

Czech University of Life Sciences Prague

Faculty of Economics and Management

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Diploma Thesis

**International Agricultural Trade of Wheat: Case Study
of the United States of America**

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CZECH UNIVERSITY OF LIFE SCIENCES PRAGUE

Faculty of Economics and Management

DIPLOMA THESIS ASSIGNMENT

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Economics and Management

Thesis title

International Agricultural Trade of wheat: Case Study of the United States of America

Objectives of thesis

The United States of America is a major wheat producing country. Wheat ranked third among United States field crops in both planted acreage and gross farm receipts, behind corn and soybeans. The main objectives of this thesis is to analyze the global trade of this commodity with emphasis on the United states. Wheat foreign trade development, its economic importance and its impact on agriculture sector in the United States of America will be analyzed.

Methodology

The diploma thesis will be divided into two parts. The first part will be theoretical and the second part will be analytical. To achieve its aims the thesis will mainly use descriptive and comparative methods. Time series analysis will be conducted for analyzing time series data in order to extract meaningful statistics and other characteristics of the data.

The proposed extent of the thesis

60 – 80 pages

Keywords

Foreign trade, International Trade, Wheat, United States, Agriculture,

Recommended information sources

Brett F. Carver: *Wheat – Science and Trade*, ISBN: 978-0-8138-2024-8

Elaine Kub, *Mastering the Grain Markets: How Profits Are Really Made*, ISBN-13: 978-1477582961

HRONOVÁ, S. – HINDLS, R. – NOVÁK, I. *Metody statistické analýzy pro ekonomy*. Praha: Management Press, 2000. ISBN 80-7261-013-9.

James B. Bittman: *Trading and Hedging with Agricultural Futures and Options*, ISBN: 978-1-59280-329-3

Ralph Ainsworth: *Profitable Grain Trading*, ISBN-13: 978-0934380041

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Declaration

I declare that the diploma thesis on the topic: "**International agricultural trade of wheat: Case study of the United States of America**" was written by me, by the help of specific literature and other sources which are included in the review of the used material, and by the help of consultations and advices with my supervisor **Ing. Jiří Mach, Ph.D.**

In Prague 21st of March 2018

Signature.....

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Mezinárodní zemědělský obchod s pšenicí: případová studie Spojených států amerických

Souhrn

Diplomová práce je rozdělena do dvou hlavních částí, teoretické a praktické. První část popisuje pšenici a její využití. Dále charakterizuje trh pšenice z hlediska mezinárodního obchodu. Vývoj zahraničního obchodu s pšenicí a jeho dopad na vývoz pšenice USA je zkoumán.

Druhá část je analyticky orientována, k tomuto účelu byla provedena lineární regresní analýza za pomoci běžné metody nejmenších čtverců pro analýzu závislosti mezi vývozem pšenice USA a vybranými makroekonomickými ukazateli v letech 1995-2016. Ekonometrický model zkoumá vztah mezi vývozem pšenice USA a produkcí pšenice USA, cenou pšenice USA, finanční podporou vývozu ze strany USA (programy MAP a FMD), hodnotou amerického dolaru (index amerického dolaru), cenou pšenice konkurenční země (Kanada) a HDP země dovážející pšenici (Japonsko).

Vývoz pšenice USA je z 74% ovlivněn změnami ve vybraných proměnných. To znamená, že v modelu byly obsaženy významné proměnné, statisticky i ekonomicky. Odhadovaný model uvádí, jaké faktory významně ovlivňují vývoz pšenice USA. Ukazuje se, že vývoz je převážně ovlivněn změnami v produkci, ceně a finanční podpoře vývozu. Pokud se například cena pšenice USA zvýší o 1 dolar, vývoz pšenice USA se sníží o 58 tisíc tun ročně. Naopak, pokud se finanční podpora vývozu USA zvýší o 1 milion dolarů, vývoz pšenice USA se zvýší o 55 tisíc tun ročně. To podtrhuje význam programů podporujících export.

Na základě tohoto modelu je odvozena prognóza vývozu pšenice USA na další čtyři roky (2017-2020). Ta předpovídá, že vývoz pšenice USA se v následujících letech zvýší s výjimkou roku 2017. Vývoz by měl dosahovat 34 302 tisíc tun pšenice v roce 2019. To by bylo největší vyvezené množství od roku 2010. Navíc, pokud se prognóza potvrdí, očekává se, že USA získají zpět svou pozici největšího vývozce pšenice na světě.

Klíčová slova: zahraniční obchod, mezinárodní obchod, zemědělství, pšenice, USA

International Agricultural Trade of Wheat: Case Study of the United States of America

Summary

The diploma thesis is divided into two main parts, theoretical and practical. The first part describes wheat and its uses. Moreover, it characterizes the wheat market in terms of international trade. The wheat foreign trade development and its impact on U.S. wheat export have been explored.

The second part is analytically oriented, for that, a linear regression analysis has been conducted using the ordinary least squares method to analyse dependency between U.S. wheat export and selected macroeconomic indicators within the years 1995–2016. The econometric model has examined the relationship between U.S. wheat export and U.S. wheat production, U.S. wheat price, U.S. export promotion (MAP, FMD programs), value of U.S. dollar (U.S. dollar index), competing country wheat price (Canada), and wheat importing country GDP (Japan).

The export of U.S. wheat is impacted by 74% by changes in the chosen variables. It means that significant variables were contained in the model, both statistically and economically. The estimated model reports which factors significantly affect the export of U.S. wheat. It reveals that the export is largely affected by the changes in the production, price and export promotion. For instance, if the price of U.S. wheat increases by 1 dollar, the export of U.S. wheat will decrease by 58 thousand metric tons per year. By contrast, if U.S. export promotion increases by 1 million dollars, the export of U.S. wheat will increase by 55 thousand metric tons per year. This underlines the significance of the programs supporting export.

Based on this model, the forecast of U.S. wheat export for the next four years is derived (2017–2020). It predicts that the export of U.S. wheat will increase in the following years except 2017. The export is projected at 34,302 thousand metric tons in 2019. That would be the largest exported quantity since 2010. Moreover, if the forecast holds, it is expected that the U.S. will regain its position as the world's largest wheat exporter.

Keywords: foreign trade, international trade, agriculture, wheat, U.S.

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Abbreviations

GBP	Pound sterling
CAD	Canadian dollar
CBOT	Chicago Board of Trade
CHF	Swiss franc
EU	European Union
EUR	Euro
FAS	Foreign Agricultural Service
HRS	Hard Red Spring
HRW	Hard Red Winter
HW	Hard White
JPY	Japanese yen
KCBT	Kansas City Board of Trade
MGEX	Minneapolis Grain Exchange
OLS	Ordinary least squares
SEK	Swedish krona
SI	International System of Units
SRW	Soft Red Winter
SW	Soft Winter
US	United States
USDA	United States Department of Agriculture
USW	United States Wheat Associates

1. INTRODUCTION

Wheat is harvested on more land than any other commercial food. Moreover, given to its great climatic adaptability, it is cultivated almost in all temperate areas. Wheat is one of the most important commodities in the world, because it is the main ingredient in most basic food. Human nutrition depends heavily on the production of wheat. From nutritional point of view, wheat contains many important substances, it represents 20% of all the calories consumed by people today.¹

Since the second half of the 20th century, the international agricultural trade of wheat has grown by three times, and as the world's population is constantly growing, the production is increasing as well. People consume around 700 million tons of wheat per year. Moreover, in the current agricultural season 2017/2018, the consumption forecast is at a record of 743 million metric tons. Majority of wheat is consumed in the country where it is produced. An increase in total utilization is further driven by its use in industry and as an animal feed. In addition, other commodities have a tendency to stimulate new uses of wheat, such as ethanol and plastics production.

Wheat is grown across the United States as the main cereal grain, following corn and soybeans. The U.S. is ranked fourth in the world wheat production with 62,833 thousand metric tons of wheat in the year 2016, exceeded only by China, India and Russia. It is about 8% of the world production.² Almost 50% of that production is exported, even though U.S. share of the global wheat market has declined due to high competition, while the European Union and the post-Soviet states have greatly increased their exports. In the year 2016, the U.S. share of the global wheat exports was around 15% as one of the world's leading wheat exporters. The main importers of U.S. wheat are Mexico, Japan, and the Philippines.³

¹ National Association of Wheat Growers [online]: "Wheat 101 - Key Facts About the World's Essential Grain." 2011. WWW: <<https://www.wheatworld.org/wp-content/uploads/2016/12/wheat-101.pdf>>

² AgMRC [online]: "Wheat." 2017. WWW: <<https://www.agmrc.org/commodities-products/grains-oilseeds/wheat>>

³ USW [online]: "Summary of Commercial Sales for 2017/18." 2018. WWW: <[http://www.uswheat.org/whatsNew/doc/532BBC99D5AC27178525824A00758CD2/\\$File/CS%20180301.pdf?OpenElement#>](http://www.uswheat.org/whatsNew/doc/532BBC99D5AC27178525824A00758CD2/$File/CS%20180301.pdf?OpenElement#>)

2. OBJECTIVES AND METHODOLOGY

2.1 Objectives

One of the main objectives of this thesis is to analyse the global trade of wheat commodity with emphasis on the United States. In particular, to characterize and investigate the aspects of international trade of wheat in terms of production, export and import. The key players will be listed and described. Furthermore, to use statistical and econometric methods to investigate a relationship between U.S. wheat export and selected macroeconomic indicators within the period 1995–2016. On the basis of the regression analysis, the aim will be to determine the impact of the chosen variables on U.S. wheat export, and make the forecast for the coming four years.

Hypotheses:

- If the production of U.S. wheat increases, the export of U.S. wheat will increase.
- If the price of U.S. wheat increases, the export of U.S. wheat will decrease.
- If the export promotion increases, the export of U.S. wheat will increase.
- If the U.S. dollar index increases, the export of U.S. wheat will decrease.
- If the price of Canadian wheat increases, the export of U.S. wheat will increase.
- If the GDP of Japan increases, the export of U.S. wheat will increase.

2.2 Methodology

To analyse the subject in detail, the thesis will be divided into the theoretical and practical part. The methodology of the thesis should therefore first provide literature review and theoretical information on wheat and its utilization. For that purpose, secondary data from articles, books, official documents, publications, reports, statistical bulletins and other materials relevant to the topic were used.

Then collect and process the data on U.S. wheat export and selected indicators during the period 1995–2016, and that graphically display using charts and tables. Firstly, the practical part will deal with the developments of the chosen variables. Then, all the data will be examined by employing the linear regression analysis in Gretl software to determine dependency and validity of the relationship of the variables. The obtained results will be verified with the use of economic, statistical and econometric verifications. The last part of the econometric analysis will deal with the application of the given model for the forecasting purposes.

2.2.1 Econometric Modelling

An econometric study begins with a set of propositions about some aspect of the economy. The linear regression model is the single most useful tool in the econometrics. The linear regression model is used to study the relationship between a dependent variable and one or more independent variables.⁴ It evaluates whether the independent variables explain the dependent variable. The regression has these key assumptions:⁵

- Linear relationship
- Multivariate normality
- No or little multicollinearity
- No autocorrelation
- Homoscedasticity

The assumptions are extraordinarily important because violation of any of them would make the model unreliable.

⁴ Greene, William: "Econometric Analysis." 2003. p. 7. ISBN: 0-13-066189-9.

⁵ Statistics Solutions [online]: "Assumptions of Linear Regression." 2017. WWW: <<http://www.statisticssolutions.com/assumptions-of-linear-regression>>

2.2.1.1 Formulation of Economic Model

All econometric work has to start from an economic model. The model follows the rules of deductive logic.⁶ The first step is to formulate theoretical assumptions and relationships between macroeconomic indicators. Then, the economic model is proposed which corresponds to set assumptions. However, the economic model is only a logical description of what the researcher believes is true.⁷ Moreover, it is necessary to emphasize the appropriate selection and classification of variables, including units in which they will be measured. When formulating the model, it is necessary:

- Define subject.
- Select appropriate variables.
- Determine functional form.

The economic model can be mathematically written as follows:

$$y = f(x_{1t}, x_{2t}, x_{3t}) + u$$

Where:

y = Explained variable

x_{1t-3t} = Explanatory variables

u = Random variable

The explained variable is the subject that is expected to be explain. The explanatory variables are the indicators that are supposed to be associated with changes in the explained variable. The random variable is the stuff that changes the explained variable that is not part of the model.

In addition, the economic model must fulfil the assumption that there is no simultaneous relationship between the explained and explanatory variables, or between the explanatory variables. The defined economic model serves to confront the economic theory with reality.⁸

⁶ Lumen Learning [online]: "Economic Models." 2009. WWW: <<https://courses.lumenlearning.com/boundless-economics/chapter/economic-models>>

⁷ Academic library [online]: "The simple regression model." 2014. WWW: <https://ebrary.net/1000/economics/simple_regression_model>

⁸ Čechura, Lukáš: "Cvičení z ekonometrie." 2017. p. 12. ISBN: 978-80-213-2405-3.

2.2.1.2 Formulation of Econometric Model

In order to confirm that the made assumptions are in accordance with the reality, it is important to specify an econometric model. In general, the econometric model is one of the tools used to predict future developments. The econometric model fundamentally differs from the economic model:

- Contains stochastic variable.
- Contains parameters.
- Has specific functional form.

The formulation of the econometric model consists mainly of the following steps:

- Determination and classification of all variables included in the model
- Assumption of expected values of estimated parameters
- Selection of mathematical shape of the model

The econometric model can be mathematically written as follows:

$$y_t = \gamma_1 x_{1t} + \gamma_2 x_{2t} + \gamma_3 x_{3t} + u_t$$

Where:

y_t = Endogenous variable at time t

γ_{1-3} = Parameters of exogenous variables

x_{1t-3t} = Exogenous variables at time t

u_t = Stochastic variable

The endogenous variables are those whose values are determined or generated within the model, whereas the exogenous variables are determined outside the model.⁹ However, terms explained (dependent) and explanatory (independent) variables are more often used. The explained variable can be identified with the endogenous variable that is generally labelled y_t , which denotes the variable at time t . The value of the explained variable is then created and explained by the given model. Therefore, the explained variable is always on the left side of the equation.

⁹ Hušek, Roman: "Ekonometrická analýza." 2007. p. 13. ISBN: 978-80-245-1300-3.

The explanatory variables can be identified with the exogenous variables that are labelled x_t , which denotes the variables at time t . The values of these variables come from real data and explain the explained variable. The explanatory variables are always on the right side of the equation.

The stochastic variable plays a very important role in the econometric model. Above all, because it includes all other influences that affect the explained variable and for various reasons, these influences are not explicitly mentioned in the model. The stochastic variable, also referred as random variable, is labelled u_t , which denotes the random variable at time t , and is part of each stochastic model equation.¹⁰

The econometric model would be also expressed in the matrix form:¹¹

$$\beta y_t + \Gamma x_t = u_t \quad t = 1, 2, \dots, T$$

Where:

β = Matrix of structural parameters of endogenous variable

y_t = Vector of endogenous variable

Γ = Matrix of structural parameters of predetermined variables

x_t = Vector of predetermined variables

u_t = Vector of stochastic variable

T = Number of time series observations

2.2.1.3 Estimation of Parameters

There are several methods to estimate the parameters of the econometric model. The most common method is ordinary least squares (OLS). It is the default method for fitting linear models. Its advantage over other methods is that it has not a problem when dealing with small sample observations. The essence of OLS is to find parameters that minimize the sum of squares of the deviations between the observed values of dependent variable and the predicted values of dependent variable.¹²

The estimation function minimizing the sum of squares of the deviations is in the form:

¹⁰ Vance, Martin: "Econometric Modelling with Time Series - Specification, Estimation and Testing." 2012. p. 161. ISBN: 978-0521139816.

¹¹ Hendry, David: "Econometric Modeling - A Likelihood Approach." 2007. p. 100. ISBN: 978-0691130897.

¹² NIST/SEMATECH [online]: "Linear Least Squares Regression" 2013. WWW: <<http://www.itl.nist.gov/div898/handbook/pri/section2/pri24.htm>>

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

Where:

$\gamma = k \times 1$ vector of parameters to be estimated

$\mathbf{X} = n \times k$ matrix of explanatory variables

$\mathbf{y} = n \times 1$ matrix of explained variable

3. LITERATURE REVIEW

The theoretical background on wheat and its utilization with focused on the United States is described and evaluated in this part. Furthermore, it covers wheat in terms of the international trade; information on the historical and current leading wheat producers, exporters, and importers in the world. I have used secondary data for the research, mainly from articles, books, official documents, reports, and statistical bulletins. This will serve as the basis for the compilation of economic theory and the specification of the econometric model in the analytical part.

