Czech University of Life Sciences Prague

Faculty of Economics and Management

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Bachelor Thesis

Economic analysis of coffee commodity

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CZECH UNIVERSITY OF LIFE SCIENCES PRAGUE

Faculty of Economics and Management

BACHELOR THESIS ASSIGNMENT

David Eremiáš

Economics and Management

Thesis title

Economic analysis of coffee commodity

Objectives of thesis

Aim of this thesis is to analyse and describe coffee beans as an agricultural commodity. Theoretical part of this thesis will provide general overview about coffee plant, its processing, production, consumption and trading.In theoretical part synthesis, induction, deduction and extraction is used to provide reader with information gained by literature review and document study.
In practical part fundamental analysis, technical analysis, correlation analysis and cointegration is used to examine factors influencing price of selected commodity.

Methodology

Fundamental analysis in general examines every aspect of the trading activity, which can influence price of selected commodity. Technical analysis works with results of previous trading activities and predicts future development based on statistical factors. Correlation analysis helps to find potential relationship between two variables and specify, whether the relationship is positive or negative and how strongly one variable influences the other. Cointegration examines, whether time series variables are cointegrated by using statistical test.

The proposed extent of the thesis

40 pages

Keywords

coffee, coffee beans, export, import, production, agricultural commodity, market

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Recommended information sources

International Coffee Agreement, 2007. International Coffee Organization. London.
International Trade Center, 2001. Executive Forum 2000: Export Development in the Digital Economy, United Nations. New York.
International Trade Center, 2012. The Coffee Exporter's Guide. Third edition. United Nations. New York.

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Declaration

I declare that I have worked on my bachelor thesis titled "Economic analysis of coffee commodity" by myself and I have used only the sources mentioned at the end of the thesis. As the author of the bachelor thesis, I declare that the thesis does not break copyrights of any their person.

In Prague on 14th of March 2019 _____

Acknowledgement

I would like to thank Ing. Petr Procházka, Ph.D., MSc, for his advice and support during my work on this thesis.

Economic analysis of coffee commodity

Abstract

This bachelor thesis is focused on coffee beans agricultural commodity and its trading on commodity markets. With the use of correlation, fundamental and technical analysis, author sets the goal to determine key factors affecting the price of coffee and describe basis, impact and significance of each of these factors. The main factors are assumed to be price of substitutes (tea), amount of coffee produced, consumption and currencies values. Although there are several different aspects described in fundamental analysis, the main factor affecting the price is production.

Keywords: Coffee, coffee beans, export, import, production, agricultural commodity, market

Ekonomická analýza komodity káva

Abstrakt

Tato bakalářská práce je zaměřena na kávová zrna jakožto zemědělskou komoditu a její obchodování na komoditních trzích. Autor si vytyčil za cíl pomocí metod korelační, fundamentální a technické analýzy určit základní faktory ovlivňující cenu kávy a popsat jejich podstatu, vliv a význam. Očekávanými faktory jsou cena substitucí (čaj), množství vyprodukované kávy, spotřeba a hodnoty měn. Přestože fundamentální analýza popisuje mnoho různých faktorů ovlivňujících cenu komodity, hlavním se ukazuje být produkce.

Klíčová slova: Káva, kávová zrna, export, import, produkce, zemědělská komodita, trh

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1 Introduction

Coffee is one of the most commonly traded food industry products all over the world, even though it is produced only in some regions of southern hemisphere. It is considered an essential good and it is part of daily routine for majority of population in many regions. It has strong attitude in culture as well as in pop culture.

This thesis has been written to describe how international coffee market works and if coffee is good commodity for trading and what are the risks of its trading. Author put a big effort into description of all aspects of coffee market, its risks and key factors influencing the price. Also, a brief overview familiarize reader with basic facts about coffee planting, processing and history.

The main reason of creation of this thesis is very strong position of coffee commodity on the worldwide markets as well as its enormous consumption in some parts of the world, especially Europe and North America. Similarly to cocoa, coffee has strong position on food market, even though it is not fundamental foodstuff for human. It cannot be used as foodstuff because of its caffeine and other substances content, even so there are described several positive effects on health.

Aim of this thesis is to determine key factors influencing the price of coffee and provide useful arguments to decision, whether coffee is a good commodity for potential investors.

2 Objectives and Methodology

In this part summary of objectives of the thesis and used methods are introduced. Methodology explains procedures used in theoretical as well as practical part. Methodology is mainly focused on description of methods used in practical part.

2.1 Objectives

The goal of this thesis is to provide overall overview about coffee as an agricultural commodity on worldwide market. Its theoretical part is expected to provide reader with all information needed to understand whole process of coffee production and factors, which are affecting it. Also, it explains specific terminology and a brief history.

2.2 Methodology

In this part author explains methods used in this thesis. The goal of this thesis is to provide overall overview about coffee as an agricultural commodity on worldwide market. Its theoretical part is expected to provide reader with all information needed to understand whole process of coffee production and factors, which are affecting it. Also, it explains specific terminology and a brief history.

2.2.1 Fundamental analysis

Vonko (2017) describes fundamental analysis as follows:"*The fundamental approach is based on an in-depth and all-around study of the underlying forces of the economy, conducted to provide data that can be used to forecast future prices and market developments. Fundamental analysis can be composed of many different aspects: the analysis of the economy as the whole, the analysis of an industry or that of an individual company.*".[1] From this definition we can derive, that fundamental analysis examines all possible factors to provide trader with detailed information, from which he can decide whether the value is overrated or underrated.

[1] Vonko, Dima. (2017) *Fundamental Analasis forTraders*. (online) Investopedia. Available at: https://www.investopedia.com/articles/trading/06/fundamentalapproach.asp (Accessed 17 Feb. 2019).

In case of this thesis, fundamental analysis is supposed to detect factors influencing the supply and production of coffee and through supply and demand model also affects on the price of coffee.

2.2.2 Correlation test

Correlation analysis is used to decide, whether two variables are dependent or independent on each other and to measure the strength of such dependency. The aim of correlation analysis is to find linear relationship between two variables in time series data. Result of such analysis is correlation coefficient, noted by letter "r" or "ρ", while value of this coefficient lies in interval ⟨-1;1⟩. The value of correlation coefficient indicates, how strongly are variables x_1 and x_2 dependent on each other. As absolute value of correlation coefficient is approaching 1, the dependence is getting stronger, while in case when correlation coefficient is approaching 0, the dependence is getting weaker. In case $-1 \leq r < 0$, we are talking about negative correlation, where positive change of x_1 causes negative change of x_2. In case $0 < r \leq 1$, we are talking about positive correlation, where positive change of x_1 causes positive change of x_2.

2.2.3 Technical analysis

Hayes (2019) in his article states:"*Technical analysis is a trading discipline employed to evaluate investments and identify trading opportunities by analyzing statistical trends gathered from trading activity, such as price movement and volume. Unlike fundamental analysts, who attempt to evaluate a security's intrinsic value, technical analysts focus on patterns of price movements, trading signals and various other analytical charting tools to evaluate a security's strength or weakness.*"[2] Even though his article is focused on stocks mainly, he states that the same principle applies for all kinds of securities, including commodities.

As we can see from the definition, technical analysis examines historical trading data by using statistical methods. Then the main difference between fundamental and technical analysis happens to be, that technical analysis examines primarily the results of trading activities and its purpose is to predict future value based on statistical trends. Similar principle as for example in analysis of time series in statistics. From statistics we

[2] Hayes, Adam. (2019) Technical Analysis Definition. (online) Investopedia. Available at: https://www.investopedia.com/terms/t/technicalanalysis.asp (Accessed 17 Feb. 2019)

know, that such predictions are useful in case of short term predictions and general trends, but for long term predictions are very inaccurate.

2.2.4 **Cointegration test**

Cointegration is state of relationship between two time series variables, in our case between price of coffee and price influencing factor. Test of cointegration is usually done by one of two procedures, which are Engle-Granger test or Johansen test. Kočenda and Černý (2014) state following definition of cointegration:*"If two time series are cointegrated, then the time series of the deviations from the cointegrating linear combination is stationary. Therefore, the cointegrating linear combination defines a long run equilibrium relationship. The existence of this equilibrium must be due to some real economic forces."*[3] For purposes of this thesis author decided to use Engle-Granger test of cointegration. This test consists of two steps.

In first step we have to check, that both time series contain a unit root. For this purpose, we will use augmented Dicky-Fuller test. Null hypothesis of this test is, that unit root is present. Our intension is to accept this null hypothesis to be able to continue to the Engle-Granger test of cointegration. To accept null hypothesis, the calculated test criterion has to be bigger than critical value for selected level of significance and test model.

If we accept null hypothesis of unit root existence, we continue to Engle-Granger test itself. Firstly, we have to choose which time series variable is dependent. Because this thesis is trying to define factors influencing price of coffee commodity, dependent variable will be price of coffee. At the end of test, if asymptotic p-value is higher than level of significance α, we can state that cointegration between dependent and independent values exists.

[3] KOČENDA, Evžen a Alexandr ČERNÝ. *Elements of time series econometrics: an applied approach*. 2nd ed. Prague: Karolinum, 2014. ISBN 9788024623153. p.155

3 Theoretical part

After statement of the topic and description of methodology, theoretical part should provide reader with relevant information needed for understanding of the concept of selected commodity trading and movement of its price. Coffee crops, beans production, processing, leading producers as well as companies are mentioned and described.

