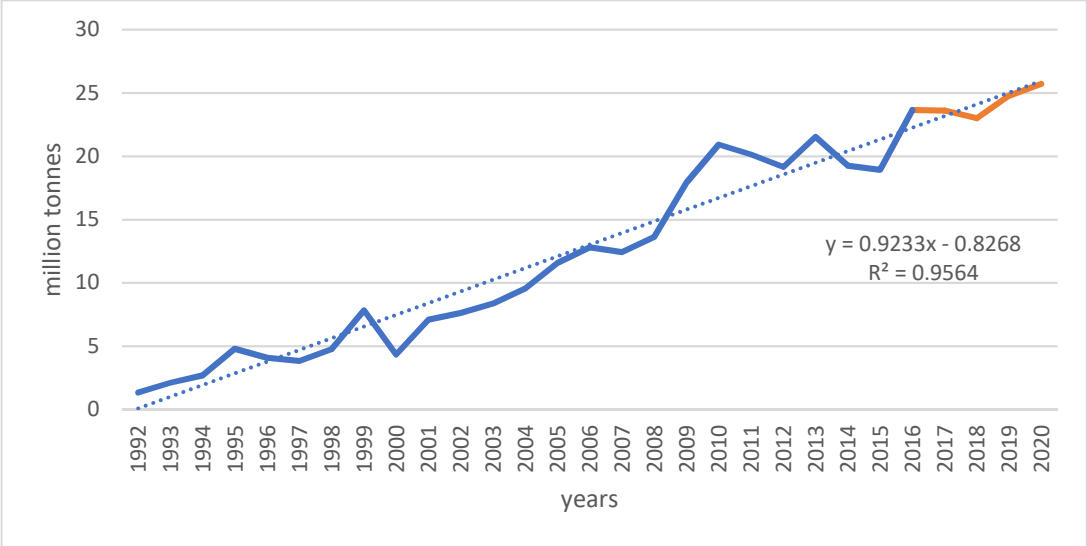
Table 8. Calculated prognoses of endogenous variable

Year	Calculated values
2017	23.6119
2018	23.0052
2019	24.7876
2020	25.7151

Source: Own elaboration based on Gretl software and data from Faostat (2019)

From the values, in table 8 can be concluded that the volume of raw centrifugal sugar exported from Brazil in the following four years will have an increasing trend. For the better illustration see figure 19 below.

Figure 19: The sugar raw centrifugal Brazil export quantity from 1992 to 2016 & prognoses for time period 2017-2020



Source: Own elaboration based on Gretl software and data from Faostat (2019)

From the figure19 it is evident that the orange color stands for values obtained from prognoses computation. The estimated value for the year 2020 is the highest with the value of 25.7151 million tonnes, but it is important to say that these estimated values are not exactly same as those in the real-life because there are much more factors and externalities which can influence real values.

5 Results and Discussion

In the practical part, there was firstly analyzed Brazil overview and trade of Brazil for the year 2016 in the mean of agricultural products. Based on findings Brazil is the 21st largest economy in the world with a high degree of protectionism in the country, and its trade balance was positive in the year 2016. the most imported agriculture product was wheat with the value of almost 7 million tonnes, and the top exported agricultural product was soybeans with the volume of 51.58 million tonnes and second most exported was sugar raw centrifugal with the quantity of 23.66 million tonnes in the year 2016. In the section called Bazilian's sugar production and export is mentioned that part of trade connected with sugar cane is created by trade with cane ethanol. Sugar cane production in Brazil is divided between sugar stocks, 72% of which is exported and ethanol for domestic use. And more than one hundred countries are dependent on the sugar exported from Brazil. There are countries such as India, China, Algeria, Bangladesh, Indonesia, respectively, in the rank of top ten importers of raw centrifugal sugar exported from Brazil. Thus raw centrifugal sugar is a significant commodity for Brazilian international trade. The world's biggest importer of raw centrifugal sugar was Indonesia but in a term of Brazilian raw centrifugal sugar was India in the year 2016 as it was mentioned. Brazil was the significant leader in export quantity of raw centrifugal sugar for the year 2016 with more than 23 million tonnes exported which is more than 20 million tonnes more than the second largest exporter, namely Australia.