3.1 Wheat characteristics

Wheat is the common name referring to genus *Triticum* of the grass and the cereal grains which contain many growing and breeding species.¹³ It is one of the oldest plants originated in Southwest Asia, southeast of modern Turkey. Wheat was one of the first domesticated food crops and for thousand years has been the fundamental staple food of the major civilizations to have ever existed in the world.¹⁴ Egyptians grown and baked breads in ovens over 5,000 years ago. Farmers have always improved it by breeding. In the United States, wheat was first planted at the end of the 18th century as a hobby crop. Nowadays, the wheat is grown in around 120 countries of the world.

Wheat can be grown in every temperate climate in the world. Wheat cultivation relies upon rainfall, temperature and soil conditions. The most suitable are dry areas where soil quality is poor.¹⁵ Given wheat contains several essential vitamins and minerals, it is a basic food of millions of people. The international wheat trade is greater than for all other crops combined. The global and national importance of wheat lies in both food and non-food uses. In the food industry, grain of wheat serves for pastry, pasta and confectionery. It is also a valuable feed for livestock. Wheat can also be used as a seed and a raw material for technological processing, ethanol, alcohol and starch. The commodity even plays a role in the energy and cosmetic industries.¹⁶

¹³ Zimolka, Josef: "Pšenice - Pěstování, hodnocení a užití zrna." 2005. p. 9. ISBN: 978-80-8672-609-0.

¹⁴ FAOSTAT [online]: "Wheat in the world." 1996. WWW:
<<http://www.fao.org/docrep/006/y4011e/y4011e04.htm>>

¹⁵ Bushuk, Walter: "Wheat - Production, Properties and Quality." 1994. p. 22. ISBN: 978-0751401813.

¹⁶ Cornell, Hugh: "Wheat - Chemistry and Utilization." 1998. p. 35. ISBN: 978-1566763486.

3.1.1 U.S. Wheat Classes

U.S. wheat is known worldwide for its quality. However, wheat is a general expression related to different varieties of the grain. There are hundreds types of wheat in the world, specifically, in case of the United States all of them fit into six basic classes.¹⁷ This is very different from other countries, where one or two wheat classes are produced. Every wheat class has distinct uses, and production tends to be regional. Due to the different wheat varieties are intended for different purposes, wheat prices frequently vary in price range.

In the U.S. six classes of wheat are grown; hard red winter (HRW), soft red winter (SRW), hard red spring (HRS), hard white (HW), soft white (SW) and durum.¹⁸ In addition to an unclassified class and a mixed wheat class. Mixed wheat is the category designation for shipments that contain less than 90% of one wheat class and more than 10% of one or more other classes.¹⁹ Wheat has two distinct growing seasons; winter and spring. The first four classes mentioned above are winter planted types and the last two are spring types. About 70-80% of U.S. wheat production consists winter wheat. Winter wheat is sown in the fall and harvested in the spring or summer. Spring wheat is planted in the spring and harvested in late summer or early fall. The classes are also determined by hardness, colour and shape of kernels.²⁰ In general, the hard wheat classes consist higher amount of the proteins. HRW and HRS are the most produced and exported U.S. wheat classes. The next figure No. 1 shows the production of each wheat class in the United States.

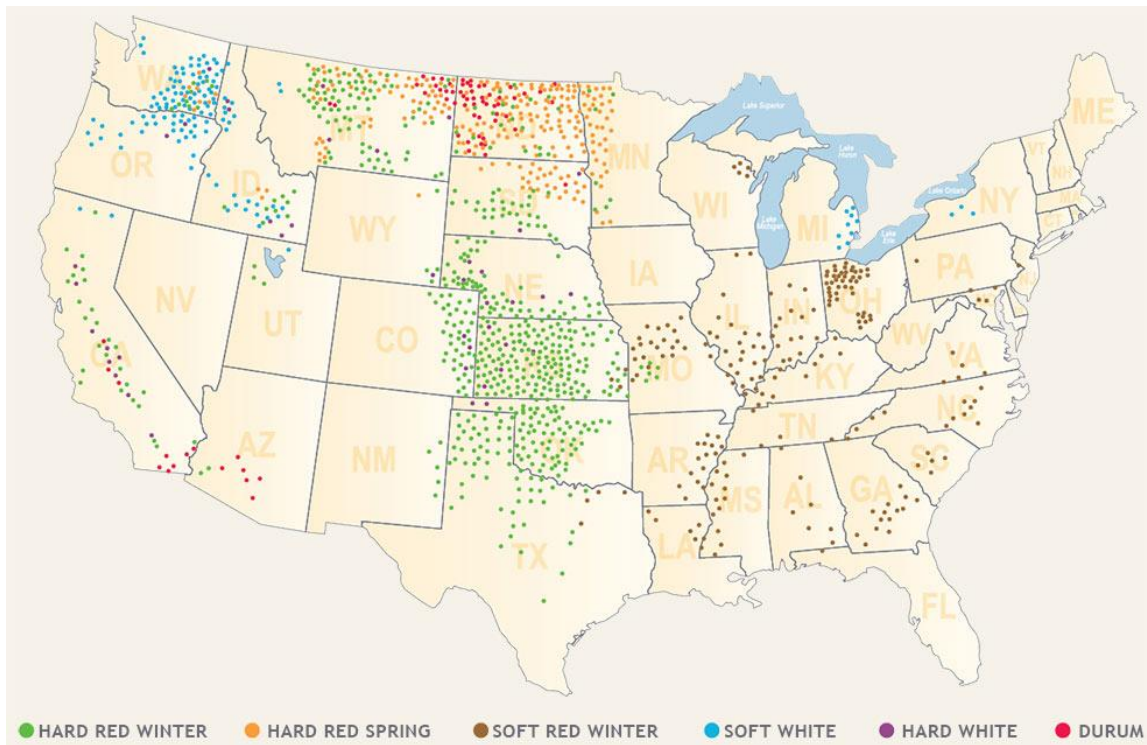
¹⁷ Hladik, Maurice: "Demystifying Food From Farm to Fork." 2012. p. 16. ISBN: 978-1462068036.

¹⁸ Nebraska Wheat Board [online]: "Wheat Types." 2017. WWW: <<https://nebraskawheat.com/buyers-processors/wheat-types>>

¹⁹ Kansas State University [online]: "Wheat and Flour Testing Methods - A Guide to Understanding Wheat and Flour Quality." 2008. WWW: <<http://www.grains.k-state.edu/igp/wheatflourbook/wheat-flour-book.pdf>>

²⁰ ProAg [online]: "6 Classes of Wheat Infographic." 2017. WWW: <<https://www.proag.com/news/6-classes-of-wheat-infographic>>

Figure No. 1: Wheat Production in the U.S.



Source: National Association of Wheat Growers [online]: "Wheat Production Map." 2017. WWW:

<<https://www.wheatworld.org/wheat-101/wheat-production-map>>

3.1.1.1 Hard Red Winter

Hard red winter wheat is a leading class of wheat produced in the Great Plains states, including areas of Colorado, Kansas, Nebraska, Oklahoma, Texas, Wyoming, and South Dakota. Kansas farmers rank first in the production of HRW.²¹ It is of moderate hardness and consists medium level of protein content. HRW is highly versatile wheat with great factors for milling and baking bread.²² It is used to produce Asian noodles, hard rolls, flat breads, tortillas and general purpose flour. U.S. farmers produced a total of 1 billion bushels of HRW wheat in 2016. This class of wheat covers more than 40% of the wheat grown in the U.S. and half of U.S. wheat exports.²³ It is exported mainly to Brazil, Nigeria, Mexico and Japan.

²¹ LCS [online]: "Hard Red Winter Wheat." 2017. WWW: <<http://limagraincerealseeds.com/products/hard-red-winter-wheat>>

²² USW [online]: "Wheat Classes." 2017. WWW: <<http://www.uswheat.org/wheatclasses>>

²³ Prairie Californian [online]: "All Wheat is Not Created Equal - Six Classes of Wheat." 2014. WWW: <<http://prairiecalifornian.com/wheat-created-equal-six-classes-wheat>>

3.1.1.2 Soft Red Winter

Soft red winter is high-yielding wheat produced mainly in the eastern third of the U.S., east of the Mississippi River. It has a low protein content, nevertheless excellent characteristics for milling and baking cookies, crackers, pretzels, pastries and flat breads.²⁴ 345 million bushels of SRW wheat were produced in the U.S. in 2016. It represents 23% of U.S. wheat production. It makes up around 14% of U.S. wheat exports, the major export destinations are China, Mexico, Nigeria and Colombia.²⁵

3.1.1.3 Hard White

Although hard white wheat is not a new crop, it is the newest class of wheat to be marketed in the United States. The largest producer states are Colorado and Kansas.²⁶ It has a medium to high protein content. Closely related to red wheats, this wheat has a milder, sweeter flavor, equal fiber and similar milling and baking properties.²⁷ It is used in oriental noodles, whole wheat or high extraction flour applications, pan and flat breads. HW is sold mostly in the domestic markets, and only limited amounts are exported.

3.1.1.4 Soft White

Soft white wheat has a low protein content, however, it is high yielding wheat grown predominantly in the Pacific Northwest. It is sweeter and softer than hard wheat.²⁸ This makes soft white wheat flour a good choice for bakery products such as cakes, pastries and cereals. SW is suited to Middle Eastern flat breads, where it is exported in a huge amount. 20% of total U.S. wheat export is made of soft white wheat. The main importers are from Far-East Asia, Philippines and South Korea in particular.²⁹

²⁴ California Wheat Commission [online]: "U.S. and California Wheat Classes." 2017. WWW: <<http://www.californiawheat.org/industry/classes-of-us-wheat>>

²⁵ Wheat Trading Explained [online]: "Soft Red Winter Wheat." 2010. WWW: <<http://www.hotgrain.com/wheatclasses/srw>>

²⁶ North Dakota Wheat Commission [online]: "Hard White Wheat." 2006. WWW: <<http://www.ndwheat.com/uploads/resources/568/hardwhitewheatbrochure.pdf>>

²⁷ Allgrains exports DMCC [online]: "Hard Wheat." 2015. WWW: <<http://allgrains.co/hard-wheat.php>>

²⁸ Daybreak Mill [online]: "Soft White Wheat." 2017. WWW: <<https://www.daybreakmill.com/blogs/health-benefits/soft-white-wheat>>

²⁹ World Grain [online]: "Korean millers examine U.S. wheat quality." 2016. WWW: <http://www.world-grain.com/articles/news_home/World_Grain_News/2016/08/Korean_millers_examine_US_whea.aspx?ID=%7B7080B12F-6878-419B-B9A4-9A091F7B915A%7D>

3.1.1.5 Hard Red Spring

Hard red spring wheat is grown in a wider and more diverse geography than any other class.³⁰ It is produced primarily in Montana, North Dakota, South Dakota and Minnesota. North Dakota farmers rank first in the production. HRS has the highest protein content.³¹ Its characteristics are excellent for making pan breads, hearth breads, rolls, croissants, bagels, hamburger buns and pizza crust. U.S. produced 493 million bushels of HRS wheat in 2016. This important class of wheat encompasses more than 20% of U.S. wheat exports. The main buyers are states in Central America, Philippines, Japan and Indonesia.

3.1.1.6 Durum

Durum is the hardest of all six wheat classes and its production takes place largely in the northern areas as in case of hard red spring, especially in North Dakota. It has a very dense and high protein content.³² Durum wheat is used primarily for pasta, couscous and some Mediterranean breads.³³ It has several subclasses based on portion of vitreous kernels. U.S. producers grew 50 million bushels of durum wheat in 2016. It accounts for less than 5% of U.S. wheat export volume. About 20 countries purchase U.S. durum and Europe is the single largest importer. The major foreign buyers are Algeria and Italy.³⁴

3.1.2 Wheat Growing Regions

Wheat is grown in a wide range of climatic environments and geographic regions, namely in Europe, America, Africa and Asia. The most climatically optimal regions are rather warm and dry. Temperature is an important factor for germination, which takes place at a temperature of 4 °C, preferably at a temperature about 20 °C.

The growing area is most often expressed in hectares (ha). The largest areas of wheat cultivation in 2016 as follows (in million hectares); India (30.23), Russia (27.31), the

³⁰ LCS [online]: "Hard Red Spring Wheat." 2017. WWW: <<http://limagrainscerealseeds.com/products/spring-wheat>>

³¹ Minot Milling [online]: "Hard Red Spring Wheat." 2017. WWW: <<http://www.minotmilling.com/hard-red-spring-wheat/hard-red-spring-wheat>>

³² USDGA [online]: "Home." 2017. WWW: <<https://www.durumgrowers.com>>

³³ Kansas Wheat [online]: "Six classes of U.S. wheat." 2014. WWW: <<http://kswheat.com/news/2014/12/02/which-wheat-for-what>>

³⁴ Bloomberg [online]: "Why Italy Can't Get Enough U.S. Wheat." 2015. WWW: <<https://www.bloomberg.com/news/articles/2015-12-11/viva-la-pasta-italy-dishes-up-rare-good-news-for-u-s-wheat>>

European Union (26.71), China (24.34), the United States (17.76), Kazakhstan (12.37), and Australia (11.28). The numbers fluctuate in the long term, however, the fluctuations do not indicate any trend.

The final production is likewise greatly influenced by the size of average yield. Wheat yield causes uncertainty each year, it is especially affected by weather. Governments often respond to low harvest with restrictions or even export bans.³⁵ The worldwide wheat yield per hectare constantly becoming higher with the development of better wheat varieties and production procedures. Historically, most of the increase in global wheat production resulted from the greater yield. The production had almost increased by three times since the beginning of second half of the 20th century.³⁶ In 1951, the world's wheat yield amounted to almost 1 ton per hectare. It managed to get to 2 tons by the early 1980s and reached 2.5 tons per hectare by 1995. Nowadays, the value is a little over 3.³⁷ In terms of wheat yield per hectare, the highest returns have been achieved over the long-term in Ireland, Belgium, the Netherlands, Germany, New Zealand and the United Kingdom.³⁸

3.1.2.1 North America

Wheat was introduced to North America in the late 15th century and 16th century. Wheat is produced in most of the 50 states of the United States. Nevertheless, majority of U.S. wheat is grown in the Great Plains. Six basic classes of wheat are grown (see chapter above). More than 50% of U.S. wheat production consists of the hard red wheat. In terms of Canada's agricultural production, wheat is the most important cultivated crop. Almost all Canadian wheat is grown in the southern areas. Due to its well-known superior protein content and quality, Canada's wheat is highly demanded abroad.³⁹ Canadian yields average around 2.9 tons per hectare in August 2017, down 18% from last year.⁴⁰

³⁵ Singh, S. S.: "Wheat - Productivity Enhancement Under Changing Climate." 2012. p. 56. ISBN: 978-8184871487.

³⁶ Encyclopedia [online]: "The Natural History of Wheat." 2003. WWW: <<http://www.encyclopedia.com/food/encyclopedias-almanacs-transcripts-and-maps/natural-history-wheat>>

³⁷ Statista [online]: "Global wheat yield per hectare from 2010/2011 to 2025/2026." 2017. WWW: <<https://www.statista.com/statistics/237705/global-wheat-production>>

³⁸ Satorre, Emilio: "Wheat - Ecology and Physiology of Yield Determination." 1999. p. 303. ISBN: 978-1560228745.

³⁹ Cereals Canada [online]: "Canadian Wheat - Meeting Customer Demand." 2016. WWW: <<https://cerealscanada.ca/cereals-corner/23-canadian-wheat-meeting-customer-demand>>

⁴⁰ USDA FAS [online]: "Canada Wheat and Rapeseed: Hot, Dry Conditions in the Prairies Decrease Yield Forecast." 2017. WWW: <https://ipad.fas.usda.gov/cropeexplorer/pecad_stories.aspx?regionid=can&ftype=prodbriefs>

3.1.2.2 Western Europe

In Europe, wheat production mostly contains the soft variety. The season for growing is long, it takes up to 11 months. The leading wheat producing countries in Western Europe are France, Germany, the United Kingdom, Italy, Spain and Portugal. These countries' wheat yields are the world's highest, usually the range is from 6 to 8 tons per hectare.⁴¹ The reason is that it is produced on the well-watered, rainfed wheat fields. France is the largest producer of wheat in Europe, the production takes place mainly in the northern regions of France.⁴² France and Germany together account for almost 50% of overall EU wheat production. In Germany, winter wheat is the major cereal crop grown on 54% of the cereal production area. Wheat yields in Germany generally average around 7.7 tons per hectare.