3.1 Commodity

Commodities are one of the most traded securities in the world. From linguistic point of view, commodity could be described as follows: *"A raw material or primary agricultural product that can be bought and sold, such as copper or coffee."*[4] More specific definition, which is much more usefull for purposes of this thesis, describes commodity as follows: *"A commodity is a basic good used in commerce that is interchangeable with other commodities of the same type. Commodities are most often used as inputs in the production of other goods or services. The quality of a given commodity may differ slightly, but it is essentially uniform across producers. When they are traded on an exchange, commodities must also meet specified minimum standards, also known as a basis grade."*[5] These two definitions could be sumed into assumption, that commodity is a product or material, that can be used or consumed without any other processing, or can be processed to become secondary product. Also we can conclude, that commodity is a good of more or less unified quality and price, which is sold in standardised amounts. These standardised amounts, or units, can differ for differents commodities. Standardised unit for coffee on the market is bag, which represents 60 kilograms of green, dried, not roasted coffee beans.

We can divide commodities into several categories. If we are looking for types of commodities according to sectors of economy, we could state categories such as agricultural commodities or industrial commodities. If we look at the main usage of commodities, they could be divided into four categories, which may slightly overlap.

[4] Oxford dictionaries | English. (2018). Commodity | Definition of commodity in English by Oxford Dictionaries. (online) Available at: https://en.oxforddictionaries.com/definition/commodity (Accessed 18 Jun. 2018).

[5] Staff, I. (2018). *Commodity*. (online) Investopedia. Available at: https://www.investopedia.com/terms/c/commodity.asp (Accessed 18 Jun. 2018).

3.1.1 Metals

Metals are group of elements defined by specific characteristics. Metals are good conductors of electricity and heat conduction, are malleable and ductile. Examples of metals commodities are gold, silver, aluminum, iron or magnesium.

3.1.2 Agricultural commodities

Agricultural commodities are basic products of biological production of both plants and animals. These commodities could be farther divided into groups like seeds, meat, oils, milk products and many others. Coffee, as the main subject of this thesis, belongs to agricultural commodities and is often classified as beverage commodity, together with tea, cocoa beans and others.

3.1.3 Industrial commodities

Industrial commodities could be defined as side products of processing of both agricultural and energetic commodities. These are then used in production of different goods. As an industrial commodity could be considered bioethanol, cellulose or methanol.

3.1.4 Energetic commodities

Energetic commodities are usually raw materials used for production of energy. This energy can be electricity, heat, radiation or any other type of energy. Materials considered as energetic commodities are for example coal oil and its derivates, uranium, coal or natural gas.

3.2 Commodity markets

Market is generally a place, where seller and buyer meet to realize trades. Usually markets follow free market principals, even tough they are being regulated somehow. The essential principle is, that good or any other product of trading has to be subject of scarcity. Over the world, there are two main ways of trading.

3.2.1 Exchange markets

Exchange markets are usually, but not necessarily, physical places, where buyers and sellers realize their trades following certain rules and trading hours. Nowadays big

portion of trading is done through electronic trading platforms, which are incorporated by these exchange market. Thanks to digitalization of market the trades can be realized and documented almost in real time. Prices of buyers and sellers are recorded and shown, which allows other participants either to sell or buy according to reported price, or to make own offer.

3.2.2 Over-the-Counter markets

Duffie (2012) describes Over-the-Counter markets in his publication as follows: *"An over-the-counter (OTC) market does not use a centralized trading mechanism, such as an auction, specialist, or limit-order book, to aggregate bids and offers and to allocate trades. Instead, buyers and sellers negotiate terms privately, often in ignorance of the prices currently, available from other potential counterparties and with limited knowledge of trades recently negotiated elsewhere in the market. OTC markets are thus said to be relatively opaque; investors are somewhat in the dark about the most attractive available terms and about whom to contact for attractive terms. Prices and allocations in OTC markets are to varying extents influenced by opaqueness and by the role of intermediating brokers and dealers.*"[6] From his description we can see certain concern about OTC markets. Since there is no central mechanism of trading, there can't be control by higher instances. Also, if investors and sellers negotiate with limited knowledge, in ignorance of prices from other counterparties and other, higher mentioned, conditions, it leads to inconsistency of the price through the market place and nontransparent techniques.

3.3 Coffee commodity

Coffee beans as a commodity can be used almost exclusively for production of different forms of products for coffee beverage preparation and for cosmetics. Even though coffee beans contain nutrients such as protein, fat and carbohydrates in sufficient amount for foodstuff usage, the amount of caffeine, which in higher amounts causes high blood pressure, excludes beans form such uses.

Coffee beans are harvested as fruit of plants from genus *Coffea*. Coffee beans for coffee production are growing almost exclusively on two species of plants, *Coffea Arabica*

[6] DUFFIE, Darrell. *Dark markets: asset pricing and information transmission in over-the-counter markets*. Princeton: Princeton University Press, c2012. ISBN 9780691138961., p.16

and *Coffea Canephora*. Each of these species requires different conditions and also the final product is different in matter of taste, smell and also caffeine content.

Most of the world coffee beans production is represented by harvest of Coffea Arabica. Usually called simply *Arabica*, this species accounts for about 70-80% of world production of coffee. The plant itself grows in tropical regions with altitude above 1000 metres and is less sensitive for temperature fluctuations between day and night. Nowadays, Arabica coffee is produced mainly in countries of South America.

The rest of the world coffee beans production is harvested from Caffea Canephora. Generally called *Robusta*, this species stands for the rest of the production. It is grown mainly in Africa and Asia and content of caffeine in its beans is higher than in case of *Arabica*.

3.3.1 **Processing of coffee beans**

Coffee processing starts by harvesting of matured coffee beans, also called coffee cherries. Coffee cherry is term determining fruit of the plant. For coffee production, only certain part of this fruit is needed. Therefore, the skin has to be removed. From now on we call this product coffee bean. After harvest the bean has white or beige colour. Right after harvest the bean contains too much water to be roasted and therefore has to be dried. After drying the beans are packaged in bags and transported to roastery, which is usually connected with process of trading transaction between farmer and roastery.

After the drying process there comes the most important part of coffee processing called roasting. This process is crucial for creation of product, which can be then grinded and used for coffee beverage preparation. Also roasting prolongs durability of the final product. The temperature and time of roasting determines the final taste of coffee beverage. Usually coffee is roasted in closed cylindrical barrel by hot air. The shape is used because of need of some stirring mechanism. This technique together with hot air method of roasting guarantees that the whole amount of coffee is roasted uniformly, and amount of incorrectly roasted beans is minimized. There is very wide range of coffee roast types, which differs mainly by the time for which beans are being roasted.

Immediately after roasting the roasted beans are cooled down by cold air. This is done in open cylindrical barrel as the beans are again being stirred. The process of cooling is important in matter of preventing the beans to absorb humidity. Roasted coffee has strong hygroscopic ability. Absorption of humidity by the beans would lead to disabling

the coffee beans from being grinded. Also, any humidity absorbed represents potential threat of mildew attack.

Next step, grinding, is optional and depends on type of final product. Since coffee beverage is being prepared by consumer with use of different techniques, companies usually produce several different products.

3.3.2 Factors influencing production of coffee

As stated before, coffee production is dependent on environment in which the coffee plant is cultivated. The most influencing factors are altitude, temperature and humidity. Coffee plant is sensitive to temperature extremes, especially to any decrease below average temperature in winter months.

Second, much more important, factor affecting production of coffee are epidemies of diseases and parasites. Flood (2009) describes relevance of such epidemies on example of African coffee production as follows:"*During the 20th century, a devastating disease (coffee wilt disease [CWD]) spread across Africa reducing yields, destroying millions of coffee trees in affected countries and costing hundreds of millions of dollars in lost earnings to farmers. The disease has also contributed to a decline in revenue for several African nations due to reduced coffee production and will be a contributory factor in any attempt at revitalization of the African coffee sector in the future.*"[7]

3.3.3 Note about history of coffee

Both species of coffee plants have their origins in central Africa, where stimulation abilities of coffee beans were known. During 13th century coffee was introduced to Yemen, where the habbit of drinking coffee was established and then spreaded to the rest of the world[8]. This fact lead to interest of coffee cultivation in greater scale. Since then, coffee became important part of trade, similarly to tea.

3.4 Producers and exporters

In terms of plant growing, coffee is produced almost exclusively in countries of southern hemisphere, sometimes called Coffee belt, which you can see in Figure 1. This

[7] FLOOD, J. *Coffee wilt disease*. Cambridge, MA: CABI, c2009. ISBN 9781845936419., p.1

[8] Ferwerda, F.P. (1976) Coffees Coffea spp (Rubiacceae). In: Simmonds, N.W. (ed.) Evolution of Crop Plants. Longman, London, pp. 257-260.

area consists of countries of South America, Africa, Asia and Australia. Generally, we can say that this area is bordered by the tropic of cancer and the tropic of capricorn. From this fact we can say, that coffee is produced in tropic zone.

In Figure 2 you can see development of production in top twelve countries (order based on data from year 2017/2018). These twelve countries stand for nearly 92,7% of total world production of coffee beans in year 2017/2018.[9]

In Figure 3 we can see development of amount of coffee exported by top twelve countries (order based on data from year 2017). These twelve countries stand for nearly 93,9% of total exports by producing countries.[10] As expectable, leading exporting countries are at the same time leading producers.

