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**INSTITUTE OF AGRICULTURAL
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Warsaw 2014

**Projection of income
for the selected
agricultural products
for 2020**



**COMPETITIVENESS OF THE POLISH FOOD
ECONOMY UNDER THE CONDITIONS OF
GLOBALIZATION AND EUROPEAN INTEGRATION**

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Projection of income for the selected agricultural products for 2020

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**COMPETITIVENESS OF THE POLISH FOOD
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Warsaw 2014

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The work was carried out under the following theme:

**Competitiveness of Polish agricultural holdings and agricultural products
at present and in a mid-term perspective**

in the task:

*Economic surpluses of selected agricultural products, their current analysis and
assessment of the scale and scope of changes expected in a mid-term perspective*

The research was focused on the analysis of results of the selected agricultural products in the
last period, i.e. on average in the years 2011-2013, and on the evaluation of results anticipated
for 2020. The purpose was to determine the impact of changes in prices of means for
agricultural production, yields and product prices forecasted until 2020 on the level of income
from agricultural products. Analysis covered also the structure of the selected time series of
prices of selected agricultural products.

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*due to the electronic method of data processing for certain calculations – due to rounding
– there may be differences*

Introduction

The publication contains the results of research conducted under the research task entitled *"Economic surpluses of selected agricultural products, their current analysis and assessment of the scale and scope of changes expected in a mid-term perspective"*, under the multi-annual programme executed by the Institute of Agricultural and Food Economics - National Research Institute – "Competitiveness of the Polish food economy in the conditions of globalization and European integration", established by the Resolution of the Council of Ministers for the years 2011-2014.

The research issues were focused on the analysis of results of the selected agricultural products in the last period, i.e. on average in the years 2011-2013, and on the evaluation of results anticipated for 2020.

In recent years, many spheres of economic life have been undergoing very dynamic changes which increases uncertainty and risk. In the case of agricultural production, due to its biological and technical nature, and in the light of changes in the Common Agricultural Policy and under the conditions of global competitiveness, the issue is particularly important. For this reason, when making decisions, agricultural farms frequently use tools that support this process and, at the same time, enable justifying reasonably made choices. One of such tools is forecasting; it enables recognition of future conditions for the implementation of undertaken actions. Thus, we may assume that in the case of agriculture, forecasting is a necessary element of effective and efficient management of a farm. It fulfils also an important role when determining consequences of decisions, i.e. anticipated benefits and necessary costs.

The paper discusses the method that was applied to prepare a projection of income of agricultural products and presents a projection of cultivation profitability for winter wheat, winter rye, spring barley, winter rapeseed and sugar beets in 2020. The projection was conducted on average on a research sample of farms; this approach was adopted as average production and market conditions, namely resulting from long-term trend. Moreover, models were built that made it possible to specify impact on the scope of changes in income of particular profit-generating factors, i.e. yield, price and costs of cultivation.

The purpose was to determine the impact of changes in prices of means for agricultural production, yields and product prices forecasted until 2020 on the level of incomes from agricultural products. The assessment covered also direction and dynamics of changes in the level of income and profitability of production, expressed as a percentage ratio of production value to costs of its production.

The scope of the conducted research included only a certain percentage of individual farms in Poland. In spite of that, it is assessed that in separated groups they reflect faithfully trends in costs and give a credible image of changes in production profitability. In this context, they provide the basis for formulation of conclusions relating not only to the analyzed sample. The primary importance in the conducted analyses is attached to the direction of changes, rather than only absolute figures, which should be addressed with certain caution. Agriculture is a section that is characterized by a great variability and high risk, therefore forecasting the future nearly always is burdened with error. The projection results should be a hint for agricultural producers and decision-makers of what we may expect in the near future under specified conditions of operation of farms. In consequence, actions undertaken accordingly earlier will enable also counteracting negative factors of changes.

The analytical part is supplemented by graphic annex (charts: B.1-B.31) which shows empirical values of the analyzed time series and theoretical values calculated on the basis of the selected trend models. They show the direction of changes in the analyzed phenomena.