3.1.2.3 Eastern Europe

Much of the agricultural area in the eastern part of the European continent is similar to the area cultivated in Canada and the north of the United States. Wheat grown in Eastern Europe is in most cases winter type. Since 2003, wheat production in Russia and Ukraine increased dramatically. The Black Sea region and other Eastern European countries like Kazakhstan have emerged as the main players in the world wheat market. Their successful marketing strategy is based on good quality wheat at prices with which others cannot compete, furthermore, it is underpinned by greater cost efficiencies in its wheat supply chains. It is expected that Eastern European countries will continue to challenge their competitors.

3.1.2.4 East Asia

Wheat is grown all over China, moreover, it is grown on 33% of all cereal area in the country. Environmental stresses vary across the regions. Wheats cultivated in China contain winter and spring wheat varieties. As of 2013, wheat yield in China was 5 tons per hectare. The northern winter wheat region is the most important wheat-producing area, it represents about 70% of the total Chinese wheat production.⁴³ Today, China is the world's top wheat producer and consumer. Both Korea produces a very small

⁴¹ Earth Policy Institute [online]: "Grain Yields Starting to Plateau." 2012. WWW: <<http://www.earth-policy.org/mobile/books/fpep/fpepch7>>

⁴² World Atlas [online]: "Top Wheat Producing Countries." 2017. WWW: <<https://www.worldatlas.com/articles/top-wheat-producing-countries.html>>

⁴³ The Global Yield Gap Atlas [online]: "China." 2012. WWW: <<http://www.yieldgap.org/china>>

amount of wheat, and they are greatly dependent on the imports. In case of Japan, over 90% of the wheat consumed in Japan is imported, mostly from the United States.⁴⁴ Japan wheat domestic consumption equalled 6,490 thousand metric tons in 2016.⁴⁵

3.1.2.5 South Asia

Wheat is grown across a huge area in South Asia. The main wheat-producing countries are India, Pakistan, Nepal and Bangladesh. The Ganges basin, with its fertile soil, is an important source of the production of wheat for both India and Bangladesh. Besides, India is the third largest wheat producer in the world. It is likewise the third largest wheat consumer after EU and China, and has a huge and growing demand for wheat.⁴⁶ In Pakistan, the main agricultural province is Punjab where wheat is the most produced. Pakistan's wheat production supplies mainly the domestic market, nevertheless, Pakistan has been enjoying a surplus of wheat over the past few years.

3.1.2.6 Oceania

Australia is one of the most important wheat producer in the world. Production takes place primarily on the eastern side of South Australia. In general, wheat produced in Western Australia is mostly exported and the prices are more driven by international factors, whereas approximately 40% of wheat produced in the eastern part of Australia is used for domestic consumption. Australian wheat classes including: Australian Prime Hard, Australian Hard, Australian Premium White, Australian Standard White, Australian Soft, and Australian Durum.⁴⁷ Wheat yields in Australia are low and highly variable especially due to extreme fluctuations in annual rainfall. Even though wheat is grown only on a small area in New Zealand, it is a major crop in the country. With an average yield of 12 tons per hectare. Furthermore, a farmer in New Zealand has

⁴⁴ Slate [online]: "Waves of Grain." 2012. WWW: <http://www.slate.com/articles/life/food/2012/04/wheat_in_japan_how_the_nation_learned_to_love_the_american_g_rain_instead_of_rice_.html>

⁴⁵ Index Mundi [online]: "Japan Wheat Domestic Consumption by Year." 2017. WWW: <<https://www.indexmundi.com/agriculture/?country=jp&commodity=wheat&graph=domestic-consumption>>

⁴⁶ Index Mundi [online]: "Wheat Domestic Consumption by Country in 1000 MT." 2017. WWW: <<https://www.indexmundi.com/agriculture/?commodity=wheat&graph=domestic-consumption>>

⁴⁷ Wheat Quality Australia [online]: "Classes." 2017. WWW: <<http://wheatquality.com.au/classification/how-it-works/classes>>

achieved the world record for wheat growing with a yield of 16.791 tons per hectare in 2017.⁴⁸

3.1.3 Measurement of Wheat

In most cases, wheat is measured in bushels, pounds or tons. According to practices in the United States, wheat yields are calculated as bushels per acre, wheat prices are cited as dollars per bushel. Even though there is existence of the long-standing arrangements of international trade in wheat, there is still no common agreement how to measure it. Most countries in the world have embraced the International System of Units (SI), international decimal system of weights and measures. However, the British and U.S. variations of the system of imperial units are still common.⁴⁹ The U.S. bushel came from the Winchester bushel, a British measurement dating back to the 15th century. Agricultural products were measured in accordance with how much they fit in a bushel basket at that time.

A current bushel has a weight equivalent. 1 U.S. bushel of wheat is equal to 27.2155 kilograms, or 0.0272155 ton. In other words, one ton is equivalent to 36.7437 U.S. bushels of wheat.⁵⁰ In the United States, one acre of wheat produces an average of 37.1 bushels. A bushel of wheat yields 42 loaves of bread. Put another way, for each acre of wheat planted, 1,558 loaves of bread are produced. Today, U.S. farmers grow about 50 million acres of wheat.

⁴⁸ AgriLand [online]: "New Zealand farmer breaks wheat growing world record." 2017. WWW: <<http://www.agriland.ie/farming-news/new-zealand-farmer-breaks-wheat-growing-world-record>>

⁴⁹ Lorton, Sherry: "Merchant's Edge - A Complete Guide to Grain Merchandising." 2002. p. 14. ISBN: 978-1588741257.

⁵⁰ Khan, Khalil: "Wheat - Chemistry and Technology." 2009. p. 8. ISBN: 978-1-891127-55-7.

3.2 International Trade in Wheat

Wheat is one of the basic globally traded commodities, whose importance is already found in Ancient civilizations, when it served as a currency. Easy grain measurement was a way to recalculate the value of goods. Nowadays, it is the most important globally traded agricultural commodity. It is thanks, in particular, to its low risk investment due to relatively low fluctuations in the value. The commodity's stability is linked to its easy cultivation on a large scale and its steady sales in many markets including basic foodstuff, raw material for food production, or feed.⁵¹ Nevertheless, only approximately 16% of world's wheat serves as feed for animals.

Trade with wheat performs an essential role within today's world financial system, and with a rapid increase in the world's population, its importance will become even more significant in near the future. The international wheat trade is impacted by changes in world economic growth, global supplies and prices, changes in exchange rates, government support for agriculture, and trade protection policies.⁵² Moreover, world's wheat trade is effected many limitations that change over time. Subsidies, tariffs and quantity restrictions are some of the regulations which leading exporting and importing countries employ. For instance, the United States employ subsidies on wheat exports in order to let U.S. producers sell at lower prices and remain competitive in the global market. As well as many other countries that protect domestic producers from low international prices by restricting market entry.

There is a dozen of countries which regularly export a million tons of wheat every year. However, the international market does not trade all the wheat produced, nearly 20% of the world's wheat production is traded globally, notably as exports from the developed countries such as Australia, Canada, EU and the U.S. to developing countries in Asia, Latin America and North Africa. Although, many developing nations look for to be self-sufficient when it comes to wheat consumption. India is one of the best examples of this development, they were not known for wheat production in the past, however, India has become a major wheat producing and exporting country. The same pattern is followed by China which is becoming less dependent on wheat imports from abroad each year.

⁵¹ Gooding, Mike: "Wheat Production and Utilization - Systems, Quality and Environment." 1997. p. 18. ISBN: 978-0851991559.

At present, world wheat trade is estimated at 181 million metric tons, 10% above the 5-year average.⁵³

3.2.1 History of Wheat Trade

The early wheat trade date back to the ancient Mediterranean trade routes, which allowed both Greeks and Romans to import wheat from the Middle East.⁵⁴ Through another important route, the Silk Road, wheat was delivered to China. In the Medieval Period, the wheat trade was more associated with milling. Tenant farmers were forced to process their grain at landlord's mill, and one-sixteenth of the production was kept by the landlord as a fee. The system was abolished in the late 18th century. After that millers were allowed to buy wheat of their choice that were produced outside their region.

When settlers arrived in the Americas, they couldn't find wheat, something unusual from what they were used to in Europe. They had to import flour from the Old Continent, till they were able grow wheat by themselves. People did not consider shipping wheat all over the world as something profitable at that time. The United States started exporting wheat to England in the early 18th century. Later, during Napoleonic Wars and First and Second World War, the U.S. exported a record quantity of wheat to European countries.

In the latter part of the 20th century, tremendous changes occurred in the international wheat trade. Regions that were once centres in growing wheat became dependent on wheat imports. For instance, Turkey and other countries in the Middle East, the earliest exporters, started to import million tons of wheat every year to satisfy their growing population. Moreover, global wheat production increased greatly within the period 1950–1990.⁵⁵ Since 1990, production has remained relatively constant. Due to an increase in global competition, the market share from developed countries has significantly fallen from 45% in the early 1950s to 35% in the late 1990s. For example,

⁵² USDA ERS [online]: "U.S. Agricultural Trade - Overview." 2017. WWW:
<<https://www.ers.usda.gov/topics/international-markets-trade/us-agricultural-trade>>

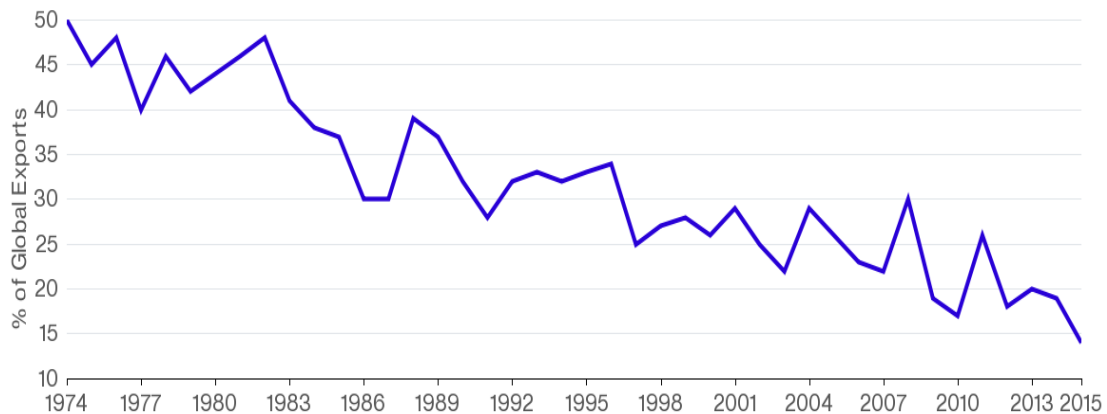
⁵³ USW [online]: "World Wheat Supply and Demand Situation." 2018. WWW:
<[http://www.uswheat.org/supplyDemand/doc/4DA08B3625ECE3CC8525824A006EC37E/\\$File/S&D%20180308.pdf?OpenElement#](http://www.uswheat.org/supplyDemand/doc/4DA08B3625ECE3CC8525824A006EC37E/$File/S&D%20180308.pdf?OpenElement#)>

⁵⁴ Ancient History Encyclopedia [online]: "Trade in Ancient Greece." 2012. WWW:
<<https://www.ancient.eu/article/115/trade-in-ancient-greece>>

⁵⁵ Bonjean, Alain: "The World Wheat Book - A History of Wheat Breeding." 2001. p. 361. ISBN: 978-2743020910.

the U.S. faced fall of its market share of wheat exports from 49% to around 28% in 1998. This phenomenon and how U.S. global wheat's dominance is over is shown in the following figure No. 2.

Figure No. 2: U.S. Fading Market Share



Source: IKAR [online]: "Wheat Glut Erodes U.S. Exports as Cheap Russia Grain Wins Buyers." 2015. WWW: <<http://www.ikar.ru/eng/press.php?id=1004>>

3.2.2 Wheat Futures

Wheat, as well as other agricultural commodities, is traded in form of futures. Wheat futures has begun trading in the year 1877. At the present times, wheat futures are standardized, exchange traded contracts in which the contract importer agrees to take delivery, from the exporter, a certain quantity of wheat at a predetermined price on a future delivery date.⁵⁶ That primarily occurs in March, May, July, September, and December.

In the United States, wheat is traded at the Chicago Board of Trade (CBOT), Kansas City Board of Trade (KCBT) and the Minneapolis Grain Exchange (MGEX).⁵⁷ In Europe, wheat is trade on NYSE Euronext (Euronext). Each of these markets offers distinct class of wheat. CBOT bids soft red winter wheat, the prices are stated in dollars and cents per bushel, and the wheat is sold in units of 5000 bushels.⁵⁸ KCBT offers hard red winter wheat. MGEX specializes on hard red spring wheat.

⁵⁶ The Options Guide [online]: "Wheat Futures Trading Basics." 2017. WWW: <<http://www.theoptionsguide.com/wheat-futures.aspx>>

⁵⁷ Kleinman, George: "Trading Commodities and Financial Futures - A Step-by-Step Guide to Mastering the Markets." 2013. p. 95. ISBN: 978-0134087184.

⁵⁸ RJO Futures [online]: "Wheat Futures." 2017. WWW: <<https://rjofutures.rjobrien.com/futures-markets/agriculturals/wheat-futures>>

In general, wheat futures sold at CBOT and KCBT are employed as benchmarks for wheat prices.⁵⁹ In addition to that, Chicago SRW wheat is the most actively traded and liquid wheat futures in the world. The liquidity is crucial for producers and exporters in order to manage risk management. Given to changes in the weather, the wheat futures are greatly variable. The wheat consumers and producers may manage a price risk by purchasing and selling wheat futures.⁶⁰ It means to lock in a future selling price for an ongoing production of wheat that is only ready for sale sometime in the time to come.

3.2.3 Wheat Prices

The price of wheat is governed by the supply/demand relationship in the markets. The price is not constant and changes over time. Moreover, wheat prices tend to be volatile. The price is highest in period of year when wheat is delivered, specifically, in March, May, July, September, and December. Price fluctuations in a wider understanding and on a longer-term basis result from the effects of structural and transient factors. The wheat price development is put forward in the figure No. 3 below.

Figure No. 3: Wheat Price 1866–2015



Source: Harvest Investor [online]: "Historic Wheat Prices: Real vs. Nominal." 2016. WWW:
<http://harvestinvestor.blogspot.cz/2016/05/historic-wheat-prices-real-vs-nominal.html>

The structural factors causing a long-term and gradual shift in the market equilibrium. The factors include constant growth in demand in emerging countries such as Brazil, China and India, economic growth, urbanization, and change in local eating habits. The

⁵⁹ Pugh, Burton: "Science and Secrets of Wheat Trading." 2013. p. 66. ISBN: 978-1607966494.

⁶⁰ Droke, Clif: "How to Trade Wheat Futures." 2002. p. 39. ISBN: 978-0971785205.

demand growth is related to the growth of the world's population and the price of other agricultural commodities such as barley. Energy prices also play a role as it influences input costs of the production as well as cost of the transport. The biofuels market currently has a negligible impact on wheat prices, but it is a factor that has a potential to develop and have significant impact in the future.

The transient factors reinforce the direction, speed and intensity of price developments. Climatic fluctuations and extreme events have a very significant impact on wheat prices, such as drought and floods, which can affect larger areas and completely destroy the crops. The price fluctuates also as a result of the financial markets, especially during crisis, which lead to the growth of speculative investors wishing to protect themselves against the risk of price fluctuations.⁶¹ These activities further lead to greater instability and increase ongoing price developments. Exchange rates have also a significant influence on the price, especially U.S. dollar.⁶² The most affected countries are those whose currency is directly tied to the American dollar. Wheat prices are likewise affected by a ban on the export imposed by exporting countries, or by an increase in the export tax.⁶³ These measures serve to protect domestic markets from short-term shocks or lack of food. However, they damage importing countries. In the medium term, these measures reducing motivation of domestic farmers to increase production.

The price fluctuations lead to very diverse consequences. The most threatened by negative impacts are developing countries, notably when they are dependent on food aid. A rise in wheat prices may lead to violent riots locally.⁶⁴ In the short term, it may cause higher poverty and increased vulnerability to further external shocks. However, it can often also be an opportunity for rural communities to get out of poverty. The high prices are more profitable for food retailers.

⁶¹ Bittman, James: "Trading and Hedging with Agricultural Futures and Options." 2012. p. 102. ISBN: 978-1-118-53876-0.