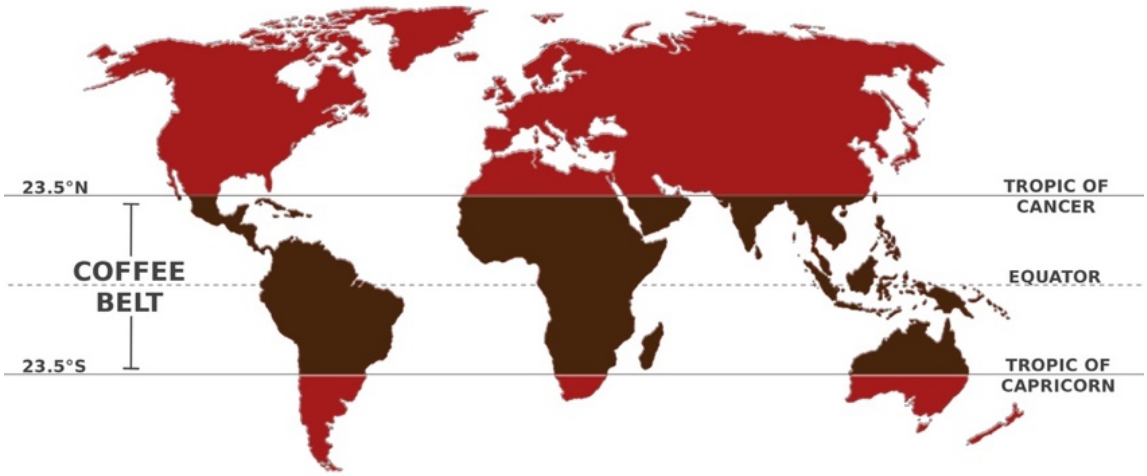

Figure 1: Growing areas of coffee beans (Source: Seasia.co: The Coffee Belt, A World Map of the Majir Coffee Producers, 2018, online, https://seasia.co/2018/01/27/the-coffee-belt-a-world-map-of-the-major-coffee-producers)

3.4.1 Brazil

Brazil, similarly to other coffee producers in South America, produces mainly arabica coffee beans. It is world leading producer of coffee beans. In Figure 2 we can see that production of coffee in Brazil has increasing trend. On the other hand, we can see significant fluctuations in production.

[9] Calculation: own, Data source: ICO, Historical Data on the Global Coffee Trade, Total Production, online

[10] Calculation: own, Data source: ICO, Historical Data on the Global Coffee Trade, Exports, online

3.4.2 Columbia

Columbia used to be the second largest producer of coffee. In Figure 2 we can see, that Columbian production is mainly stable with fluctuations between 10 and 20 million bags.

3.4.3 Vietnam

Production of coffee beans in Vietnam rapidly increased in last 30 years. In Figure 2 we can see, that Vietnam have risen from peripheral producer to a position of the second largest producer on a world market.

3.4.4 Indonesia

As we can see in Figure 2, Indonesia production is showing slightly increasing trend in last decade, remaining on the fourth place. At the same time Indonesia represents the last country to overcome production of at least 10 million bags per year with nearly 11 million bags produced in season 2017/2018[11].

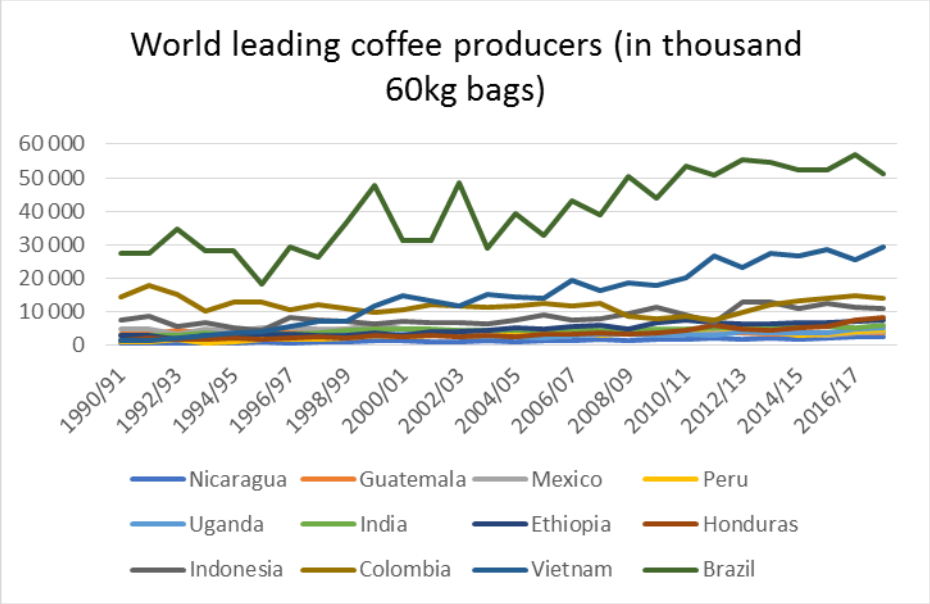

Figure 2: World leading coffee producers (Source: own input, Data source: ICO, Historical Data on the Global Coffee Trade, Total Production, online)

[11] ICO, Historical Data on the Global Coffee Trade, Total Production, online

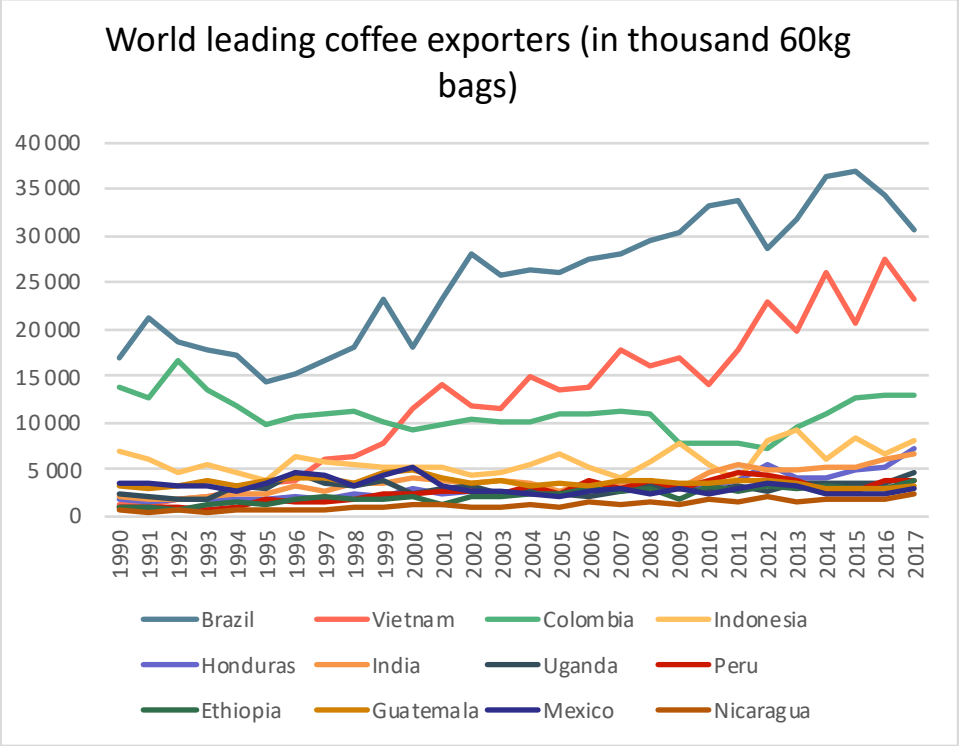

Figure 3: World leading coffee exporters (Source: own input, Data source: ICO, Historical Data on the Global Coffee trade, Exports, online)

3.5 Importers

As expectable, most of the imports are done by countries, where coffee is not produced. In case of import, we can distinguish several portions of the total amount imported by each country, according to what happens with the coffee after it is imported. Most of the coffee imported is also consumed in the importer's country. Some portion of the import is represented by coffee, which is further processed and then re-exported to another country. And finally, certain portion of the imported coffee is stored as an inventory. But since production of coffee exceeds the consumption just by relatively small surplus, the amount of coffee used as inventory is not very high. That is also caused by the fact, that coffee, especially green coffee beans which are usually traded, can't be stored for more than a few months without quality loss.

In Figure 4 we can see development of imports between years 1990 and 2017. At the last data from year 2017 is visible, that leading importer by far is European Union as a whole, followed by United States of America. Both of them are showing significant increasing trend. We can also see slightly increasing trend of consumption in Russian Federation in last two decades. Taking into account population of Russian Federation author assumes, that this trend could continue in the future.

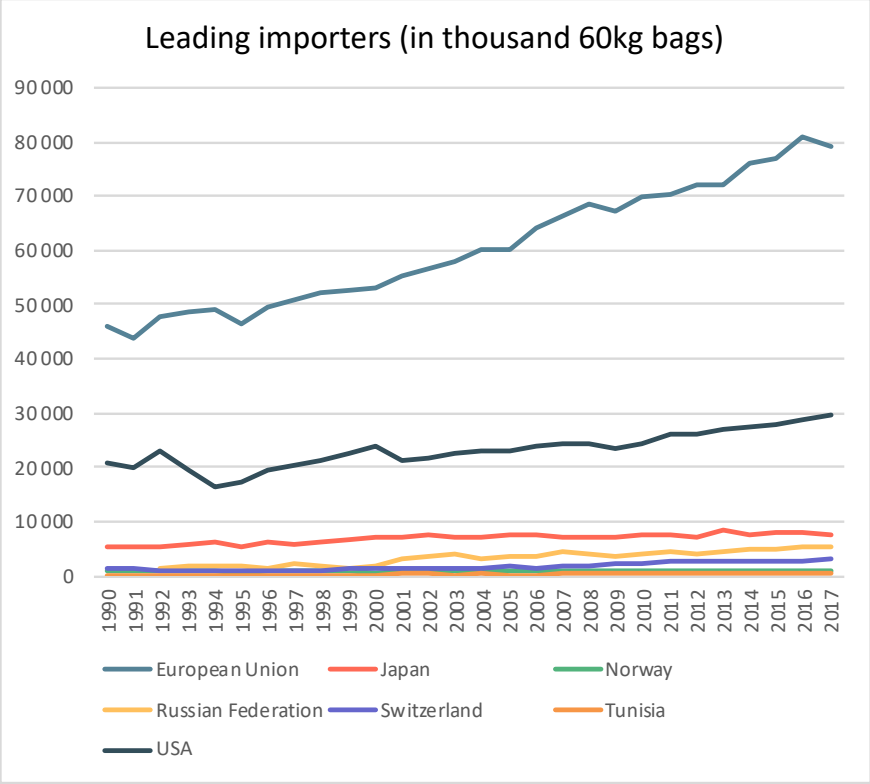

Figure 4: Leading coffee importers (Source: own input, Data source: ICO, Historical Data on the Global Coffee trade, Imports, online)

As we can see in Figure 4, European Union is absolute leader of coffee importers and is attacking threshold of 80 million bags. To see how this amount of imports is distributed between individual member countries, please see Figure 5, which is based on data 2013. It is clear, that leading importer is Germany.