Secondly, the practical part analyzed development trends of raw centrifugal sugar export quantity of Brazil and chosen export determinants and subsequently, there was constructed a one-equation econometric model. Brazilian sugar raw centrifugal export quantity indicated an increasing trend with the average value of 10.827 million tonnes. The increasing trend, based on results of prognoses, is estimated for the next four years as well. The other chosen variables, namely Brazilian sugar raw centrifugal export value, the total population of India, sugar cane produced in India and first differences of Brazilian sugar cane production indicated increasing trend as well and their averages are 3637.2 million USD, 1113.1 million persons, 296.05 million tonnes, and 20.307 million tonnes, respectively. The one-equation model consists of one endogenous variable, Brazilian sugar raw centrifugal export quantity in this diploma thesis, and Brazilian sugar raw centrifugal export value, the total population of India, sugar cane produced in India, and first differences of Brazilian sugar cane production stand for explanatory variables. The correlation matrix

was used to detect high multicollinearity of exogenous variables. There was not detected high multicollinearity between exogenous variables. Next step was to estimate individual parameters which were after used for the final one-equation econometric model. Subsequently, the model was verified. Economic verification has assessed the intensity and direction of exogenous variables on the endogenous variable and according to the assumption formulated in theoretical part. The result of economic verification was that all the calculated values from the final model were in consensus with economic theory. Statistical verification was made for the whole model, and also for the individual parameters. The statistical verification of the model itself was interpreted as the changes in the explained variable are explained by explanatory variables by 98.15%. The model as a whole was considered as statistically significant because the p-value (F) was 5.06e-17, thus lower than a level of significance α with a value of 0.05. In the case of statistical verification of each parameter, the p-values were compared with a level of significance α. Parameters of Brazilian sugar raw centrifugal export value and the total population in India were statistically significant at the level of significance α=0.01. Indian sugarcane production was significant on the level α = 0.1, and first differences of Brazilian sugarcane production is not statistically significant since its p-value was bigger than the level of significance. In the econometric verification, there were tested the presence of heteroscedasticity, autocorrelation, and normality of residuals by use of output from Gretl programe. The calculated p-values of tests were compared with a set of hypothesis. The results of econometric verification detect that there is no autocorrelation in the model, there is homoscedasticity in the model, and the residuals are normally distributed. The last step was the application of the model. The elasticities were calculated to find which of the exogenous variables has the highest impact on endogenous variable and was found that India has the most significant influence on the export quantity of Brazilian raw centrifugal sugar from all chosen explanatory variables. The result can be interpreted as, if the India total population increases by 1%, the Brazilian sugar raw centrifugal export quantity increases by 3.64% per year, ceteris paribus. The prognoses of the endogenous variable were also performed for the years 2017, 2018, 2019 and 2020. Based on the result, the sugar raw centrifugal Brazil export quantity tend to decrease in the year 2017 to 23.6 million tonnes and 2018 to 23 million tonnes but grow is expected for years 2019 to 24.7 million tonnes and 2020 to 25.7 million tonnes.

6 Conclusion

Brazil is the 21st largest economy in the world with a high degree of protectionism in the country, and its trade balance was positive in the year 2016. Agriculture trade plays a significant part in the economy of Brazil. The raw centrifugal sugar is the second most exported agriculture commodity in the Brazilian export. Sugar cane production is the highest in the world, and it is used for the production of sugar as well as ethanol.

The first goal was to examine the biggest producers of sugar crops, foreign trade of sugar crops as well as the raw centrifugal sugar trade. From the analysis was found that the most significant producer is Brazil significantly and plays a dominant role in the export of raw centrifugal sugar. Indonesia as the biggest importer of raw centrifugal sugar as it was founded but in the detailed matrix of export from Brazil the biggest importer is India with a value of 2.44 million tonnes and on the second rank is China with almost same quantity (2.39 million tonnes) imported in the year 2016.

Another aim was to identify which determinants influence Brazilian sugar raw centrifugal export quantity and detect which of these factors has a significant impact on Brazilian sugar raw centrifugal export quantity. The determinants are represented by the Brazilian sugar raw centrifugal export value, the total population of India, sugar cane produced in India, and first differences of Brazilian sugar cane production. Based on the results from estimation of the parameters and model via Gretl programme was found that Brazilian sugar raw centrifugal export value and the total population in India were statistically significant at the level of significance $\alpha=0.01$ and sugarcane production in India was significant at the level of significance $\alpha=0.1$. Even though the first differences of Brazilian sugarcane production was not significant, it plays an important role in the development of Brazilian raw centrifugal sugar quantity exported.