⁶² Iowa State University [online]: "Value of the dollar and exports of major agricultural crops." 2015. WWW: <<https://www.extension.iastate.edu/AgDM/articles/others/RayApr15.html>>

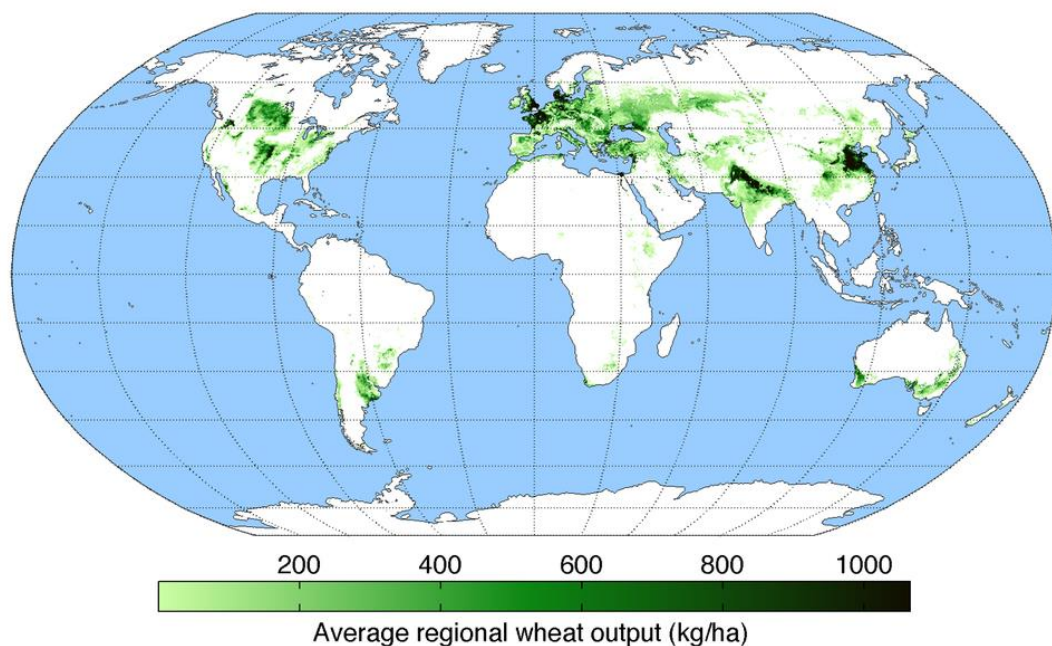
⁶³ Stratfor [online]: "The Effect on Egypt of Ukraine's Wheat Export Ban." 2012. WWW: <<https://worldview.stratfor.com/article/effect-egypt-ukraines-wheat-export-ban>>

⁶⁴ Guardian [online]: "Use your loaf - why food prices were crucial in the Arab spring." 2011. WWW: <<https://www.theguardian.com/lifeandstyle/2011/jul/17/bread-food-arab-spring>>

3.2.4 Wheat Producers

Global wheat production is permanent, wheat is harvested in some part of the world within each month over the year. In June 2017, the United States Department of Agriculture (USDA) has calculated that the global wheat production in the agriculture season 2017/2018 will be 757 million metric tons. The largest wheat producing countries in 2017 in order of production (in 1,000 metric tons): the European Union (151.600), China (130.000), India (98.380), Russian Federation (85.000), and the United States (47.371).⁶⁵ They are followed by: Canada, Ukraine, Pakistan, Australia, and Turkey. The European Union, a combination of 28 European nations, holds first place. China is single largest wheat producing country. The next figure No. 4 displays the production of wheat worldwide.

Figure No. 4: Wheat Production in the World



Source: National Geographic [online]: "Worldwide Wheat Production." 2014. WWW:

<<https://blog.nationalgeographic.org/2014/08/25/geography-in-the-news-worldwide-wheat-production>>

France and Germany are the largest EU's producers of wheat.⁶⁶ Even if China has only 15% land of its total area where crops can grow well, Chinese farmers produce about

⁶⁵ Index Mundi [online]: "Wheat Production by Country in 1000 MT." 2017. WWW:
<<https://www.indexmundi.com/Agriculture/?commodity=wheat&graph=production>>

⁶⁶ Eurostat [online]: "France produced almost one quarter of cereals in the EU." 2017. WWW:
<<http://ec.europa.eu/eurostat/web/products-eurostat-news/-/DDN-20170413-1?inheritRedirect=true&redirect=%2Feurostat%2F>>

18% of worldwide wheat production.⁶⁷ It represents food for around 20% of the world's population. India produces more than enough wheat to feed a population of 1.324 billion people, and even to export millions tons of wheat abroad. Russian wheat production continues in a rising trend that began in the year 2013. In 2014, almost 50% of the total world wheat production was narrow to four countries, China, India, Russian Federation, and the United States. Nevertheless, nowadays the producers once considered as largest are producing less wheat and newcomers are producing more. In particular, international trade in wheat has been shaken up by a huge increase in the production in Russia. In the agricultural season 2017/18, wheat production in Russia is estimated at 85 thousand metric tons, 17% above 2016/17. In the same period, U.S. wheat production is projected at 47 thousand metric tons, 19% below the 5-year average.⁶⁸ Russian neighbours' wheat production such as Ukraine and Kazakhstan have continued to rise as well.⁶⁹

3.2.5 Wheat Exporters

Global wheat exports totalled US \$36.3 billion in 2016. Top five exporters in 2017 are listed as follows (in 1,000 metric tons): Russian Federation (36.000), the European Union (26.000), the United States (25.855), Canada (22.500), and Ukraine (17.000).⁷⁰ They are followed by: Australia, Argentina, Kazakhstan, Turkey, and Mexico. The following figure No. 5 shows the development of the largest exporters of wheat worldwide.

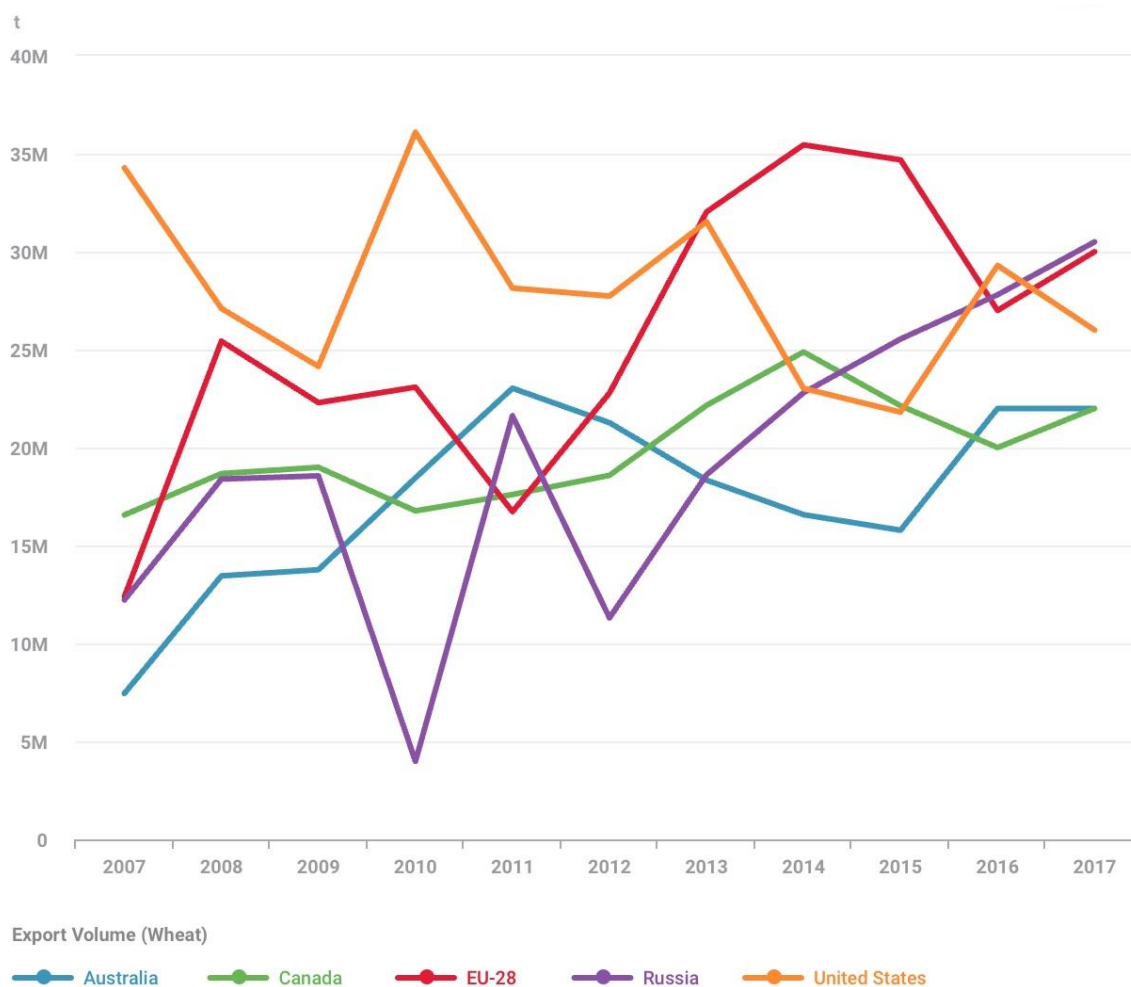
⁶⁷ Commodity Basis [online]: "Wheat Prices." 2014. WWW: <https://www.commoditybasis.com/wheat_prices>

⁶⁸ Index Mundi [online]: "United States Wheat Production by Year." 2017. WWW: <<https://www.indexmundi.com/Agriculture/?country=us&commodity=wheat&graph=production>>

⁶⁹ Grain Central [online]: "Little change in world wheat production." 2017. WWW: <<https://www.graincentral.com/markets/little-change-in-world-wheat-production-usda>>

⁷⁰ Index Mundi [online]: "Wheat Exports by Country in 1000 MT." 2017. WWW: <<https://www.indexmundi.com/agriculture/?commodity=wheat&graph=exports>>

Figure No. 5: Top Wheat Exporters (2007–2017)



Source: LinkedIn [online]: "Hard Times for Hard Wheat." 2017. WWW: <<https://www.linkedin.com/pulse/hard-times-wheat-sara-menker>>

The European Union had been exporting the largest quantity of wheat over the past decade, but in the year 2017, EU wheat exports have dropped by 25%. The largest EU's exporters are France and Germany. A decline in the EU wheat exports is due to a significant fall in French production. Europe's bad weather has severely hit their wheat production. Besides, Russian wheat exports have gone up by 20%.⁷¹ This is the first time when Russia ranks that position among exporters. It was a huge wheat importer in the latter half of the 20 century, but since the collapse of the Soviet Union, wheat exports from former members have risen sharply.⁷² The Russian wheat boom is caused mainly by government support, weak currency and high yields. The future performance

⁷¹ Bloomberg [online]: "Europe Is Feeling the Power of Russian Wheat as Exports Drop." 2017. WWW: <<https://www.bloomberg.com/news/articles/2017-11-15/europe-is-falling-behind-russia-in-the-global-wheat-market>>

⁷² Kub, Elaine: "Mastering the Grain Markets - How Profits Are Really Made." 2012. p. 87. ISBN: 978-1477582961.

of Russian wheat exports relies mainly on the weather as well as currency fluctuations. The United States, Canada, and Australia are other prominent exporters of wheat. In the year 2016, U.S. exported the largest amount of wheat worldwide. U.S. wheat exports were reduced by 3,577 metric tons in 2017, especially because of severe drought conditions. While Canada has increased wheat exports, it produces high quality wheat, as more than 75% of their wheat is exported abroad.⁷³ The same pattern applies to Australia, the majority of Australian wheat is exported into the major export markets, especially within the Asia continent.

It is important to underline that the United States were the largest exporter for decades until recently. Russia's Black Sea has always been the main supplier to the Arab world, but now, an increasing number of nations in the Middle East and North Africa are switching from the U.S. to Russia even more. The cheap freight rates caused that even countries such as Mexico, which has traditionally been a U.S. wheat importer, is buying Russian wheat. However, in case of the United States, still almost half of the wheat farmers grow is traded abroad, in some states, the portion is even higher. For example, around 80% of Montana wheat is exported overseas.⁷⁴ The U.S. expects to regain some of the market share in the near future.

3.2.6 Wheat Importers

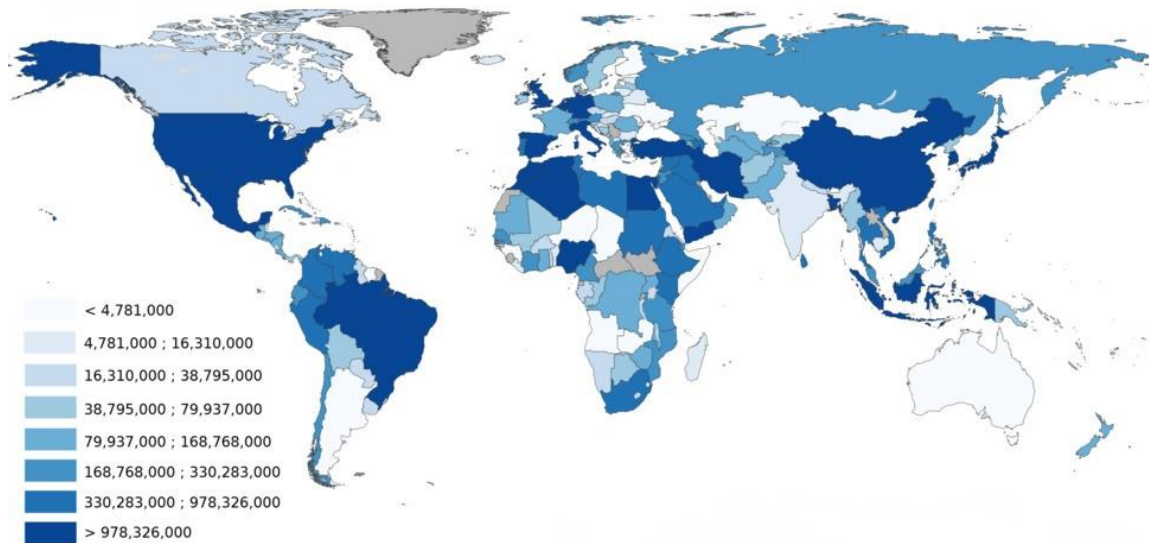
Even though most wheat is consumed within the country where it is grown, more or less one-fifth of the annual production is imported from abroad. The biggest wheat importing countries in 2017 as follows (in 1,000 metric tons): Indonesia (12.500), the Arab Republic of Egypt (12.000), Brazil (7.800), Algeria (7.700), and Bangladesh (6.200).⁷⁵ They are followed by: Japan, Philippines, the European Union, Mexico, and Nigeria. The figure No. 6 below reveals global wheat imports in the year 2013, quoted in U.S. dollars.