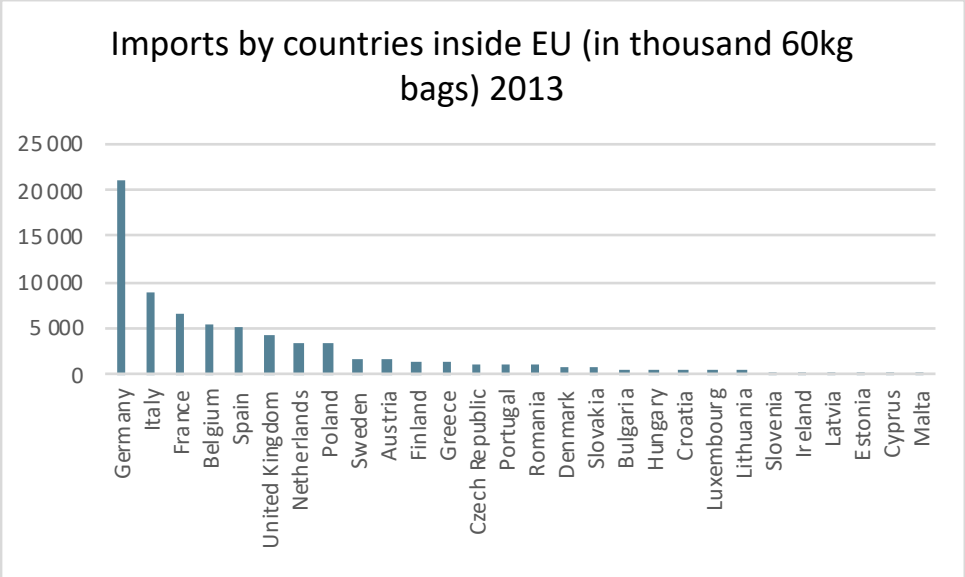

Figure 5: Imports by countries inside EU (Source: own input, Data source: ICO, Historical Data on the Global Coffee trade, Imports, online)

3.5.1 Coffee brands

This part is focused on big coffee companies, which are dominating world coffee market. These companies are usually producing uniform products through the time. Their products are produced by mixing coffee beans from different sources to create the same quality and taste at any point of time. This requires wide network of suppliers, who are able to deliver large amounts of coffee beans with demanded quality and continual adjustments of recipe to create standard product.

One and probably the best example of coffee brand is Nescafé. Nescafé is coffee brand owned by swiss company Nestlé. It is world leader in production of instants coffee and is responsible for many innovations of this particular product. During second World War, Nescafé raised its popularity and market share by being supplier of the US army, which of course helped the company to raise awareness, popularity and sales.

3.6 Coffee products

There is a wide range of products which coffee beans are used for. Basic input element for all of them are green coffee beans, because each of the products requires different processes and therefore different roasting method, which is usually secret know-how of the company.

3.6.1 Instant coffee

Instants coffee is one of the most common foodstuffs in the world. It was invented at the end of 19th century and quickly gained popularity thanks to its simple preparation, low price and durability. Also, the fact that it was suitable for army supplies during the wars of 20th century helped this product to gain popularity. Instant coffee is made by drying strong coffee concentrate either by heat or freezing.

3.6.2 Grinded coffee

Some companies are offering pre-grinded coffee at different grind size level. Usually it is the same coffee mixture as for their main product in roasted coffee beans category. Advantage of this product is, that customer doesn't need any grinder. On the other hand, grinded coffee is loosing its aroma and flavour within minutes after the grinding process.

3.6.3 **Roasted coffee beans**

This category represents simply roasted coffee beans. The market leading companies always produce several different variations of coffee with different roasting, in order to produce coffee for wide range of preparation types, from professional espresso machines to french press.

3.6.4 **Coffee based beverages**

This category contains coffee-bases beverages such as ice coffee and different products produced as mixture of coffee and other drinks, such as lemonades. These are usually produced as peripheral products in companies, which produce generally coffee or cold drinks. As example, Tchibo company introduced product called Mazagrande, as mixture of coffee and lemonade.

3.6.5 **Coffee systems**

In last years, big coffee companies such as Nescafe, Lavazza or Segafredo introduced their own systems of coffee machines for households. This was reaction to social trend of demanding better quality of coffee, combined with maintaining affordable price and simple handling of the machines. As result of this demand, companies developed coffee machines based on preparation of coffee beverage from prefilled capsules or pods. Most of these systems are not compatible with use of coffee beans or other company's capsules. This system allows companies to keep loyalty of their customers by selling unique capsules for these machines. These systems could be criticized, because of large amount of waste from packaging materials, since the capsules are usually made of aluminium or plastics. Some companies, such as Nescafe, is setting up recycling strategies including capsules collection points.

4 Practical Part

After necessary review of theoretical background of coffee beans production, processing, trading and overview of leading producers, exporters and importers, in next chapters there comes the practical part of this thesis. In next chapters reader is provided with several analyses describing the movements of price of selected commodity. Author also attempts to identify and understand factors influencing these movements. Practical part is focused mainly on trading of Arabica coffee, since it represents majority of all coffee trading activities on the market.

As mentioned in methodology section, there are several analyses used. First chapter contains fundamental analysis, describing major possible factors influencing price of coffee through the time.

Second chapter is about technical analysis. This is concerned about historical trading data and uses Simple Moving Average to analyze historical development of coffee price.

In third chapter, author uses correlation analysis, particularly Pearson correlation coefficient. Price of coffee is compared with price of tea and cocoa as a main possible substitutes in order to find potential relationship between these two variables. Identical procedure is used to find out, whether there is such relationship between price of Arabica and Robusta.

In fourth chapter, author attempts to use cointegration analysis to find relationship between amount of over production and price of Arabica and also between price of Robusta and Arabica, to find whether these pairs of time series variables are cointegrated.

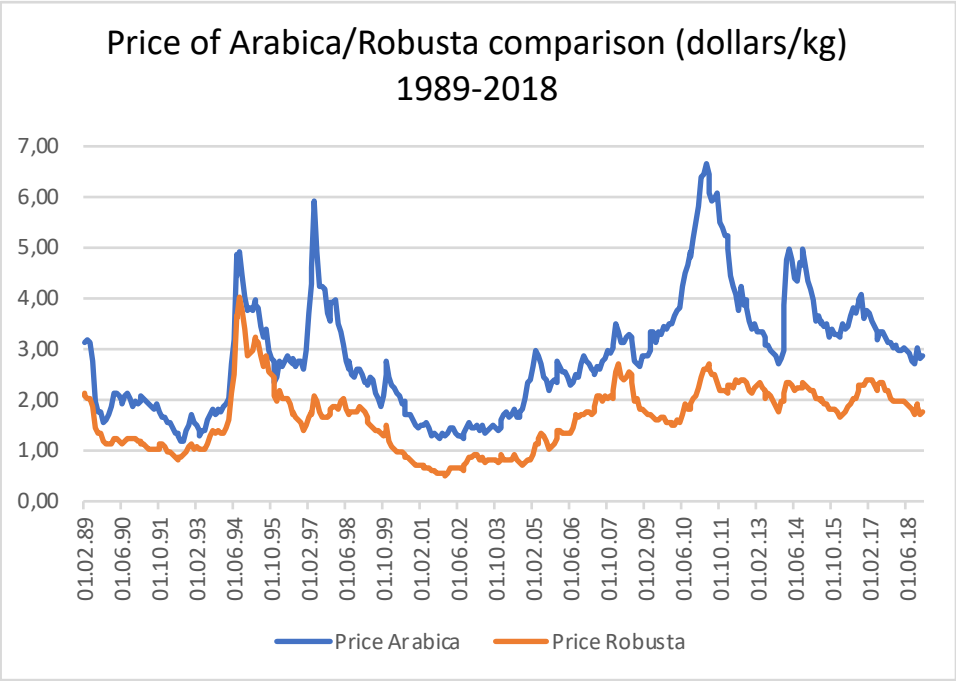

Figure 6: Price of Arabica/Robusta comparison (Source: own input, Data source: Index Mundi, 2019, online)

At first, let's introduce development of historical prices of both Arabica and Robusta coffee. In Figure 4 we can see comparison of prices of both Arabica and Robusta coffee in dollars per one kilogram. We can see, that price of Arabica is slightly higher in whole time range and it usually differs for about 1 dollar. Both prices, even though they have slightly increasing trend, are fluctuating irregularly. Both Arabica and Robusta tend to move in similar direction, but Arabica seems to be much less stable and has more significant peaks. Robusta price, on the other hand, appears to be relatively stable.