Analysis covered also the structure of the selected time series of prices of agricultural products, i.e. wheat, rye, barley and live pigs. The purpose of the analysis of the structure of time series is to identify particular components of time series variability. This procedure is recommended as it helps to reduce prediction errors and facilitates interpretation of the projection results in particular periods. This representation is of special importance in the case of time series of prices whose level is determined by the combination of factors interacting systematically in the long, middle and short term. This type of analysis also helps to assess the effect of overlapping periodical fluctuations of different lengths, e.g. cyclical fluctuations with the period of approximately 10 years, 3.5 years, 2 years, one year, namely seasonal character. Other important factors are assessment of strength and nature of the factors with one-time effect, causing accidental fluctuations in changes in the level of prices. Often this type of events are symptomatic events (in particular in prices' time series) preceding important, and, at the same time, hardly detectable trend changes. The trend changes in such time series are relatively rare but cause key effects – usually negative for prediction accuracy. It is of a greater importance, as, by definition, models of time series used in the projection are mechanical, most often they do not have substantive interpretation and serve only for forecasting. We are interested in the description and forecast of the phenomenon without penetration into the economic mechanisms lying at the root of the forecasted phenomenon.

Results of the analyses of structure of time series might be used in expert's analyses, or for further quantitative processing. For expert's analyses, graphic presentation of time series is important, showing courses of particular components and separated typical patterns. In the quantitative analyses components of time series may be subject to further processing as separate diagnostic signals, helpful in the interpretation of changes in prices and their projections.

From the point of view of this paper, a particular role is fulfilled by the analysis of slowly-changing components. The impact of many long-term factors is reflected in these components. The analysis of quickly-changing components reflects sudden quality events, both incidental (disclosing as short-term deviations) and causing long-lasting effects. In the case of identification of such events, it is necessary to conduct further analysis aiming to evaluate the nature of impact on the course of time series in the future. An important element of the selection of information is elimination of less important features of time series, permitting more effective evaluation of the most important features of the analyzed phenomena and correct interpretation of the projections.

The analysis of time series variability is an important issue from the point of view of target users and decision-makers. It consists in separation from the input time series of a time component of trend, random component and seasonal component, and in the event of cyclical fluctuations, also regular component. These components can be identified often by visual evaluation of the chart. It permits also detection of non-standard observations and turning points (change in trend direction). The interpretation problem appears, however, when different kinds of changes co-occur with each other, mutually mitigating or intensifying the effect of impact. Another important factor of that analysis is the correct interpretation of forecasts formulated on the basis of the data at annual interval, and relating only to the development trend projection. Such forecasts indicate the overall direction of changes, but are not (by definition) sensitive to the impact of mid-term factors causing, e.g. cyclical or seasonal fluctuations. Therefore, it is important to interpret projection results with regard to the specific moment of development of the phenomenon taking into account the impact of cyclical and seasonal fluctuations.

The time series decomposition brings about numerous benefits, enables examining the structure of phenomena, improving accuracy of built forecasts. It facilitates and simplifies research, and basic benefits of such analysis include:

- the identification of the real direction of mid and long-term changes,
- assessment of the actual scale of effects of specific events which in the time series are often "masked" by the seasonal or accidental effect,

- obtaining separate time series in the form of values resulting from trend, cyclic fluctuations, seasonal fluctuations,
- separate forecasting of particular separated variability components,
- the possibility to make use of data cleared from trend, seasonality and accidental changes in the analysis of economic cycles,
- the possibility to estimate the scale of price risk depending on decision-making horizon.

I. The notion of model and selected forecasting issues

In the beginning, it should be marked that there is no one, expressly specified and commonly adopted theory of predicting economic phenomena. There is no well justified and commonly accepted consistent knowledge about the determination of economic phenomena. Economists do not have such knowledge and there are no uniform, commonly adopted principles of economic forecasting which set would be worthy of stable theory of economic forecast. In view of this, in economic research various models are used, by means of which economists attempt to justify the suggested ways of proceeding from observing the past to predicting the future.

The notion of a model shall be understood as presentation of the existing or hypothetical part of reality created for a given purpose, free from details and features insignificant to achieve the presented purpose¹.

In the opinion of Machaczka², the most important from among many functions of models is *the communication function*. Models are not intended to explain simple phenomena – to aid in their imagination and intellectual cognition – such phenomena do not require creating models. On the other hand, such models are required by phenomena difficult to imagine and experience: models enable presenting them in a simple, communicative form. In the opinion of this Author, *"modelling is always a result of the compromise between striving for possibly exact projection of a phenomenon and striving for its maximum simplification"*. Thus, communication function is not fulfilled by too complicated models and by models that do not reflect many significant features.

¹ B.R. Kuc, *Rola modelu i modelowania w pracy naukowej*. <http://wydawnictwoptm.pl/connent/8-artykuly-naukowe> [access: August 2014].