⁷³ Index Mundi [online]: "Canada Wheat Exports by Year." 2017. WWW:
<<https://www.indexmundi.com/agriculture/?country=ca&commodity=wheat&graph=exports>>

⁷⁴ National Association of Wheat Growers [online]: "International Trade." 2015. WWW:
<<https://www.wheatworld.org/wp-content/uploads/2016/12/international-trade-briefer-1-2015.pdf>>

⁷⁵ Index Mundi [online]: "Wheat Imports by Country in 1000 MT." 2017. WWW:
<<https://www.indexmundi.com/agriculture/?commodity=wheat&graph=imports>>

Figure No. 6: Wheat Imports in 2013 (\$)



Source: Actualitix [online]: "Wheat - Import (\$)." 2016. WWW: <<https://en.actualitix.com/country/wld/wheat-importing-countries.php>>

Historically, the world's largest wheat importer is Egypt, it is predominantly politically driven. This has changed recently and Indonesia has taken that position. An Egyptian government has intention to become less dependent on the import of wheat, however, it is not likely to lead to any significant change in the time coming. Indonesia's consumption has greatly grown and is expected to remain as the largest wheat importer in the long run. The Indonesian wheat imports have been growing due to the growing food and feed demand. Bangladesh's wheat import has risen by 24% in the 2016–17 season compared to the previous year. The other major wheat importers are Algeria and Brazil. It also is worth mentioning India, the fastest-growing wheat importer. From 2011 to 2016 India's wheat import went up by 39,206%.⁷⁶

Egypt and Algeria depend strongly on imported wheat. In addition to that, the population growth and rising revenues will simple deepen their dependency on the wheat imported from abroad in the future.⁷⁷ Much of the Arab states importing wheat from Russia, taking advantage of lower prices. The import of wheat in Egypt is politically delicate as it is used by the government to supply a bread helping subsidy card programme depended on by millions of Egyptian people at a time of faltering

⁷⁶ World's Richest Countries [online]: "Wheat Importers." 2015. WWW: <<http://www.worldsrichestcountries.com/top-wheat-importers.html>>

⁷⁷ Carver, Brett: "Wheat - Science and Trade." 2009. p. 51. ISBN: 978-0813820248.

economy.⁷⁸ By means of maintaining wheat prices low the Egyptian government holds political leverage. Egypt's wheat import in the 2017/18 season is expected at 12 million tons, approximately the same amount as the preceding year and approximately 9% above the average for the last five years. Wheat consumption in Indonesia is increasing rapidly, encouraged by a growing middle class which has taken a liking to western food. Indonesia is Australia's leading wheat customer for the past 15 years. Brazil has imported the largest amount in a decade recently. Brazil generally buys most of its wheat from the nearby Argentina.⁷⁹ Bangladesh has become a main wheat importer, despite the global importers have problems with selling to the country due to difficult buying conditions. The demand for wheat increased after floods destroyed Bangladesh's crops, pushing rice prices to record highs that incited people to switch to flour.⁸⁰

⁷⁸ Arab News [online]: "Egypt ruling to reinstate ergot ban renews wheat import uncertainty." 2017. WWW: <<http://www.arabnews.com/node/1193746/business-economy>>

⁷⁹ CNBC [online]: "Brazil decree allows wheat imports from Russia." 2017. WWW: <<https://www.cnbc.com/2017/12/13/reuters-america-update-2-brazil-decree-allows-wheat-imports-from-russia.html>>

⁸⁰ Successful Farming [online]: "Bangladesh wheat imports jump 30 pct in July-October." 2017. WWW: <<https://www.agriculture.com/markets/newswire/bangladesh-wheat-imports-jump-30-pct-in-july-october>>

4. Practical Part

In this chapter, I examine descriptively and statistically the relationship between U.S. wheat export and U.S. wheat production, U.S. wheat price, U.S. wheat export promotion, U.S. dollar index, Canadian wheat price, and Japan GDP. I have chosen yearly data between the years 1995–2016. The period has been selected for the reason that the strong fluctuations in values of the variables, which occurred at that time, should distinctly demonstrate dependence among the exported quantity of U.S. wheat and selected macroeconomic indicators. For example, U.S. had been producing a large amount of wheat in 1998, then, after four years, the production fell to the lowest level since 1972.⁸¹ Likewise, the export quantity was at the lowest level since 1971 at that time.⁸²

Export promotion is done via programs designed to attract more companies into exporting by giving a hand in product/market identification and development. USDA's Market Access Program (MAP) and Foreign Market Development Program (FMD) have a significant impact on U.S. wheat exports. The programs are key to the U.S. wheat trade to keep market share in a more and more competitive market.⁸³ In the analysis, I combine the MAP and FMD programs spending to measure the total export promotion impact.

I have selected Canada as competing country, it is a main wheat exporter and source for high protein wheat in the world. Supplies of high quality wheat, which dominates U.S. wheat exports, make Canada keen competitor in the global wheat trade. Japan has been selected as wheat importing country. At present, Japan is the largest U.S. wheat buyer, with Canada seen as the main competitor in that market. Japan was always the top importer of Canadian wheat till the mid-2000s, when the U.S. started to take the lead.⁸⁴ This dynamic has increased competition rapidly and has affected the global market.

⁸¹ USDA ERS [online]: "Wheat Outlook." 2002. WWW:
<<http://usda.mannlib.cornell.edu/usda/ers/WHS//2000s/2002/WHS-08-14-2002.pdf>>

⁸² USDA ERS [online]: "Wheat Data." 2017. WWW:
<<https://www.ers.usda.gov/webdocs/DataFiles/54282/Wheat%20Data-All%20Years.xls?v=43140>>

⁸³ UkrAgroConsult [online]: "U.S. ag groups support funding increase for MAP, FMD programs." 2017. WWW:
<<http://www.blackseagrains.net/novosti/u-s-ag-groups-support-funding-increase-for-map-fmd-programs>>

⁸⁴ Western Producer [online]: Japan top buyer of Canadian wheat, barley last year." 2013. WWW:
<<https://www.producer.com/2013/09/japan-top-buyer-of-canadian-wheat-barley-last-year>>

At first, the data were gathered and organized using excel functions and table. I found a number of data sets on USDA's Foreign Agricultural Service (FAS) website. The rest of the data were collected from several data portals such as Index Mundi that gathers statistics from multiple reliable sources. In the analysis, U.S. wheat production and export data are measured in thousand metric tons. The wheat prices are expressed in dollars per metric tons. U.S. export promotion, the gross domestic product in Japan is stated in million dollars. The U.S. dollar index is a measurement of the dollar's value according to a basket of six foreign currencies.⁸⁵ The following table No. 1 contains all the gathered data between the years 1995–2016.

Table No. 1: Time Series Data of Selected Variables

	1 000 MT	1 000 MT	\$ per MT	1 000 000 \$	\$	\$ per MT	1 000 000 \$
Year	US export	US production	US price	Export promotion	Dollar index	CA price	JP GDP
1995	33 778	59 404	150	122.723832	83.41	232	5 450 805
1996	27 257	61 980	175	113.642466	87.25	204	4 834 019
1997	28 315	67 534	136	114.185428	93.93	173	4 415 715
1998	28 460	69 327	107	140.523433	98.45	158	4 034 448
1999	29 570	62 475	95	111.243517	97.04	150	4 546 050
2000	28 904	60 641	94	113.492275	101.76	151	4 887 301
2001	26 190	53 001	104	112.984632	107.85	149	4 304 758
2002	23 139	43 705	125	120.492275	106.15	194	4 115 197
2003	31 524	63 805	127	152.231745	93.13	188	4 447 378
2004	29 009	58 698	131	165.472657	85.49	202	4 815 772
2005	27 291	57 243	123	182.357231	83.88	204	4 755 980
2006	24 725	49 217	148	181.928321	82.60	230	4 530 475
2007	34 363	55 821	212	206.561982	77.97	447	4 515 264
2008	27 635	68 363	295	230.542381	74.47	350	5 037 910
2009	23 931	60 117	195	226.234921	77.65	280	5 231 384
2010	35 147	58 868	188	219.916784	75.39	394	5 700 099
2011	28 606	54 244	273	226.111958	70.87	416	6 157 460
2012	27 544	61 298	279	212.681889	73.59	359	6 203 213
2013	32 012	58 105	269	198.138699	75.92	331	5 155 716
2014	23 523	55 147	233	196.518573	78.34	285	4 848 733
2015	21 168	56 117	194	199.943333	90.98	232	4 379 868
2016	28 716	62 833	151	200.309149	91.51	216	4 936 543

Source: Own elaboration based on the collected data from USDA and data portals.

⁸⁵ Forbes [online]: "What Is The US Dollar Index?" 2015. WWW: <https://www.forbes.com/sites/davidmarotta/2015/01/17/what-is-the-us-dollar-index/#79c1a792701e>

4.1 Selected Variables and Their Developments

In the first part of the analysis, the developments of U.S. wheat export and selected macroeconomic indicators over the period 1995–2016 are displayed and described. The explained variable is U.S wheat export and the rest are explanatory variables. In other words, values of U.S wheat export are thought to rise or fall in a straight line according to values of the selected variables.⁸⁶ The aim is to spot a pattern of the relationship between the variables over the selected 22 years, since what has happened in the past helps to predict what will happen in the future. In other words this should be helpful to project the future direction of this pattern.

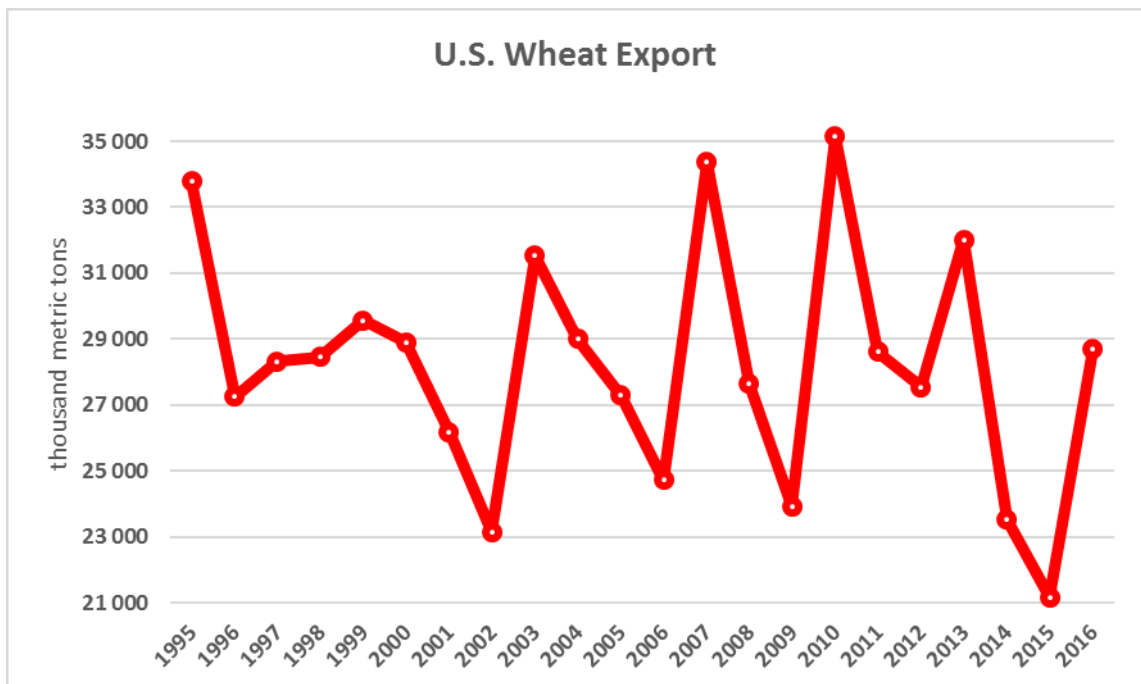
4.1.1 U.S. Wheat Export

The United States had dominated world wheat trade since the Second World War until European Union and post-Soviet states production increased late in the last century. Nowadays, the U.S share of world wheat exports is around 15%. Roughly 50% of the wheat produced in the U.S. is exported to more than 100 countries every year. In the measured period, the top export destinations were: Mexico, Japan, Philippines, Brazil, Taiwan, South Korea, Nigeria, Indonesia, China, and Colombia.⁸⁷ The next figure No. 7 shows the development of U.S. wheat export during the years 1995–2016.

⁸⁶ Statistics How To [online]: "Explanatory Variable & Response Variable: Simple Definition and Uses." 2015. WWW: <<http://www.statisticshowto.com/explanatory-variable>>

⁸⁷ Statista [online]: "Major countries of destination for U.S. wheat exports in 2016." 2016. WWW: <<https://www.statista.com/statistics/190445/major-countries-of-destination-for-us-wheat-exports>>

Figure No. 7: U.S. Wheat Export 1995–2016



Source: Own elaboration based on data from USDA's Foreign Agricultural Service.

As might be seen, the export during the measured period had been moving between the values of 21,168–35,147, quoted in 1,000 metric tons. With an average of 28,219. During the whole period the export decreased by 15%, this is a decrease by 241 thousand metric tons each year on average.

In the first year, the U.S. exported 33,778 thousand metric tons of wheat. Later, the value dropped significantly and equalled 27,257 in 1996. Over the next three years, the price was slightly increasing and this trend peaked in the year 1999 with the value of 29,570. This was followed by a decrease to 23,139 over the three years. After a year, a sharp increase occurred and the value was at 31,524 thousand metric tons. In the following years, the exported amount was gradually decreasing and eventually dropped to 24,725 in 2006.

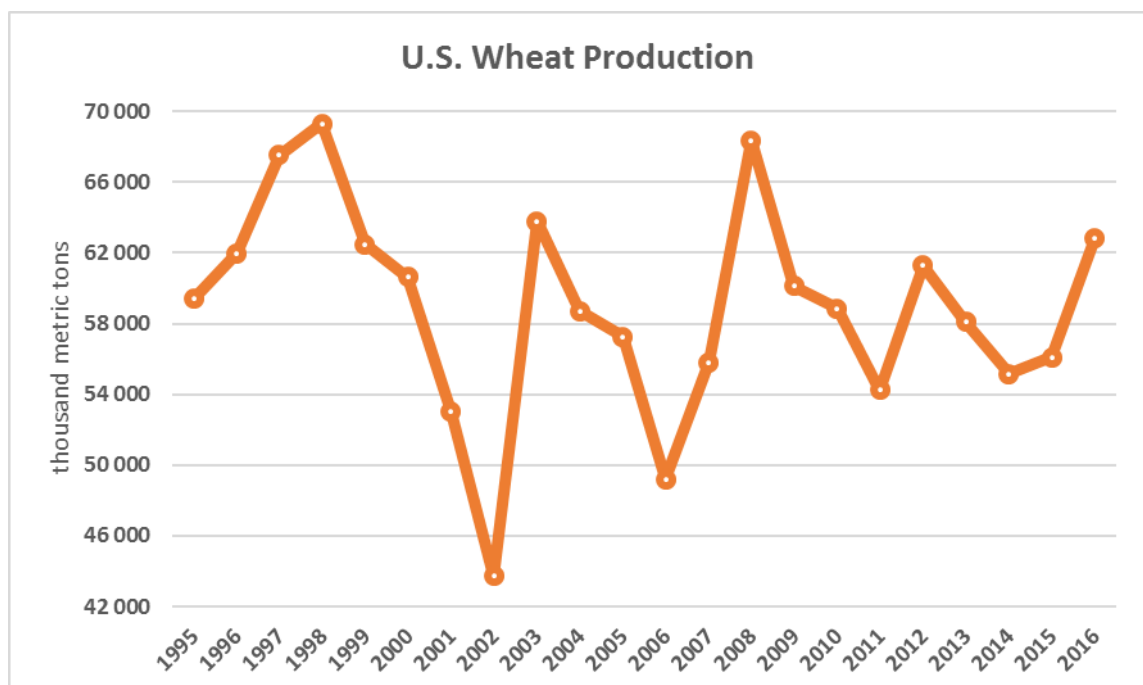
Then it started to increase and reached the value of 34,363 in 2007. That is an increase by 39% within the one year. Afterwards, U.S. wheat production gradually declined and in the year 2009 dropped to 23,931. This was followed again by a huge increase and the value climbed to 35,147, it is the largest export amount for the entire period. Representing annual growth of 47%. There was a moderate decrease over the next two years. Then the export increased to 32,012 in 2013. Later, a significant drop occurred

and the exported amount fell to 21,168. This is the lowest value over the monitored years. In the last year, the export totalled 28,716 thousand metric tons.

4.1.2 U.S. Wheat Production

Wheat ranks third among U.S. field crops in planted acreage, production, and gross farm receipts, behind corn and soybeans.⁸⁸ The United States is a major wheat producing country in the world. The U.S. share of global wheat production accounts for about 8%. Wheat is produced in 42 states in the U.S. Kansas and North Dakota are leading wheat production states.⁸⁹ The figure No. 8 displays the development of U.S. wheat production over the years 1995–2016.

Figure No. 8: U.S. Wheat Production 1995–2016



Source: Own elaboration based on data from USDA's Foreign Agricultural Service.

As demonstrated, U.S. wheat production within the selected years had been moving between the values of 43,705–69,327, quoted in 1,000 metric tons. And it averages 58,997. Throughout the whole period the production increased by 6%, this is an increase by 163 thousand metric tons every year on average.