Interesting fact is, that while we see enormous growth of Arabica price between years 2008 and 2011, which could look like reaction to financial crisis, when the price more than doubled, there is much less significant growth of Robusta price in the same period of time. Also, there is strong downturn for prices of both Arabica and Robusta after year 1999 resulting in extremely low prices in period between years 2001 and 2004.

4.1 Fundamental analysis

As described in methodology, fundamental analysis can study economy as a whole, particular industry or concrete company. In this case author decided to focus on the whole industry of coffee trading, then on one selected company, since commodity trading is very broad topic.

Also, as stated in theoretical part, market is a place where sellers and buyers meet to reach a deal under several specific conditions, including price. Therefore, the price is influenced by two sides. First is supply side, represented by producers willing to sell certain amount for price. Of course, the aim of supply side is to sell for as high price as possible. The higher the price rises, the bigger amount seller is willing to sell.

Second side, the demand side, is represented by buyers, who are willing to buy wanted amount for acceptable price, which means for as low price as possible. The higher the price gets, the smaller amount buyer is willing to purchase.

When supply side and demand side reach trade terms acceptable for both of them, the trade is realized. This situation, when supply line and demand line create intercept is called equilibrium.

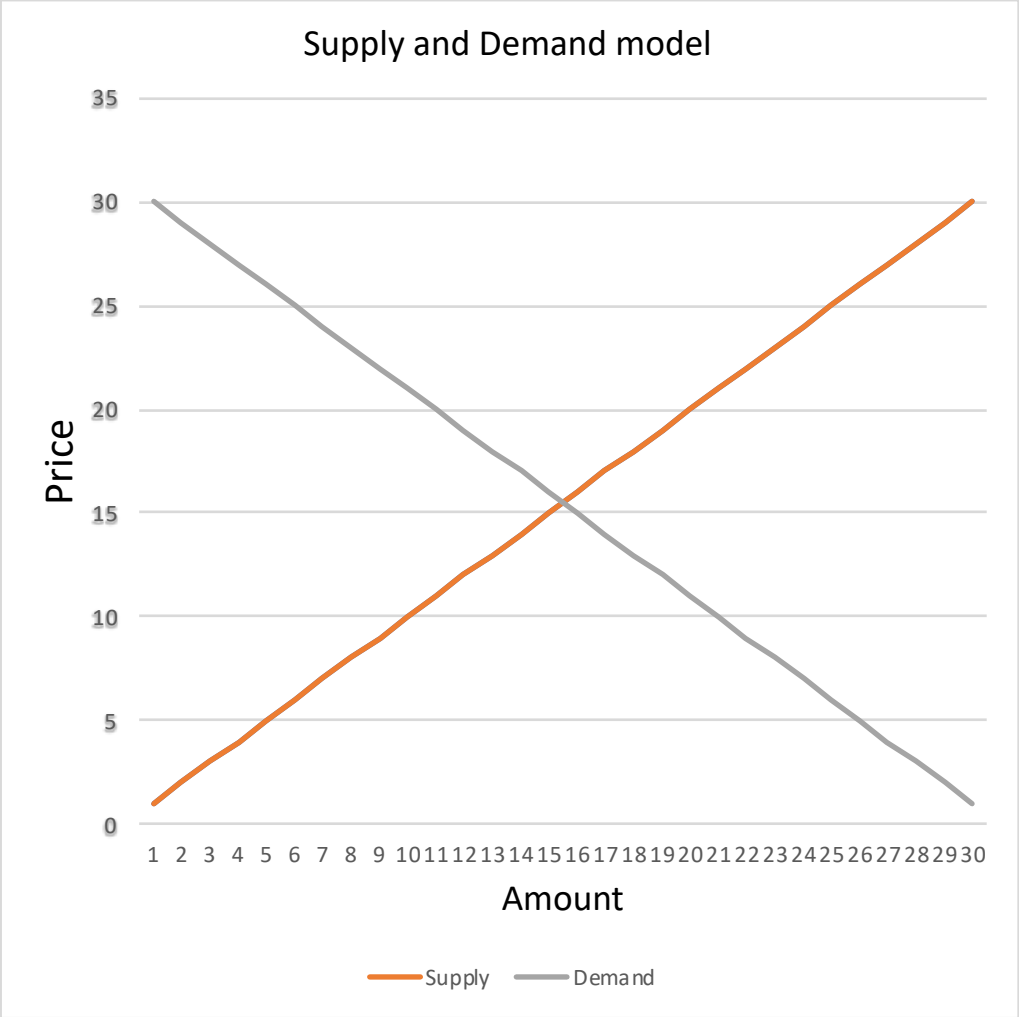

Figure 7: Supply and Demand model (Source: input based on own knowledge)

4.1.1 Supply side

Since coffee is agricultural commodity, the supply side is influenced by production and the amount of coffee beans harvested in particular period. The production itself is dependent not only on planted area, but also on the yield harvested from that area. Coffee plants are able to yield coffee beans for many years, similarly to any other fruit tree. The other way around, new plants are not able to yield immediately, but only after several years of cultivation. Even if the planted area stays stable, the yield can differ significantly in reaction to weather extremes, natural disasters, inflectional epidemies and also climate changes. On the other hand, since the coffee is a fruit, there is no crop rotation happening on the plantations, as it does for example in case of seed crops, or oil crops.

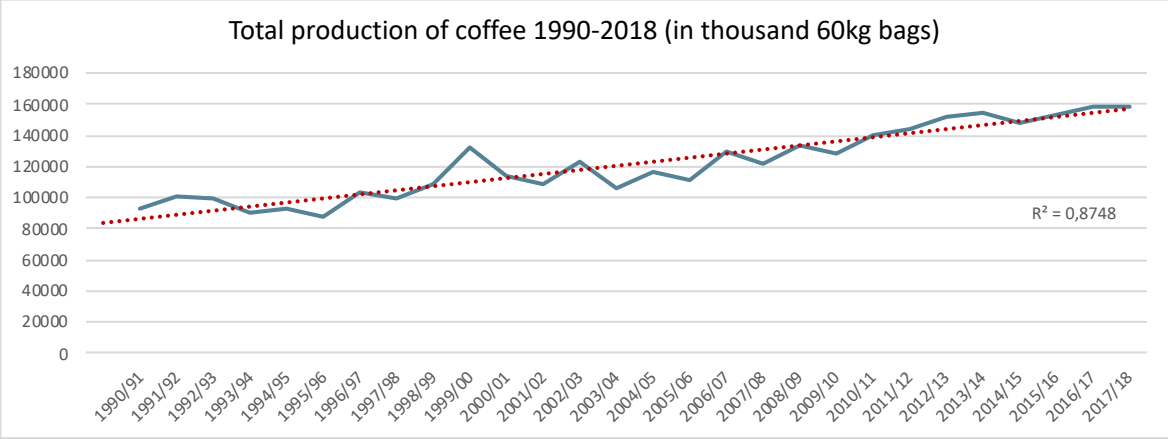

Figure 8: Total production of coffee 1990-2018 (Source: own input, Data source: ICO, Historical Data on the Global Coffee trade, Exports, online)

In Figure 8 we can see, that total production of coffee has slightly increasing trend. The linear trend function used in Figure 6 indicates approximately 60 percent increase in total production in last three decades. Coefficient of determination of this trend function tells us, that this trend line explains nearly 87,5 percent of the data variance, which makes this tradeline to be representing the data set very well.

Country/Year	1991/92	2017/18	Increase
Total	**93 102**	**158 560**	170,3%
Brazil	27 286	51 000	186,9%
Vietnam	1 310	29 500	2251,4%
Colombia	14 268	14 000	98,1%
Indonesia	7 441	10 902	146,5%
Honduras	1 568	8 349	532,5%
Ethiopia	2 909	7 650	262,9%
India	2 829	5 840	206,5%
Uganda	1 955	5 100	260,9%
Peru	937	4 280	456,9%
Mexico	4 674	4 000	85,6%
Guatemala	3 271	3 800	116,2%
Nicaragua	461	2 500	542,2%

Table 1: Increase of coffee production by countries between years 1991-2017 (Source: own input, Data source: ICO, Historical Data on the Global Coffee trade, Production, online)

This rising trend can be explained by strong growth of production over last 30 years in countries, which were almost insignificant at the start of this interval. Best example is production of coffee in Vietnam, which is now about twenty-three times higher, than 30 years ago, as we can see in Table 1. Interesting growth happened also in case of Honduras and Ethiopia, even though it didn't contribute to the total production so significantly.

Unlike any other commodity, coffee producers are facing several risks. Firstly, if production significantly overcome consumption, it can lead to significant decrease in prices. This is explanation of the extremely low prices in period between years 2001 and 2004.