² J. Machaczka, *Zarządzanie rozwojem organizacji. Czynniki, modele, strategia, diagnoza*, PWN, Warsaw-Cracow 1998.

Since the dawn of time the man has tried to get to know the future. However, he did not aim at the above in a scientific manner. Only the birth of science created the bases for explaining phenomena and predicting their possible recurrence. A new specialization appeared, termed prognostics or more sophisticatedly – futurology.

Rational forecasting requires the use of suitable methods, most adequate for examined situations. The forecasting method includes the way of processing the data about the past and the way of transition from processed data to the forecast. In this determination emphasis was placed on the presence of two phases of predictions: phase of diagnosing the past and phase of determining the future. Diagnosing the past proceeds through construction of a formal model (e.g. trend model or econometric model) or mental model (e.g. created in the expert's mind). The way of transition from processed data to forecast is termed the rule of forecast³.

According to Zeliaś⁴, prognostic methods can be divided into two groups: non-mathematical and mathematical-statistical methods (Figure I.1).

Non-mathematical methods – termed also qualitative or heuristic methods – consist in using opinions of a large group of experts, their experience and knowledge concerning the forecasted situation. Forecasting the future in this case is not extrapolation of the regularities detected in the past, but is forecasting possible variants of development of a given phenomenon and indicating the most real variants⁵.

The most often applied group of forecasting methods are mathematical-statistical methods (termed also quantitative methods). These are methods where forecasts are determined with the use of statistical or econometric models. Prognostic models are estimated on the basis of empirical data concerning fluctuations in distinguished variables, i.e. forecasted variable and explanatory variables in the past. These data assume the form of time series. Forecasting with the use of these methods usually takes place by projection (extrapolation), observed in the past regularities, in the future. For this reason, using statistical and econometric models in forecasting, stability in time of structural relations described by model and acceptability of extrapolation of the regularities beyond a statistical sample are assumed. It justifies determination of the future level of the phenomena on the basis of a model that describes the regularities in shaping of this phenomenon in time⁶.

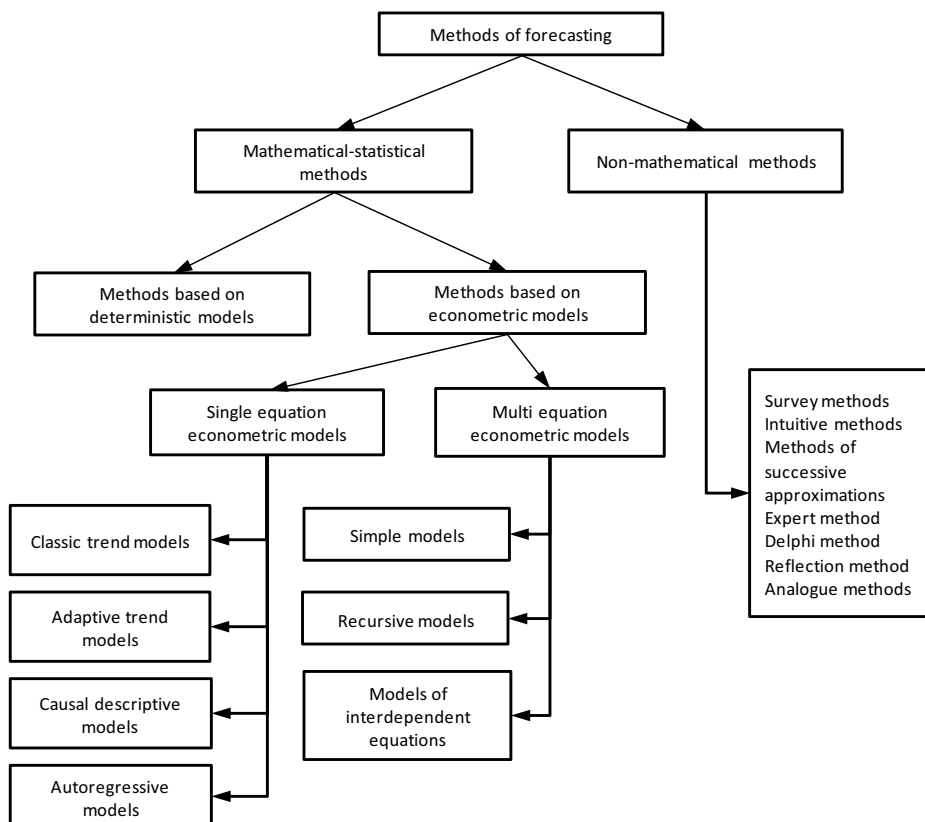
³ B.R. Kuc, *Przewidywanie jako funkcja nauki*. <http://wydawnictwoptm.pl/content/8-artykuly-naukowe> [access: August 2014].