⁸⁸ Agri-Pulse [online]: "Wheat - The Staff of Life." 2014. WWW: <<https://www.agri-pulse.com/articles/240-wheat-the-staff-of-life>>

⁸⁹ The North Dakota Wheat Commission [online]: "Quick Facts." 2017. WWW: <<http://www.ndwheat.com/buyers/default.asp?ID=293>>

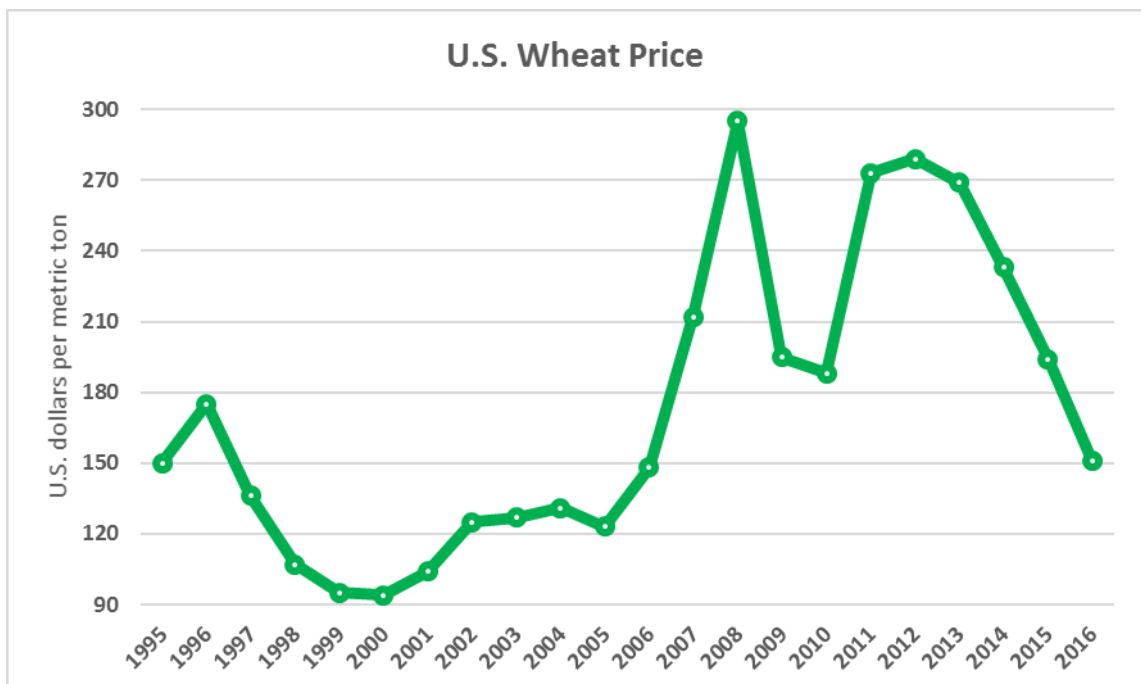
The monitored period starts with the produced quantity of 59,404 thousand metric tons. In the following years, U.S. wheat production was rising and reached the value of 69,327 in 1998. This is the largest amount over the selected years. Later, a decline took place and after the four years the value fell to 43,705. It is likewise the smallest volume of the entire period. Then it climbed to 63,805 in 2003, representing an increase of 46% in the one year. From that moment on, the quantity was gradually decreasing and amounted to 49,217 in 2006.

Afterwards the production began to increase and reached 68,363 in 2008, an increase by 39% within the two years. In the following years, a gradual decline took place and eventually it fell to 54,244 in 2011. A year on, the production rose and totalled to 61,298. After that, another decline took place until 2014. In the last year, the production totalled 62,833 thousand metric tons.

4.1.3 U.S. Wheat Price

The strongest drivers of U.S. wheat prices including: the U.S. dollar, supply and demand, emerging markets, and weather conditions. That is common for all agricultural commodities in general. According to basic economic theory, the higher value of U.S. dollar increases the price of U.S. wheat. The following figure No. 9 puts on show the development of U.S. wheat price in the years 1995–2016.

Figure No. 9: U.S. Wheat Price 1995–2016



Source: Own elaboration based on data from USDA's Economic Research Service.

As shown, the price during the examined period had been moving between the values of 94–295, quoted in U.S. dollars per metric ton. With an average of \$173. Within the years the price increased by 1%.

The monitored period starts at the value of 150. This was followed by a moderate increase. In the following period, the price was decreasing and eventually dropped to the lowest recorded value, particularly, 94 in 2000. Over the next years, the price was increasing and that trend peaked in the year 2008 with 295 dollars. An increase of almost 100% in the number. At that time the world food crisis caused a substantial rise in the cost of food, especially wheat.⁹⁰

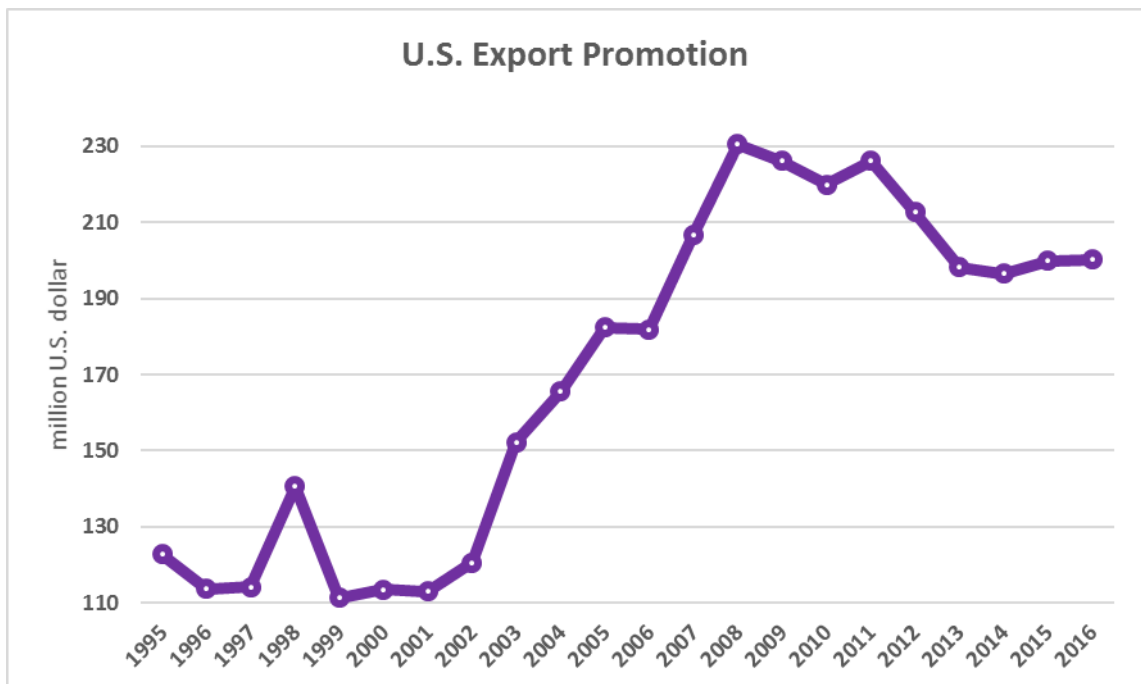
This was followed by a decline and the two years after the value fell to 188. However, afterwards the price went up once again. The price amounted to 279 U.S. dollars per metric ton in 2012. In the following years, U.S. wheat price was reduced to almost the initial value. \$151 is the last recorded value.

4.1.4 U.S. Export Promotion

The MAP and FMD programs help in promoting U.S. wheat exports. Both programs are managed by USDA's Foreign Agricultural Service. U.S. wheat farmers and associates take part in these programs. U.S. Wheat Associates (USW) represents the farmer's interests in foreign markets. The figure No. 10 below shows the development of U.S. export promotion throughout the years 1995–2016.

⁹⁰ Global Issues [online]: "Global Food Crisis 2008" 2008. WWW: <<http://www.globalissues.org/article/758/global-food-crisis-2008>>

Figure No. 10: U.S. Export Promotion 1995–2016



Source: Own elaboration based on data from USDA's Foreign Agricultural Service.

As is evident from the chart, the export promotion during the selected period had been moving between the values of 111–231, quoted in 1,000,000 U.S. dollars. In addition to that, it averages 170. During the whole period the export promotion increased by 63%, this is an increase by 4 million U.S. dollars each year on average.

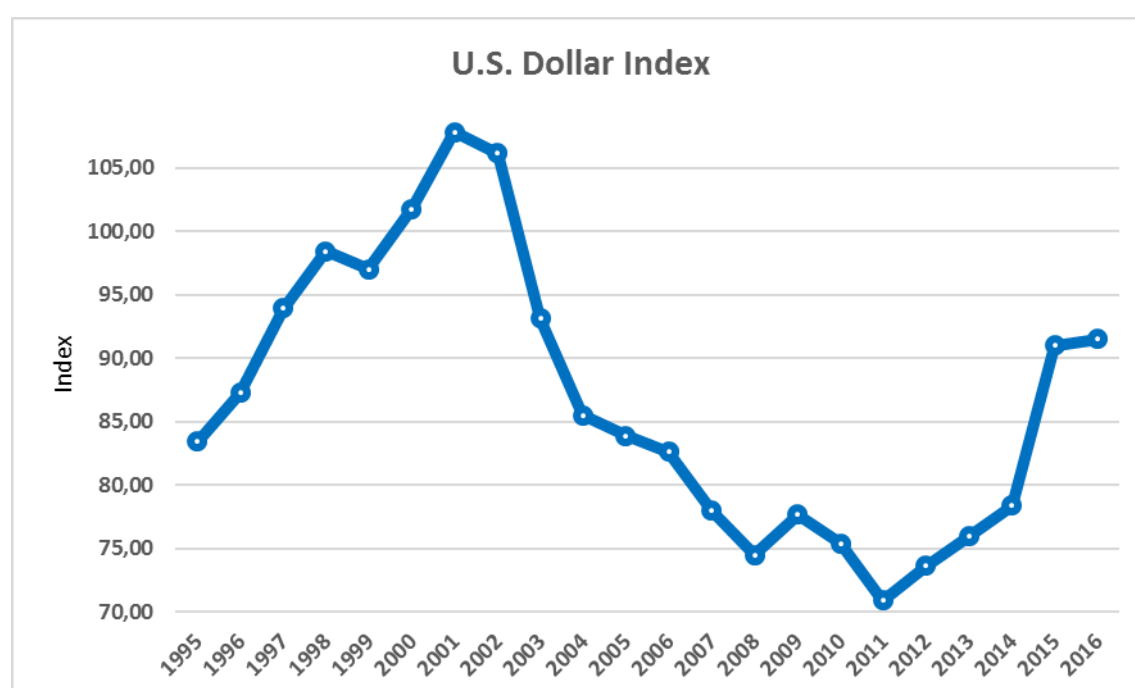
At the beginning of the recorded period, U.S. export promotion equalled 122 million U.S. dollars. A significant increase took place in the year 1998, when the value amounted to 140. A year on, the export promotion was reduced to the lowest recorded value of the whole period, particularly 111. In the next years, the value was continuously increasing and this trend peaked in the year 2008, when the number doubled to 230. It is the largest amount in the whole period, this is 103% increase over the eight years.

From that moment on, the export promotion was gradually decreasing except the year 2011, while the value amounted to 226. Nevertheless, it has remained in high values. In the last year, the programs totalled 200 million U.S. dollars, representing a decrease of 10% since 2008.

4.1.5 U.S. Dollar Index

Wheat, as well as other commodities, is quoted in U.S. dollars. In general, a strong U.S. dollar reduces the exports, while a weak U.S. dollar raises them. In other words, when the value of the dollar drops, foreign buyers have more buying power.⁹¹ The U.S. dollar index measures the value of the dollar against a basket of six foreign currencies (EUR, JPY, GBP, CAD, SEK, and CHF). Euro represents 58% weight.⁹² The index goes up when the U.S. dollar gains value against other currencies. The figure No. 11 demonstrates the development of U.S. dollar index within the years 1995–2016.

Figure No. 11: U.S. Dollar Index 1995–2016



Source: Own elaboration based on data from the FRED database.

As might be seen, the U.S. dollar index during the chosen period had been moving between the values of 70.87–107.85. With an average of 86.71. Throughout the entire period the dollar index increased by 10%, this is an increase by 0.4 index points annually on average.

⁹¹ Bizfluent [online]: "What Happens to Exports & Imports When the Dollar Appreciates & Depreciates?" 2017. WWW: <<https://bizfluent.com/info-8221802-happens-imports-dollar-appreciates-depreciates.html>>

⁹² Investopedia [online]: "U.S. Dollar Index - USDIX." 2017. WWW: <<https://www.investopedia.com/terms/u/usdx.asp>>

The first year starts with the value of 81.43. In the following years, the index was constantly increasing and this trend peaked in the year 2001 with the value of 107.85, representing the highest recorded value.

After that, the dollar started sharply falling and eventually hit the lowest value of the entire period, 70.87 in 2011. The index decreased by 15% within the ten years. Afterwards, the trend has changed and took the opposite direction. That continued up to the value of 91.51 in 2016.

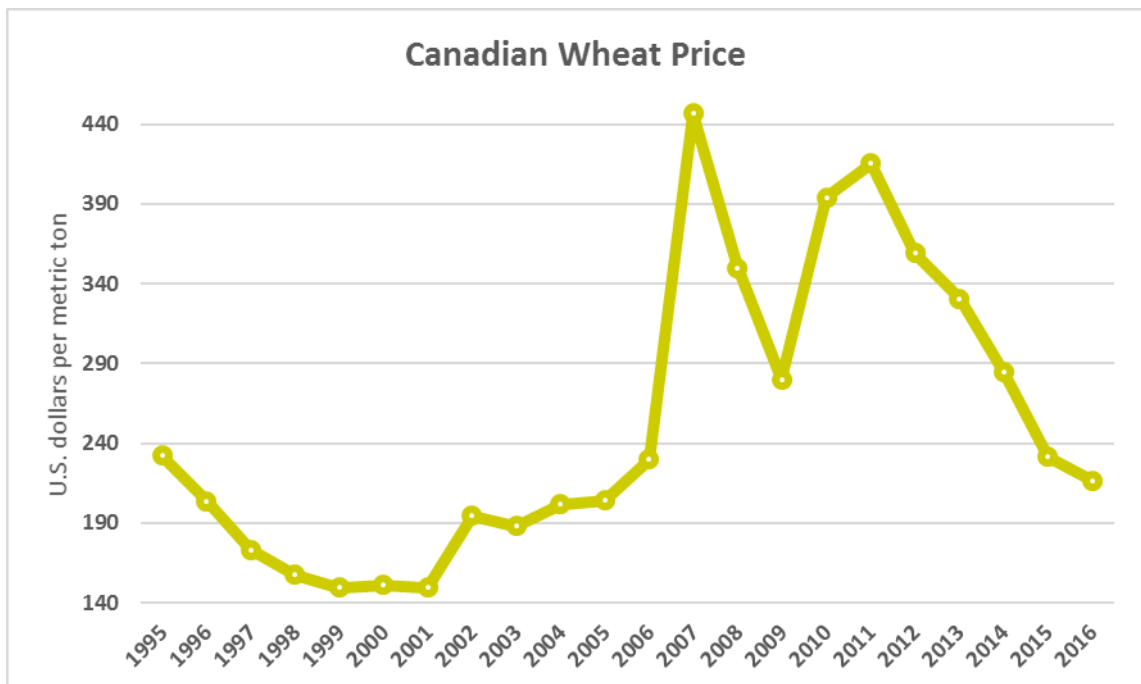
4.1.6 Canadian Wheat Price

Wheat is Canada's largest crop and the single biggest export earner of all agricultural products. The biggest wheat producing provinces are Saskatchewan and Alberta.⁹³ Canadian wheat is known in the market for its high quality and consistency. Canada represents strong competition for U.S. wheat exports, especially in the key markets in Southeast and East Asia.⁹⁴ The price of Canadian wheat is influenced by the same factors as in a case of the United States. In particular by supply and demand, weather and crop conditions. The figure No. 12 shows the development of Canadian wheat price over the years 1995–2016.

⁹³ Globe and Mail [online]: "Dry weather in Alberta, Saskatchewan to cut wheat and canola outputs." 2015. WWW: <<https://www.theglobeandmail.com/report-on-business/dry-weather-in-alberta-saskatchewan-to-cut-wheat-and-canola-outputs/article26055961>>

⁹⁴ USDA ERS [online]: "Wheat Outlook." 2018. WWW: <<https://www.ers.usda.gov/webdocs/publications/87377/whs-18b.pdf?v=43143>>

Figure No. 12: Canadian Wheat Price 1995–2016



Source: Own elaboration based on data from USDA's Economic Research Service.

As evident from the above, the price during the measured period had been moving between the values of 149-447, quoted in U.S. dollars per metric ton. Besides, it averages \$252. During the entire period the price decreased by 7%, this is a decrease by 1 U.S. dollar every year on average.