In the application of the econometric model of Brazilian sugar raw centrifugal export quantity was found that the total population of India has the most significant influence. The future development of export quantity of raw centrifugal sugar from Brazil should have positive trend according to calculated prognoses for the years 2017-2020. Brazil has a unique position in this world sugar market and export of raw centrifugal sugar to more than 100 countries around the world, but there are much more factors and externalities which can influence this position. For this reason, it is crucial to develop trade agreements and maintain strong trade links with partner countries.

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8 Appendix

Appendix 1: Ordinary Lest Square Method output from Gretl software

Model 1: OLS, using observations 1992-2016 (T = 25)
Dependent variable: y

	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
Const	−29.3914	3.25341	−9.034	<0.0001	***
x1	0.000835747	0.000117560	7.109	<0.0001	***
x3	0.0367114	0.00364512	10.07	<0.0001	***
x4	−0.0130309	0.00759206	−1.716	0.1015	
d_x2	0.00750985	0.00777428	0.9660	0.3456	

Mean dependent var	11.22088	S.D. dependent var	7.120381
Sum squared resid	22.50392	S.E. of regression	1.060752
R-squared	0.981506	Adjusted R-squared	0.977807
F(4, 20)	265.3520	P-value(F)	5.06e-17
Log-likelihood	−34.15863	Akaike criterion	78.31726
Schwarz criterion	84.41164	Hannan-Quinn	80.00759
Rho	−0.189069	Durbin-Watson	2.143754

White's test for heteroskedasticity -
Null hypothesis: heteroskedasticity not present
Test statistic: LM = 17.0954
with p-value = P(Chi-square(14) > 17.0954) = 0.25113

Breusch-Pagan test for heteroskedasticity -
Null hypothesis: heteroskedasticity not present
Test statistic: LM = 5.13861
with p-value = P(Chi-square(4) > 5.13861) = 0.273369

Test for normality of residual -
Null hypothesis: error is normally distributed
Test statistic: Chi-square(2) = 2.46616
with p-value = 0.291394

LM test for autocorrelation up to order 1 -
Null hypothesis: no autocorrelation
Test statistic: LMF = 0.626302
with p-value = P(F(1, 19) > 0.626302) = 0.438484

LM test for autocorrelation up to order 2 -
Null hypothesis: no autocorrelation
Test statistic: LMF = 1.58402
with p-value = P(F(2, 18) > 1.58402) = 0.232448

Source: Output from Gretl software (2019)

Appendix 2: Summary statistics of used variables

Variable	Mean	Median	Minimum	Maximum
y	10.827	8.9597	0.97822	23.661
x1	3637.2	1480.8	256.13	11549.
x3	1113.1	1117.1	888.05	1324.2
x4	296.05	289.84	228.03	362.33
x21stdifferences	20.307	16.542	-31.982	95.593
Variable	Std. Dev.	C.V.	Skewness	Ex. Kurtosis
y	7.2600	0.67055	0.29821	-1.3256
x1	3531.8	0.97102	0.91513	-0.62892
x3	135.25	0.12151	-0.072022	-1.2342
x4	43.830	0.14805	0.053497	-1.1523
x21stdifferences	29.016	1.4289	0.56012	0.53180
Variable	5% Perc.	95% Perc.	IQ range	Missing obs.
y	1.1069	22.912	14.700	0
x1	282.08	10949.	5264.1	0
x3	894.34	1318.9	242.27	0
x4	228.60	361.88	73.678	0
x21stdifferences	-30.471	88.604	29.795	0

Source: Output from Gretl software (2019)

Appendix 3: Forecasting output for years 2017, 2018, 2019 and 2020

For 95% confidence intervals, t(16, 0.025) = 2.120

Obs	y	prediction	std. error	95% interval
2017	undefined	23.6119	0.899420	(21.7052, 25.5186)
2018	undefined	23.0052	1.55864	(19.7011, 26.3094)
2019	undefined	24.7876	1.31137	(22.0076, 27.5676)
2020	undefined	25.7151	1.06800	(23.4511, 27.9792)

Source: Output from Gretl software (2019)