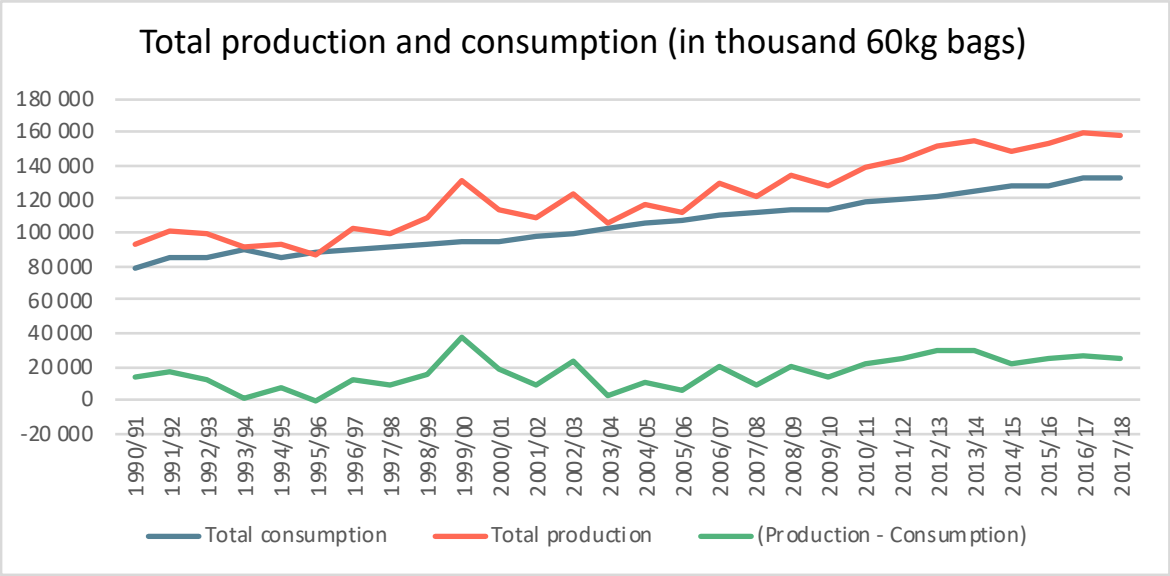

Figure 9: Total production and consumption (Source: own input, Data source: ICO, Historical Data on the Global Coffee trade, Production, online; ICO, Historical Data on the Global Coffee trade, Domestic consumption, online; ICO, Historical Data on the Global Coffee trade, Disappearance (consumption), online)

As a result of significant growth of production in year 1999/2000 and then in 2002/2003, the total production was tens of millions of bags higher than consumption. That led to creation of inventories and pushed the prices to the lowest level in last 100 years.[12]

Second risk concerning production of coffee are unpredictable events, such as natural disasters, but mainly epidemies of diseases. These can attack plants as well as beans and thus influence yields significantly, even for several years. As stated in theoretical part, Coffee Wilt Disease is one of the most aggressive diseases influencing coffee production in Africa. In Central and South America, where most of the world's arabica is produced, there is another disease generally called Coffee Rust, caused by fungus *Hemileia vastatrix*. It attacks plant's leafs. As we know from biology, leafs are organs responsible for the plant's nutritional system. Therefore, any damage of leafs lowers the yield. According to article from book Food Security (2015), the major peaks of Arabica price in years 1994, 1997, 2011 and 2014 were caused by epidemies of Coffee Rust in Central and South America.[13]

[12] BACON, Christopher M. *Confronting the coffee crisis: fair trade, sustainable livelihoods and ecosystems in Mexico and Central America*. Cambridge, Mass.: MIT Press, c2008. ISBN 9780262026338.

[13] Avelino, J., Cristancho, M., Georgiou, S. et al. Food Sec. (2015) 7: 303., online

4.1.2 **Demand side**

Demand side is driven mainly by consumption in importing countries. Since coffee is used almost exclusively for coffee beverage products, the demand is driven by companies which are producing such products. There is no other significant usage of this commodity, as would be for example animal feeding or biofuels production in case of seed crops. In case of this specific commodity, majority of the world production is consumed outside the production areas. Thus, majority of the country's production is used for exports.

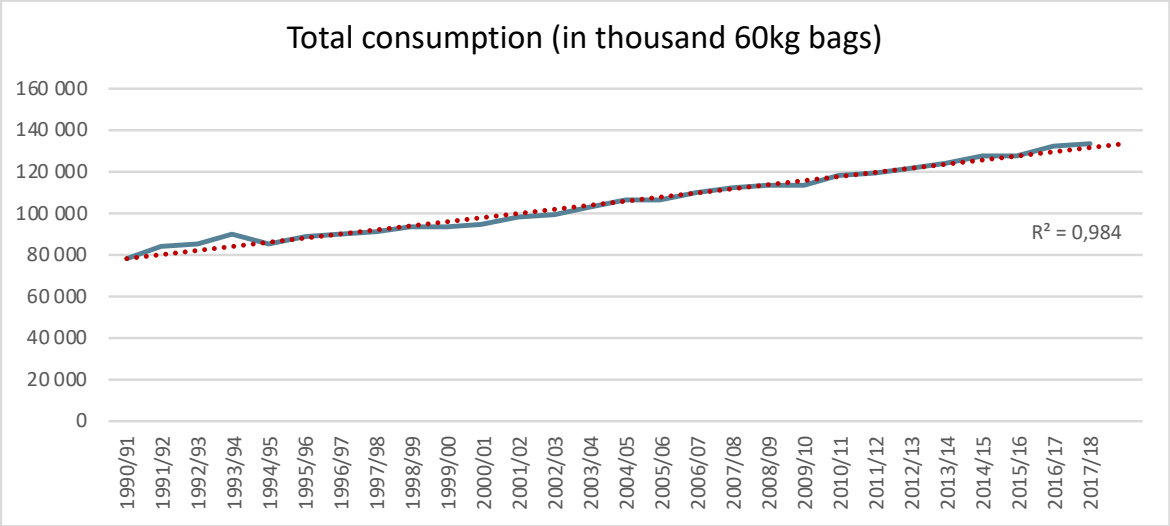

Figure 10: Total consumption (Source: own input, Data source: ICO, Historical Data on the Global Coffee trade, Domestic consumption, online; ICO, Historical Data on the Global Coffee trade, Disappearance (consumption), online)

As we can see in Figure 10, which combines data about domestic consumption in coffee producing countries and consumption in importing countries, the total consumption is showing almost perfectly linear increasing trend. Today's consumption represents nearly 170% of the consumption in year 1990. From the linear trend line and its coefficient of determination $R^2 = 0,984$ we can, as an investors, easily and relatively representatively predict further development of consumption.

Another important factor influencing demand are payments for transportation and handling of the commodity and other fees, which are usually implemented in the final price. Also changes in currency rates are influencing the demand.

4.2 Technical analysis

As introduced in theoretical part, technical analysis focuses on analyzing historical trading results, in our case prices of coffee. After fundamental analysis, which is focused on reasons and forces, which are affecting the price, which is very broad and difficult discipline, technical analysis examines only available data.

Technical analysis as a discipline contains wide variety of tools. These tools are helping investors to discover trends in price movements, either in long term or short term periods of time. Since this thesis practically studies two separate variables, price of Arabica and price of Robusta, author decided to use basic approaches. Methods are executed on monthly price data of last 30 years.

4.2.1 Simple Moving Average

Simple moving average is method based on principle of calculating average from certain number of consecutive values at every point of time in timeseries. This average can be calculated for any number of periods. The higher the number of periods is, the slower are the reactions of such simple moving average trend line to actual prices. We are always interested on how the moving average behave in comparison to real prices as well as we look for combination of movements of different period simple moving averages lines. If short time SMA cross long term SMA and goes higher, it is signal that the price is about to increase, therefore the commodity is eligible for investment. Opposite case, when short time is bellow long term, it is signal that the price will go down and it is better to sell. On used dataset of 360 prices observations, author used simple moving average calculated for 5, 20 and 50 periods.

In Figure 11 for Arabica we see, that because of several price extremes the long term indicators are reacting very slow. On the other hand, all three indicators are moving in similar directions.

In case of Robusta in Figure 12, the long term indicator is significantly shifted as well due to extreme peak of price in September 1994. But combination of long term and short term indicators are moving in similar directions.

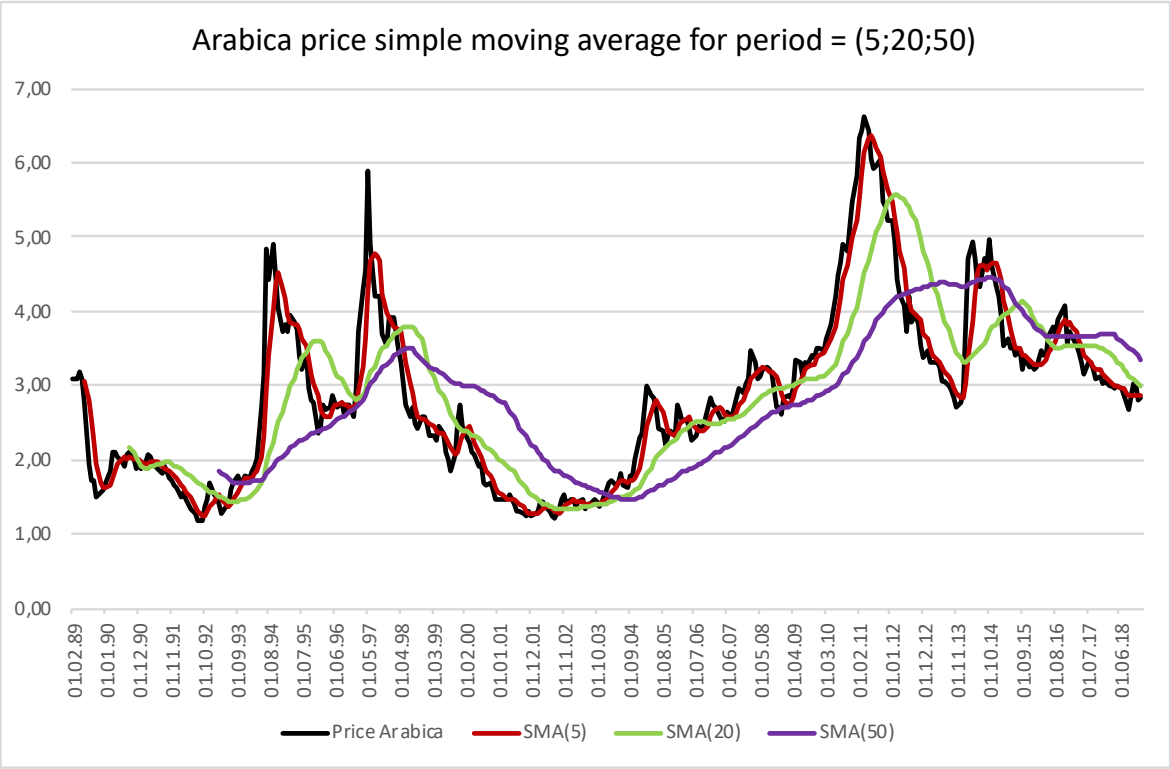

Figure 11: Simple Moving Average of Arabica price (Source: own input, Data source: Index Mundi, 2019, online)