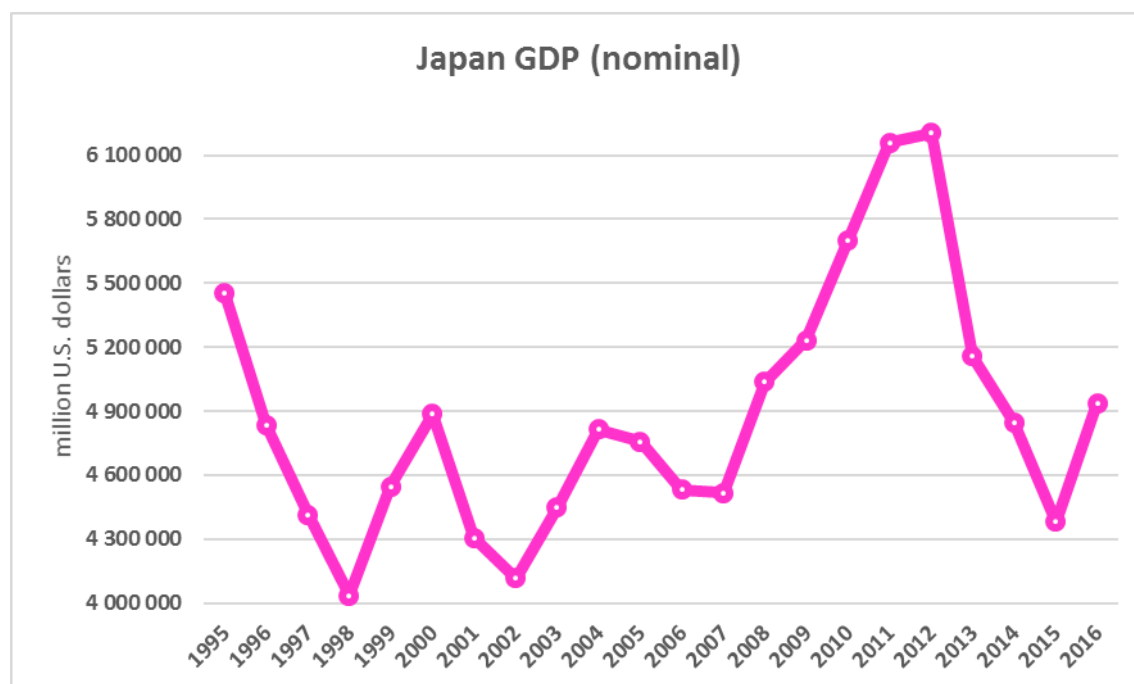
In the first observed year, the Canadian wheat price was at 232 dollars. In the coming years, Canadian wheat price was declining and reduced to the lowest recorded value, particularly, 149 in 2001. From that year forward, the price was gradually rising each year to then by a sharp increase to the record values of 447 in 2007. An increase of 200% over the six years. As written above, the same happened to U.S. wheat price. World food prices increased dramatically at that time.

After, a significant decline occurred and the price was reduced by 37% within the two years. However, the price went up once again and was at \$416 in 2011. The price was falling throughout the rest of the period. In the last year, the price equalled 216 U.S. dollars per metric ton. This is close to the initial value of 1995. The Canadian wheat price development is similar to the U.S. wheat price development.

4.1.7 Japan GDP

Japan imports 90% of the wheat that it consumes. Most of the imports have come from the United States. Furthermore, Japan is the largest U.S. wheat buyers in the world. Japan is also the third largest in the world by nominal GDP.⁹⁵ The figure No. 13 displays the development of Japan GDP in the years 1995–2016.

Figure No. 13: Japan GDP 1995–2016



Source: Own elaboration based on data from the country economy data portal.

The GDP in the selected period had been moving between the values of 4,034,448–6,203,213, quoted in 1,000,000 U.S. dollars. With an average of 4,877,459. In the selected period the GDP decreased by 9%, this is a decrease by 24,489 million U.S. dollars each year on average.

At the beginning of examined the period, Japan GDP amounted to 5,450,805 million U.S. dollars. Followed by a decrease to the lowest observed value of 4,034,448 in the year 1998. In the next two years, the GDP was rising and reached the value of 4,887,301 in 2000. Later, the amount dropped and equalled 4,115,197 in 2002. Thereafter, the GDP increased up to 4,815,772 in 2004 and then decreased back to 4,530,475 in 2006.

⁹⁵ Statistics Times [online]: "List of Countries by Projected GDP." 2017. WWW: <<http://statisticstimes.com/economy/countries-by-projected-gdp.php>>

In the year 2007, the value remained almost the same as in the previous year. Then an increasing trend was observed. The GDP gradually climbed up to 6,203,213 in 2012, representing the highest observed value and an increase by 37% within the five years. In the following years, the value was declining and reached the lowest amount, specifically, 4,379,868 in 2015. In the last year, the GDP totalled 4,936,543 million U.S. dollars.

4.2 Linear Regression Model

Linear regression is employed to model the relationships between the variables by fitting a linear equation to the examined data, which provide an important closer look on the factors affecting U.S. wheat export. Gretl software has been used for this purpose, it offers comprehensive tools for analysing data. The econometric model is based on annual data, which represent the time series with 22 observations from 1995 to 2016. The construction of the model consists of several steps:

1. Economic model creation
2. Econometric model creation
3. Data processing and analysis
4. Parameters estimation
5. Economic verification
6. Statistical verification
7. Econometric verification
8. Econometric model application

4.2.1 Economic Model

In general, an econometric model is a set of assumptions that describes certain economic behaviour and aspects of economic reality. A model derives from economic theory and it is a simplified abstraction. In the real economic system, the interrelationships between its elements are quite complex. In other words, it is not always possible and effective to describe economic reality in its full complexity. The economic model of U.S. wheat export has been compiled as shown below:

$$y_{1t} = f(X_{1t}, X_{2t}, X_{3t}, X_{4t}, X_{5t}, X_{6t}, X_{7t}, X_{8t}, X_{6t}, X_{7t})$$

Where:

y_{1t} = U.S. wheat export

x_{1t} = Unit vector

x_{2t} = U.S. wheat production

x_{3t} = U.S. wheat price

x_{4t} = U.S. export promotion

x_{5t} = U.S. dollar index

x_{6t} = Canadian wheat price

x_{7t} = Japan GDP

The basic assumption of the economic model is the dependence of U.S. wheat export on selected variables. Based on the economic theory, the relationships between the variables are assumed:

- If the production of U.S. wheat increases, the export of U.S. wheat will increase.
- If the price of U.S. wheat increases, the export of U.S. wheat will decrease.
- If the export promotion increases, the export of U.S. wheat will increase.
- If the U.S. dollar index increases, the export of U.S. wheat will decrease.
- If the price of Canadian wheat increases, the export of U.S. wheat will increase.
- If the GDP of Japan increases, the export of U.S. wheat will increase.

4.2.2 Econometric Model

The econometric model distinguishes itself from the economic model by adding a unit vector and a stochastic component to the equation.⁹⁶ Based on the econometric theory, the variables would be divided into endogenous ones that are generated within the model structure, and exogenous ones that are formed outside the model relationship.⁹⁷ The examined model contains one endogenous variable (dependent variable), seven exogenous variables (independent variables), and one stochastic variable (residual value). The stochastic variable is a random component or error, it is part of each model equation.⁹⁸ The model has a linear functional shape. The resulting model takes this form:

$$y_{1t} = \gamma_1 x_{1t} + \gamma_2 x_{2t} + \gamma_3 x_{3t} + \gamma_4 x_{4t} + \gamma_5 x_{5t} + \gamma_6 x_{6t} + \gamma_7 x_{7t} + u_{1t}$$

⁹⁶ Jorgenson, Dale: "Econometrics - Econometric Modeling of Producer Behavior." 2000. p. 20. ISBN: 978-0262100823.

⁹⁷ Leeflang, Peter: "Advanced Methods for Modeling Markets." 2017. p. 363. ISBN: 978-3-319-53469-5.

⁹⁸ Studenmund, A. H.: "Using Econometrics - A Practical Guide." 2014. p. 9. ISBN: 978-1-292-02127-0.

Endogenous variable:

$$y_{1t} = \text{U.S. wheat export}$$

Exogenous variables:

$$x_{1t} = \text{Unit vector}$$

$$x_{2t} = \text{U.S. wheat production}$$

$$x_{3t} = \text{U.S. wheat price}$$

$$x_{4t} = \text{U.S. export promotion}$$

$$x_{5t} = \text{U.S. dollar index}$$

$$x_{6t} = \text{Canadian wheat price}$$

$$x_{7t} = \text{Japan GDP}$$

Stochastic variable:

$$u_{1t} = \text{Residual value}$$

4.2.3 Statistical Data

A descriptive statistic describes and summarizes the fundamental features of the data.⁹⁹ The basic descriptive statistics tools such as mean, median, minimum, maximum, and standard deviation have been used. The resulting values of all the variables are displayed in the following table No. 2.

Table No. 2: Descriptive Statistics of Selected Variables

	Mean	Median	Minimum	Maximum	Standard deviation
y1t	28 219	28 388	21 168	35 147	3 653
x2t	58 997	59 136	43 705	69 327	6 019
x3t	173	151	94	295	64
x4t	170	182	111	231	44
x5t	87	85	71	108	11
x6t	252	223	149	447	92
x7t	4 877 459	4 824 896	4 034 448	6 203 213	588 852

Source: Own calculation and elaboration.

⁹⁹ Investopedia [online]: "Descriptive Statistics." 2017. WWW: <https://www.investopedia.com/terms/d/descriptive_statistics.asp>

4.2.4 Correlation Matrix

The correlation matrix consists paired correlation coefficients of the variables. In the regression modelling, the coefficients are used to determine the presence of multicollinearity. Multicollinearity indicates a moderate or high dependency among exogenous variables. Multicollinearity occurs when the magnitude of the correlation coefficients is higher than or equal to $|0.85|$. If it is found, it may lead to misleading results and limit the research conclusions.¹⁰⁰ The next table No. 3 contains all the calculated coefficients.

Table No. 3: Correlation Coefficients of Selected Variables

	x2t	x3t	x4t	x5t	x6t	x7t
x2t	1	0.0271	-0.0263	-0.0769	-0.1129	0.0591
x3t	0.0271	1	0.7711	-0.8278	0.8415	0.6430
x4t	-0.0263	0.7711	1	-0.8123	0.8018	0.5422
x5t	-0.0769	-0.8278	-0.8123	1	-0.8415	-0.7380
x6t	-0.1129	0.8415	0.8018	-0.8415	1	0.6505
x7t	0.0591	0.6430	0.5422	-0.7380	0.6505	1

Source: Own calculation and elaboration.

As is evident from the table above, there is no multicollinearity in the data, even though some values are high, all the values are less than $|0.85|$. Therefore, it is not necessary to modify the data, and the linear regression analysis can then be conducted to study the relationships between the variables.

4.2.5 Parameters Estimation

The term parameter estimation refers to the process of using data to estimate the parameters of the chosen distribution.¹⁰¹ Different parameter estimation methods are obtainable. In the linear regression model, an ordinary least squares method is applied to determine the parameters by minimizing the sum of the squared errors from the data.¹⁰² From the Gretl output (see Appendix No. 1), the resulting estimated parameters are summarized in the table No. 4.

¹⁰⁰ Allen, Michael: "Understanding Regression Analysis." 2004. p. 176. ISBN: 978-0306484339.

¹⁰¹ Business and Economics Journal [online]: "Parameter Estimation." 2017. WWW: <<https://www.omicsonline.org/scholarly/parameter-estimation-journals-articles-ppts-list.php>>

¹⁰² Carter, Hill: "Principles of Econometrics." 2010. p. 183. ISBN: 978-0470626733.

Table No. 4: Estimated Parameters of Selected Variables

Parameter	Value
γ_1 - Unit vector	18527.6
γ_2 - U.S. production	0.290772
γ_3 - U.S. price	-58.6777
γ_4 - U.S. Export promotion	55.2688
γ_5 - U.S. dollar index	-83.2337
γ_7 - Canadian price	58.5727
γ_8 - Japan GDP	0.000934651

Source: Own calculation and elaboration.

The final equation of the econometric model can be compiled as follows:

$$y_{1t} = 18527.6 + 0.290772x_{2t} - 58.6777x_{3t} + 55.2688x_{4t} - 83.2337x_{5t} + 58.5727x_{6t} + 0.000934651x_{7t} + u_{1t}$$

4.2.6 Economic Verification

The economic verification evaluates the direction and intensity of the explanatory variables on the explained variable. Furthermore, it compares the results of the parameter estimation with the economic theory defined in the formulation of the economic model. The parameters describe the statistical properties of the variables. The economic verification of the obtained estimates, under the ceteris paribus condition, is as follows:

- The average U.S. wheat export at zero values of the explanatory variables is at 18527.6 thousand metric tons per year.
- If the production of U.S. wheat increases by 1 thousand metric tons, the export of U.S. wheat will increase by 0.290772 thousand metric tons per year.
- If the price of U.S. wheat increases by 1 dollar, the export of U.S. wheat will decrease by 58.6777 thousand metric tons per year.
- If the export promotion increases by 1 million dollars, the export of U.S. wheat will increase by 55.2688 thousand metric tons per year.
- If the U.S. dollar index increases by 1 index point, the export of U.S. wheat will decrease by 83.2337 thousand metric tons per year.
- If the price of Canadian wheat increases by 1 dollar, the export of U.S. wheat will increase by 58.5727 thousand metric tons per year.

- If the GDP of Japan increases by 1 million dollars, the export of U.S. wheat will increase by 0.000934651 thousand metric tons per year.

All of these assumptions are in line with the economic theory outlined above.

4.2.7 Statistical Verification

The statistical verification verifies the statistical significance of the estimated parameters, coefficients and overall model. The statistical significance of the parameters will be evaluated on the basis of the calculated p-values. The p-value is the significance level at which the test becomes indifferent between rejection and acceptance.¹⁰³

4.2.7.1 Model Fitness with Data

Coefficient of determination, denoted as R^2 , is a statistical measure which indicates how close the data are to the fitted regression line.¹⁰⁴ From the Gretl output (see Appendix No. 1), the value of coefficient of determination is equal to 0.737448, meaning that the changes in the explained variable are 73.74% dependent on the changes in the explanatory variables. The output also reports adjusted R-squared, it demonstrates how well terms fit a curve or line, but adjusts for the number of terms in the model. The value of the adjusted R^2 is 0.632427, in other words variation of the dependent variable is 63.24% explained by changes in the independent variables.

4.2.7.2 Parameters Significance

The statistical significance of the estimated parameters is determined by the t-test. The significance levels and p-values are important tools in this test. The output from Gretl provides p-value for each parameter (see Appendix No. 1). The null hypothesis states that the parameter is not statistically significant at the chosen significance level. If the calculated p-value is less (or equal to) than the selected significance level, the null hypothesis is rejected.¹⁰⁵ The calculated values are shown in the following table No. 5.

¹⁰³ Ramu, Ramanathan: "Introductory Econometrics with Applications." 2001. p. 34. ISBN: 978-0030343421.

¹⁰⁴ Minitab [online]: "Regression Analysis - How Do I Interpret R-squared and Assess the Goodness-of-Fit." 2013. WWW: <<http://blog.minitab.com/blog/adventures-in-statistics-2/regression-analysis-how-do-i-interpret-r-squared-and-assess-the-goodness-of-fit>>

¹⁰⁵ Davidson, Russell: "Econometric Theory and Methods." 2004. p. 206. ISBN: 978-0195123722.

Table No. 5: P-values of Selected Variables

Parameter	P-value
γ_2 – U.S. wheat production	0.0041
γ_3 – U.S. wheat price	0.0021
γ_4 – U.S. Export promotion	0.0181
γ_5 – U.S. dollar index	0.4615
γ_7 – Canadian wheat price	0.0002
γ_8 – Japan GDP	0.4653

Source: Own calculation and elaboration

At the significance level $\alpha = 0.01$, the variables U.S. wheat production, U.S. wheat price and Canadian wheat price are statistically significant. The variable U.S. Export promotion is statistically significant at the 0.05 level. It means that the relationships between the variables are caused by something else than random chance.¹⁰⁶ The variables U.S. dollar index and Japan GDP are not statically significant according to the t-test.

4.2.8 Econometric verification

The econometric verification checks out the conditions necessary for the application of the econometric model, and if it meets the assumptions of the classical linear regression model. In order to verify the econometric model, different tests are conducted: autocorrelation, heteroscedasticity and normality of residual distribution.

4.2.8.1 Autocorrelation

Autocorrelation occurs when the errors are correlated. In the econometric verification, the Durbin-Watson statistic test is used to detect the presence of autocorrelation. The value is always between 0 and 4. The Gretl output reports Durbin-Watson value of 2.248306. The value lies in an inconclusive region. In this case, it is not possible to reject or do not reject the null hypothesis, and decide whether autocorrelation is present or not. Hence the Breusch Godfrey test must be carried out to verify the presence of autocorrelation. The p-value according to the test is 0.3693. The null hypothesis says there is no autocorrelation in the model. The calculated p-value is higher than the significance level $\alpha = 0.05$, it means that the null hypothesis is not rejected. The autocorrelation is not present in the model.

¹⁰⁶ Investopedia [online]: "Statistically Significant." 2017. WWW: <https://www.investopedia.com/terms/s/statistically_significant.asp>

4.2.8.2 Heteroscedasticity

The potential existence of heteroscedasticity, in other words the absence of homoscedasticity, is a major concern in the econometric verification. It indicates that the modelling errors are no longer independently and identically distributed.¹⁰⁷ The White test has been used to determine the occurrence of heteroscedasticity. If the test statistic has the p-value below the significance level of $\alpha = 0.05$, then the null hypothesis of homoscedasticity is rejected and heteroscedasticity is assumed. The test reports p-value at 0.707477. The p-value is higher than 0.05, therefore, the null hypothesis can not be rejected. The Breusch-Pagan test could be used likewise. In this case, the p-value equals 0.351919. And once again the p-value is higher than the significance level. Both tests confirm the homoscedasticity of the model. It means that the residuals have a constant scattering.

4.2.8.3 Normality

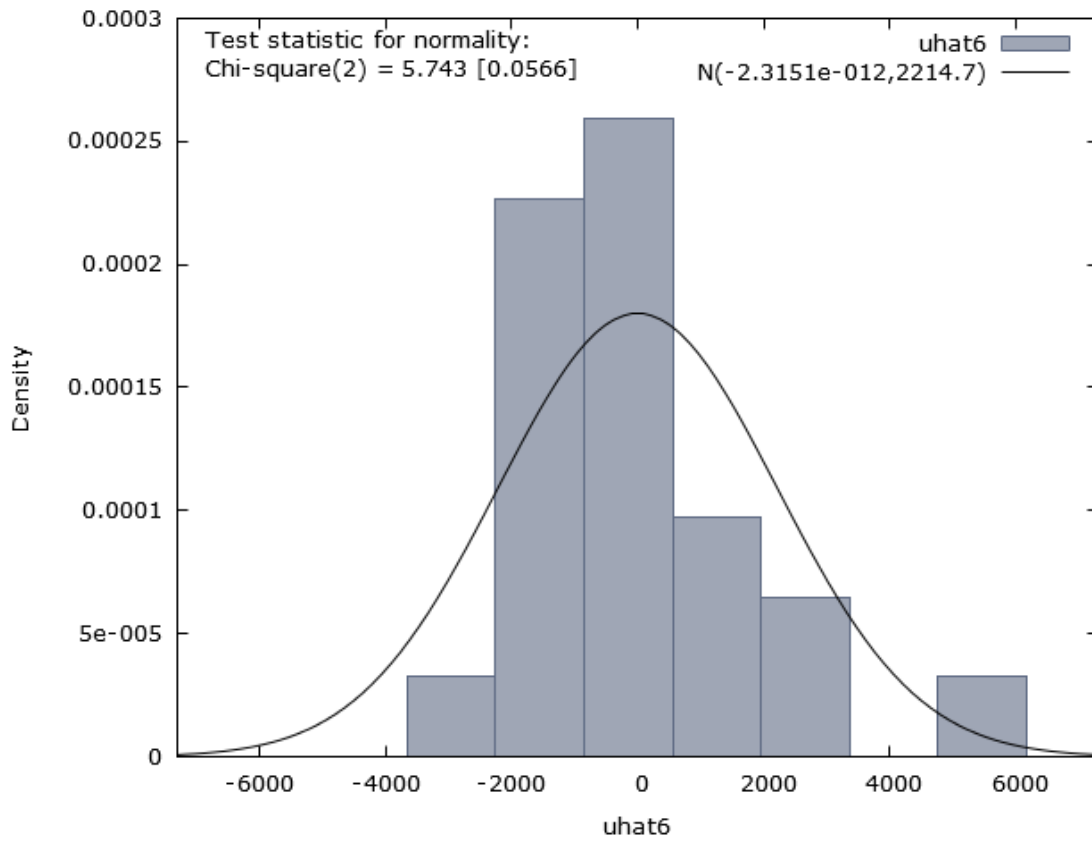
One of the assumptions for linear regression analysis is the normal distribution of the residuals.¹⁰⁸ Otherwise it is not possible to trust the results because they are not reliable. That is why examining residuals is a key part of all statistical modelling.¹⁰⁹ The Jarque-Bera test has been used to verify the normality. The test describes how well it fits the set of observations. The null hypothesis states that the residuals are normally distributed. The calculated p-value equals to 0.05661, this is greater than the significance level of $\alpha = 0.05$. Thus the null hypothesis can not be rejected, it means that there is the normal distribution of the residuals. This is also evident from the following figure No. 14.

¹⁰⁷ Verbeek, Marno: "A Guide to Modern Econometrics." 2004. p. 79. ISBN: 0-470-85773-0.

¹⁰⁸ Gujarati, Damodar: "Basic Econometrics." 2008. p. 110. ISBN: 978-0073375779.

¹⁰⁹ NIST/SEMATECH [online]: "Are the model residuals well-behaved?" 2013. WWW: <<http://www.itl.nist.gov/div898/handbook/pri/section2/pri24.htm>>

Figure No. 14: The Normal Distribution of the Residuals



Source: The Jarque-Bera test's output from Gretl.

4.2.9 Forecast

One of the main goals of econometric modelling is to be able to make a forecast. The purpose is to estimate a value of the explanatory variable outside the observation period. In particular between the years 2017-2020. It has been calculated using Gretl's forecasting tools (see Appendix No. 2 and 3). A dynamic forecasting method has been employed. In the dynamic forecasting, additional lags of the explained variable are added as regressors, and previously forecasted values for the lagged variable are used in forming forecast.¹¹⁰ In other words, the dynamic forecast uses the forecast value of the lagged explained variable instead of the actual value.¹¹¹ The lagged variables are called predetermined.¹¹² The resulting forecast is listed in the table No. 6 below.

Table No. 6: Forecast of U.S. Wheat Export 2017–2020

	Prediction
2017	25 139
2018	27 020
2019	34 302
2020	32 181

Source: Own calculation and elaboration

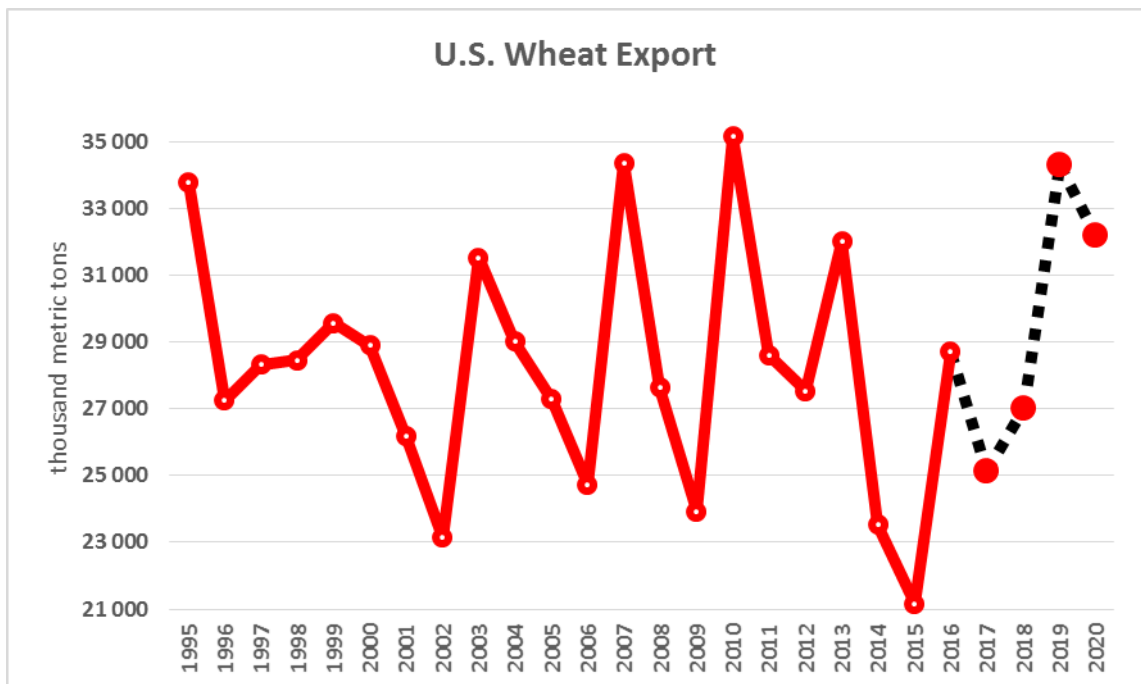
At first glance, the calculated numbers are in line with previous years. There are no extreme values. The overall development of U.S. wheat export including the forecast for the next four years is graphically shown in figure No. 15.

¹¹⁰ EViews [online]: "Forecasting from Equations in EViews." 2017. WWW:
<http://www.eviews.com/help/helpintro.html#page/content/Forecast-Forecasting_from_Equations_in_EViews.html>

¹¹¹ EViews [online]: "Forecasts with Lagged Dependent Variables." 2017. WWW:
<http://www.eviews.com/help/helpintro.html#page/content/Forecast-Forecasts_with_Lagged_Dependent_Variables.html>

¹¹² Theil, Henri: "Estimation of Parameters of Econometric Models." 1992. p. 109. ISBN: 978-94-011-2546-8.

Figure No. 15: U.S. Wheat Export 1995–2020



Source: Own elaboration

As might be seen from the table and graph above, it is predicted that U.S. wheat export will decrease to 25,139 thousand metric tons in 2016. That is decrease by 12% from 2015. A year on, the export is projected to increase to the value of 27,020. This trend will peak in 2017 with 34,302, an increase of 36% within the two years. That is the highest exported quantity since 2010. In the last year, after a moderate decrease, the U.S. is expected to export 32,181 thousand metric tons. In the forecasted period, U.S. wheat export is predicted to increase by 28%, this is an increase by 2,347 thousand metric tons each year on average.

5. Discussion and Conclusion

Wheat is the world's most cultivated cereal and is consumed in all places around the world. On top of that, most nations need to import wheat at one time or another. Wheat represents the biggest share of the global trade of all grains. Four-fifths of this quantity is consumed locally and one fifth is the subject of international trade. The United States, the European Union, Canada, Australia, Argentina, Russia, Ukraine, and Kazakhstan account for about 90% of world wheat exports.¹¹³ All leading wheat exporters use various trade enhancement programs to protect their market share. Politics plays an extraordinarily important role in the programs.

Wheat has a crucial role in the United States' agriculture sector. It ranked the second most important grain, following only corn. The U.S. is a major wheat producer and exporter. About half of the wheat produced in the U.S. is exported.¹¹⁴ It is the rare supplier that can provide all six major classes of wheat in large and reliable quantities and at the highest quality, year in and year out. Although, the U.S. share of the global wheat market has been declining as other exporters have risen in prominence.¹¹⁵

In the analytical part, the thesis focused on the factors affecting how much amount of wheat is exported by the United States. In the first phase, the developments of U.S. export and chosen determinants such as U.S. wheat price, U.S. wheat export promotion, U.S. dollar index, Canadian wheat price, and Japan GDP were analysed. During the monitored period 1995-2016 U.S. wheat export decreased by 15%, representing a decrease of 241 thousand metric tons each year on average. The relationship between U.S. wheat export and U.S. wheat production might be referred as a positive relationship, because if there is a change with the production, then there will likely be a corresponding change in the export that is typically in the same direction. Furthermore, it shows that the export had been declining mainly due to the increase in the price and stronger U.S. dollar. Nevertheless, U.S. wheat export promotion has been constantly increasing by how it helped increase the exports. Throughout the entire period the export promotion increased by 63%. The development of Canadian wheat price is

¹¹³ USDA ERS [online]: "U.S. Wheat Trade." 2017. WWW: <<https://www.ers.usda.gov/topics/crops/wheat/trade>>

¹¹⁴ USDA ERS [online]: "Background." 2017. WWW: <<https://www.ers.usda.gov/topics/crops/wheat/background.aspx>>

¹¹⁵ USDA ERS [online]: "Market Outlook." 2017. WWW: <<https://www.ers.usda.gov/topics/crops/wheat/market-outlook>>

similar to the development of U.S. wheat price with just the opposite effect. Japan GDP has a positive trend, however, it seems it doesn't have a significant impact on the wheat export. This corresponds with the assumptions drawn from this research.

In the second phase, the linear regression model was developed to explain the behaviour of U.S. wheat export. The export of U.S. wheat is affected by 74% by changes in the explanatory variables. This implies that significant variables were included in the model, both statistically and economically. The estimation of the model also revealed that the assumptions correspond to the economic theories about the dependency of explanatory variables on the explained variable. Based on the estimation, if the production of U.S. wheat increases by 1 thousand metric tons, the export of U.S. wheat will increase by 0.29 thousand metric tons per year. Furthermore, it shows that the wheat export is largely affected by the value of U.S. dollar. If the dollar index increases by 1 index point, the export of U.S. wheat will decrease by 83 thousand metric tons per year. Even though the variable is not statistically significant according to the statistical verification. Similarly, if the price of U.S. wheat increases by 1 dollar, the export of U.S. wheat will decrease by 58 thousand metric tons per year. On the other hand, if U.S. export promotion increases by 1 million dollars, the export of U.S. wheat will increase by 55 thousand metric tons per year. That emphasizes a positive and statistically significant impact of the programs. Besides, the estimated model demonstrates the importance of competition price, if the price of Canadian wheat increases by 1 dollar, the export of U.S. wheat will increase by 58 thousand metric tons per year. The variable Japan GDP appeared as not statistically significant with a little impact.

At the end, the forecast was derived from the econometric model for the period 2017–2020. It predicts that the U.S. wheat export will increase in the coming years with exception of the year 2017. Particularly, in the year 2019, the export is projected at 34,302 thousand metric tons. That would be the largest exported quantity since 2010. Based on the forecast, the United States in 2019–20 will account for a larger proportion of world wheat export than in 2011–16. Moreover, if the forecast holds, it is expected that the U.S. will regain its position as the world's largest wheat exporter despite strong international competition.

At the time when the forecast had been conducted, the exported quantity of U.S wheat for the year 2017 was already known. The U.S. has exported 25,855 thousand metric tons in this year, down 12% from 2016 and 3% behind the 5-year average.¹¹⁶ By how the U.S. lost its leading position in the market. Moreover, the number is very close to the projected value, 25,139 thousand metric tons. This may serve as evidence regarding the forecast relevance.

Furthermore, USDA's ERS publication Outlook for U.S. Agricultural Trade reports the forecast for fiscal year 2018. According to the publication, U.S. wheat export is projected at 26,400 thousand metric tons.¹¹⁷ This was published on November 30, 2017. Again, it is close to what was forecasted in the practical part, nevertheless, it is not comparable, because fiscal year differs from calendar year. However, it gives meaningful context. The outlook also mentions an expectation that U.S. wheat will be more competitive later in the year. This corresponds to the rising trend drawn from the forecast.

¹¹⁶ Index Mundi [online]: "United States Wheat Exports by Year." 2017. WWW: <<https://www.indexmundi.com/Agriculture/?country=us&commodity=wheat&graph=exports>>

¹¹⁷ USDA ERS [online]: "Outlook for U.S. Agricultural Trade." 2017. WWW: <<https://www.ers.usda.gov/webdocs/publications/85920/aes-102.pdf?v=43076>>

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7. Appendix

Appendix No. 1: Gretl Output

Model 6: OLS, using observations 1995-2016 (T = 22)

Dependent variable: US export

	<i>Coefficient</i>	<i>Std. Error</i>	<i>t-ratio</i>	<i>p-value</i>	
Const	18527.6	17493.6	1.059	0.3063	
US production	0.290772	0.0859611	3.383	0.0041	***
US price	-58.6777	15.7774	-3.719	0.0021	***
Export promotion	55.2688	20.8324	2.653	0.0181	**
Dollar index	-83.2337	110.144	-0.7557	0.4615	
Canadian price	58.5727	12.2156	4.795	0.0002	***
Japan GDP	0.000934651	0.00124735	0.7493	0.4653	

Mean dependent var	28218.50	S.D. dependent var	3652.862
Sum squared resid	73570158	S.E. of regression	2214.651
R-squared	0.737448	Adjusted R-squared	0.632427
F(6, 15)	7.021912	P-value(F)	0.001052
Log-likelihood	-196.4664	Akaike criterion	406.9329
Schwarz criterion	414.5702	Hannan-Quinn	408.7320
Rho	-0.191014	Durbin-Watson	2.248306

Appendix No. 2: Forecast Output

For 95% confidence intervals, $t(7, 0.025) = 2.365$

Obs	US export	prediction	std. error	95% interval
2017	undefined	25139.1	4426.54	(14672.0, 35606.2)
2018	undefined	27020.5	4529.24	(16310.5, 37730.4)
2019	undefined	34302.4	4757.42	(23052.9, 45551.9)
2020	undefined	32181.8	4900.16	(20594.8, 43768.8)

Appendix No. 3: Forecast Graph