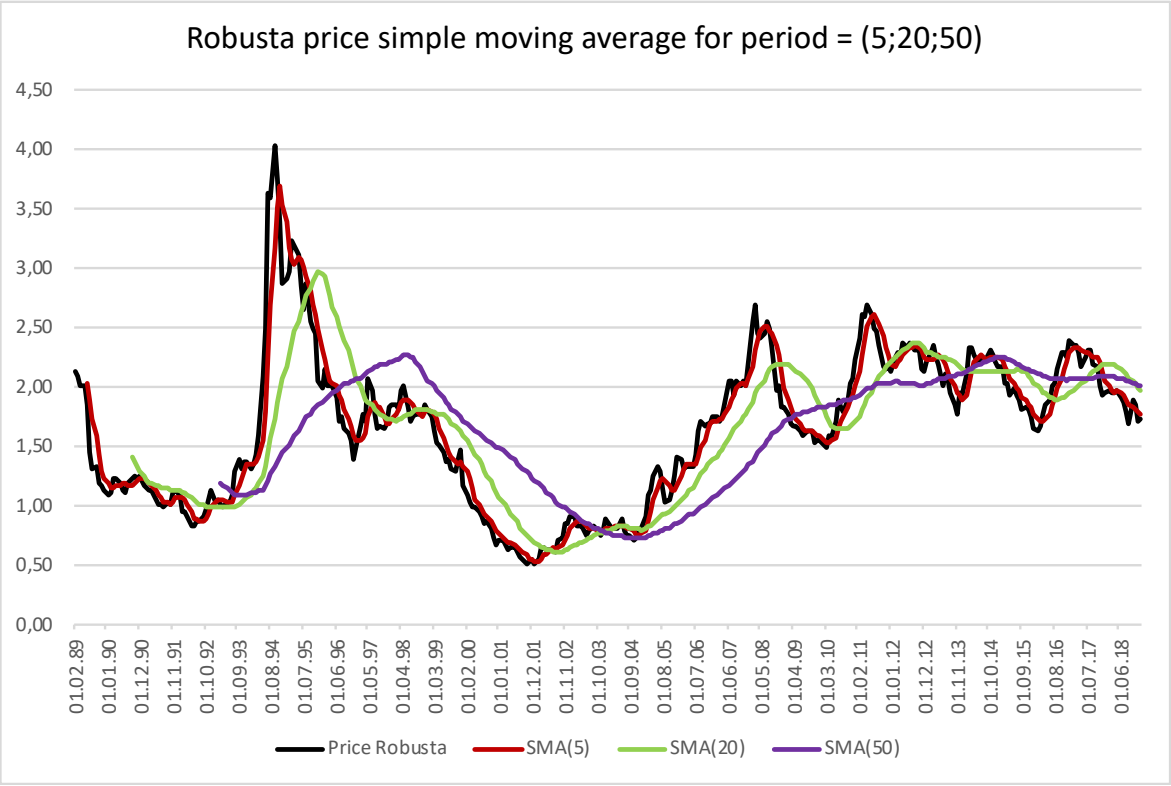

Figure 12: Simple moving average of Robusta price (Source: own input, Data source: Index Mundi, 2019, online)

4.3 Correlation

From the fundamental analysis we know, that the main driver of coffee prices are production fluctuations in reaction to epidemies, which are pushing the price higher and differences between production and consumption resulting in inventories, which are pushing the price lower. This chapter is focused on relationships between prices of Arabica, Robusta and two selected substitutional commodities, tea and cocoa.

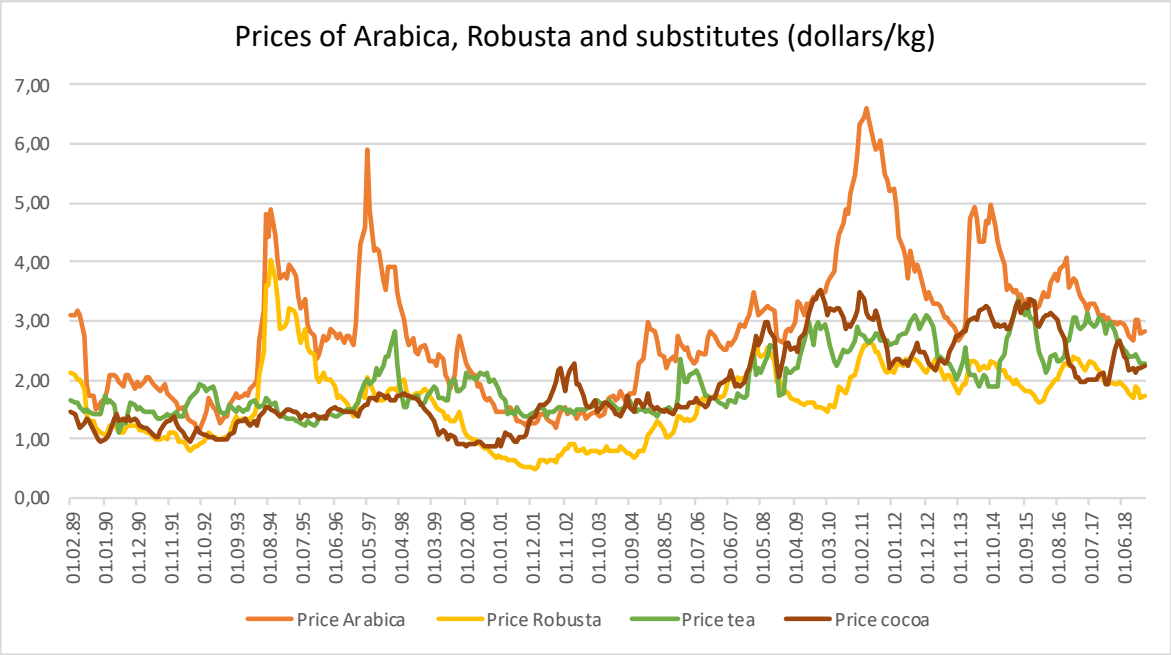

Figure 13: Prices of Arabica, Robusta and substitutes (Source: own input, Data source: Index Mundi, 2019, online)

In Figure 11 we can see, that prices of tea and cocoa are, similarly to coffee, fluctuating, but both are showing fluctuations only between 1 and 3 dollars per kilogram and the peaks are not so extreme, as in case of coffee.

In order to discover potential relationships between individual variables (prices), correlation analysis used calculation of Pearson Correlation Coefficients at significance level $\alpha = 0{,}05$.

Pearson Correlation Coefficients, N = 360 Prob > |r| under H0: Rho=0				
	Arabica	Robusta	Tea	Cocoa
Arabica	1.00000	0.78646	0.58498	0.67718
		<.0001	<.0001	<.0001
Robusta	0.78646	1.00000	0.41432	0.48122
	<.0001		<.0001	<.0001
Tea	0.58498	0.41432	1.00000	0.71090
	<.0001	<.0001		<.0001
Cocoa	0.67718	0.48122	0.71090	1.00000
	<.0001	<.0001	<.0001	

Figure 14: SAS Enterprise Guide correlation analysis output

In Figure 12 we can see output of correlation analysis returned by SAS Enterprise Guide. As first we can see, that all p-values are smaller than level of significance, thus calculated coefficients are statistically significant. We can also state, that all correlations are positive.

From calculated coefficients we can see, that prices of Arabica and Robusta are showing moderate to strong linear relationship. Second strongest relationship concerning coffee is between Arabica and cocoa, followed by Arabica and tea. Both these correlations are of moderate strength. Correlations between Robusta and both substitutes are of moderate strength as well, but significantly lower than in case of Arabica.

4.4 Cointegration

Test of cointegration of two variables is usually done by executing of one of two tests. Either Engle-Granger, or Johansen test. Author decided to use Engle-Granger testing procedure. First step is to test both variables for presence of unit root. Unit root presence is tested by augmented Dickey-Fuller test. If test of both variables succeeds in accepting hypothesis of unit root presence, we can continue with testing of cointegration by Engle-Granger test. Engle-Grenger test was done in version including both constant and trend. All tests used in this section were completed in Gretl programme.

First cointegration test was done using monthly data for Arabica and Robusta price, to find potential cointegration relationship between these time series. Second test used annual data of production and calculated average annual price of Arabica, to test if there is cointegration between production and price as concept of production influence was introduced in fundamental analysis. Last test used the same calculated annual averages of

Arabica price and calculated difference between production and consumption. As stated in previous chapters, overproduction is likely to cause drop of price.

4.4.1 Test of cointegration between price of Arabica and Robusta

To test cointegration of prices of Arabica and Robusta, in first step we have to perform augmented Dickey-Fuller test to decide, whether null hypothesis about presence of unit root can be accepted for both time series. Critical value for $\alpha = 0{,}05$ according to statistical tables for our sample size lies between critical values for 250 and 500 observations, which means it lies in the interval ⟨-3,43; -3,42⟩. As we can see in Figure 15, test statistic value for Arabica is -3,2776 and for Robusta -2,60473. Both of these values are bigger than critical value, so we can accept null hypothesis and state that both time series contains a unit root.

```
Augmented Dickey-Fuller test for PriceArabica
testing down from 7 lags, criterion AIC
sample size 357
unit-root null hypothesis: a = 1

  with constant and trend
  including 2 lags of (1-L)PriceArabica
  model: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  estimated value of (a - 1): -0.0413972
  test statistic: tau_ct(1) = -3.2776
  asymptotic p-value 0.06995
  1st-order autocorrelation coeff. for e: -0.001
  lagged differences: F(2, 352) = 11.806 [0.0000]
```

```
Augmented Dickey-Fuller test for PriceRobusta
testing down from 7 lags, criterion AIC
sample size 353
unit-root null hypothesis: a = 1

  with constant and trend
  including 6 lags of (1-L)PriceRobusta
  model: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  estimated value of (a - 1): -0.0287778
  test statistic: tau_ct(1) = -2.60473
  asymptotic p-value 0.2782
  1st-order autocorrelation coeff. for e: -0.004
  lagged differences: F(6, 344) = 8.236 [0.0000]
```

Figure 15: Augmented Dickey-Fuller test for price of Arabica and Robusta (Source: own input, Data source: Index Mundi, 2019, online)

Now we can continue to Engle-Granger test of cointegration. In Figure 16 we can see results of test executed in Gretl. We can see, that cointegration in this case is statistically significant and according to Engel-Granger procedure cointegration relationship between price of Arabica and price of Robusta exists.

```
Step 1: cointegrating regression

Cointegrating regression -
OLS, using observations 1989:02-2019:01 (T = 360)
Dependent variable: PriceArabica

                coefficient   std. error   t-ratio    p-value
  ------------------------------------------------------------
  const          0.530447     0.102762      5.162    4.06e-07  ***
  PriceRobusta   1.40732      0.0584139    24.09     6.51e-077 ***

Mean dependent var   2.836806   S.D. dependent var   1.146043
Sum squared resid    179.8773   S.E. of regression   0.708837
R-squared            0.618512   Adjusted R-squared   0.617447
Log-likelihood      -385.9286   Akaike criterion     775.8573
Schwarz criterion    783.6295   Hannan-Quinn         778.9476
rho                  0.970706   Durbin-Watson        0.057665

Step 2: testing for a unit root in uhat

Augmented Dickey-Fuller test for uhat
testing down from 7 lags, criterion AIC
sample size 358
unit-root null hypothesis: a = 1

  model: (1-L)y = (a-1)*y(-1) + ... + e
  estimated value of (a - 1): -0.0352266
  test statistic: tau_c(2) = -2.83325
  asymptotic p-value 0.1554
  1st-order autocorrelation coeff. for e: -0.016
```

Figure 16: Engle-Granger cointegration test (Source. own input, Data source: Index Mundi, 2019, online)

4.4.2 Test of cointegration between price of Arabica and Production

To test cointegration of prices of Arabica and Production, in first step we have to perform augmented Dickey-Fuller test to decide, whether null hypothesis about presence of unit root can be accepted for both time series. Critical value for $\alpha = 0,05$ according to statistical tables for our sample size is -3,60. As we can see in Figure 17, test statistic value for Arabica is -2,47128 and for Production -4,04801. And because value for Production is lower than the critical value, we cannot continue towards Engle-Granger test.

```
Augmented Dickey-Fuller test for Production
testing down from 3 lags, criterion AIC
sample size 27
unit-root null hypothesis: a = 1

  with constant and trend
  including 0 lags of (1-L)Production
  model: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  estimated value of (a - 1): -0.799368
  test statistic: tau_ct(1) = -4.04801
  p-value 0.01904
  1st-order autocorrelation coeff. for e: -0.081
```

```
Augmented Dickey-Fuller test for Arabica
testing down from 3 lags, criterion AIC
sample size 24
unit-root null hypothesis: a = 1

  with constant and trend
  including 3 lags of (1-L)Arabica
  model: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  estimated value of (a - 1): -0.534911
  test statistic: tau_ct(1) = -2.47128
  asymptotic p-value 0.3426
  1st-order autocorrelation coeff. for e: -0.076
```

Figure 17: Augmented Dickey-Fuller test for price of Arabica and Production (Source: own input, Data source: Index Mundi, 2019, online; ICO, Historical Data on the Global Coffee trade, Total production, online)

4.4.3 Test of cointegration between price of Arabica and Overproduction

To test cointegration of prices of Arabica and Overproduction, in first step we have to perform augmented Dickey-Fuller test to decide, whether null hypothesis about presence of unit root can be accepted for both time series. Critical value for $\alpha = 0,05$ according to statistical tables for our sample size is -3,60. As we can see in Figure 18, test statistic value for Arabica is -2,47128 and for Overproduction -4,22039. And because value for Overproduction is lower than the critical value, we cannot continue towards Engle-Granger test.

```
Augmented Dickey-Fuller test for ProductionConsumption
testing down from 3 lags, criterion AIC
sample size 27
unit-root null hypothesis: a = 1

  with constant and trend
  including 0 lags of (1-L)ProductionConsumption
  model: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
  estimated value of (a - 1): -0.838892
  test statistic: tau_ct(1) = -4.22039
  p-value 0.01304
  1st-order autocorrelation coeff. for e: -0.059
```

```
Augmented Dickey-Fuller test for Arabica
testing down from 3 lags, criterion AIC
sample size 24
unit-root null hypothesis: a = 1

  with constant and trend
  including 3 lags of (1-L)Arabica
  model: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  estimated value of (a - 1): -0.534911
  test statistic: tau_ct(1) = -2.47128
  asymptotic p-value 0.3426
  1st-order autocorrelation coeff. for e: -0.076
```

Figure 18: Augmented Dickey-Fuller test for price of Arabica and Overproduction (Source: own input, Data source: Index Mundi, 2019, online; ICO, Historical Data on the Global Coffee trade, Total production, online; ICO, Historical Data on the Global Coffee trade, Domestic consumption, online; ICO, Historical Data on the Global Coffee trade, Disappearance (consumption), online)

5 Results

In following chapter there is a summary of findings discovered by executing used methods.

5.1 Fundamental analysis

Fundamental analysis used principle of supply and demand to provide reader with knowledge of factors, that can influence the price of selected commodity.

On supply side there was found, that the key factor of price is level of production. Production itself can be affected by climate, weather extremes, natural disasters, epidemies of plant diseases and other factors. There was found slowly increasing trend of production with significant fluctuations, which provides potential investor with finding, that investing in coffee commodity is very insecure decision.

On demand side there was discovered almost perfect linearly increasing trend of consumption, which allows potential investor to be relatively precise in predictions of future development of selected commodity consumption.

In outcome, fundamental analysis provides findings about very good predictability of the demand side, while on the other hand discovers significant risks on the supply side.

5.1.1 Technical analysis

In technical analysis we looked at the price from perspective of available historical prices data. Technical analysis, using the tool of simple moving average, provided findings based on calculation of short term, mid term and long term trends. At the time of this study, all three indicators are showing decreasing trend for both Arabica and Robusta coffee. Therefore it provides potential investor with findings which indicates, that in present time it is better to sell. But since there were used monthly data of last 30 years, this analysis is more useful for long term trading strategy, not for day-to-day trading.

5.1.2 Correlation analysis

Correlation analysis focused on finding relationships between price of Arabica and Robusta coffee and selected substitutes tea and cocoa. In this chapter, there were calculated correlation coefficients for all pairs of these commodities. All coefficients are showing statistical significance and positive relationships, therefore if price of one commodity goes

up, the second is likely to go in the same direction. It was discovered, that strongest correlation and relationship is present between Arabica and Robusta and the correlation was evaluated as moderate to strong. Relationships between Arabica and both substitutes were evaluated as moderate. Relationships of Robusta and both substitutes were evaluated as moderate as well, but weaker than in previous case.

5.2 Cointegration analyses

Last chapter of practical part was about to discover potential cointegration relationships between price of Arabica and estimated factors, which were price of Robusta, production and overproduction, calculated as difference between total production and total consumption.

First analysis of potential cointegration relationship between price of Arabica as dependent variable, and price of Robusta as independent variable, was successful. In first step we succeeded in accepting hypothesis about unit root presence in both time series by executing Augmented Dickey-Fuller test. Subsequently Engle-Granger test discovered statistically significant relationship of selected variables.

Second and third analysis of relationships between price of Arabica and selected factors, production and overproduction, were both unsuccessful. Augmented Dickey-Fuller test failed to accept hypothesis of unit root presence in time series of production and overproduction.

6 Conclusion

As stated at the beginning of this thesis, the aim was to determine main factors influencing price movements. Several analyses used annual and monthly data of for period of last 30 years to find and describe such factors. Used analyses were executed separately on both Arabica and Robusta price, with exception of cointegration analysis executed on Arabica price only, and offered different views on the commodity price movements. Combination of knowledge from individual analysis tools provides finding, that coffee, Arabica as well as Robusta, is very unstable and almost risky commodity to trade. Fundamental analysis discovered, that supply side is very unstable due to sensitivity of coffee to natural conditions and unpredictable events such as natural disasters, weather extremes and diseases. On the other hand demand side shows significantly stable increasing trend. Technical analysis confirms present-day decreasing trend of coffee price. Recommendation of author is to combine technical analysis tools with detailed knowledge of fundamentals of coffee production, to be able to make correct decisions while trading coffee commodity.

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8 Appendix