⁴ A. Zeliaś, *Teoria prognozy*, 3rd issue, PWE, Warsaw 1997.

⁵ A. Zeliaś, B. Pawelek, S. Wanat, *Prognozowanie ekonomiczne. Teoria, przykłady, zadania*, PWN, Warsaw 2003.

⁶ E. Nowak, *Zaawansowana rachunkowość zarządcza*, 2nd issue, PWE, Warsaw 2009.

Figure I.1. Scheme of major forecasting methods



Source: [Zeliaś 1997]⁷.

The main criterion for division of economic forecasts is time horizon of a forecast, i.e. period for which it was built. The longer the period, the worse the reliability of a forecast. For this reason, long-term forecasts should be treated with a great deal of caution.

Period that is assumed as a forecast horizon is conventional, since it depends on the kind of the analyzed phenomenon. Some authors consider short-term forecasts to be economic forecasts that do not exceed one year or cover only one production cycle. Due to the function to be fulfilled, such forecasts are termed operating. They are useful to make current decisions (for instance on an agricultural farm). On the contrary, mid-term forecasts are prepared for a period from 2 to 5 years and long-term cover periods above 5 years. They are defined as strategic forecasts, and fulfill the role of a tool of long-term and

⁷ A. Zeliaś, *Teoria prognozy*, 3rd issue, PWE, Warsaw 1997.

forward planning. The main objective of these forecasts is to create the bases for making long-term business decisions⁸.

Forecasting may have a strong effect on events. Popularization of forecast results may bring its confirmation in reality in the sense that without this publicity it would not prove true. On the other hand, publicity may thwart some predictions, and their publishing can change conditions that suggested the probability of expected events. For example, an announcement of the directors that in the years to come profits are expected may be "suicidal", as it may result in the pressure for a pay rise. Predicting does not involve confidence. Even when we can make use of scientific rules as the basis for predictions, it does not ensure accuracy because it is not certain that at the given moment in the future all conditions necessary for the right to have effect will be present.

Forecasting is inseparably related to explaining. Forecasting is based on explaining, or otherwise, explaining is the basis for predictions, namely knowledge of rules and conditions which explain the occurrence of a given phenomenon or process permits correct deduction of a new fact. Typically, the better the explanation of what happened within some system, the more accurate the prediction of future events. As a result, some authors consider explaining and forecasting as logically isomorphic processes. It means that *"the possibility of explaining is the possibility of correct predicting"*⁹.

Forecasting combined with explaining is based on a certain model of reality that implies the need to understand the functioning of basic systems underlying the phenomena. It also suggests a possibility of control, rather than passive approval of the predicted future, which is considered as impossible to change¹⁰.

According to Sobczak¹¹, even when forecasts are not accurate, they show phenomena and trends that can shape the forecasted phenomenon in the years to come. Thanks to that, there is a possibility to take up actions aimed to eliminate negative events. Apt forecasting is the skill of few and it is a combination of knowledge and art. A.D. Aczel states in this context that "it is better to know the truth inaccurately than be thoroughly wrong"¹².

⁸ E. Nowak, *Ogólne zagadnienia prognozowania*, [in:] *Prognozowanie gospodarcze. Metody, modele, zastosowania, przykłady* (scientific edition E. Nowak), Agency Wyd. PLACET, Warsaw 1998.

⁹ B.R. Kuc, *Przewidywanie jako funkcja nauki*. <http://wydawnictwoptm.pl/content/8-artykuly-naukowe> [access: August 2014].

¹⁰ J.O'Shaughnessy, *Metodologia decyzji*, PWN, Warsaw 1975.

¹¹ M. Sobczak, *Prognozowanie. Teoria, przykłady, zadania*, PLACET, Warsaw 2008.

¹² A.D. Aczel, *Statystyka w zarządzaniu*, WN PWN, Warsaw 2000.

II. Research material and methodology and the way of results presentation

The projection of production and economic results until 2020 has been prepared for five plant production activities, i.e.:

- winter wheat,
- winter rye,
- spring barley,
- winter rapeseed,
- sugar beets.

To build the projection model the empirical material from the years 2011-2013 was used; these were the most up-to-date data available. They were coming from the database of the AGROKOSZTY system¹³, under which detailed information on the production level and input means of production and direct costs of agricultural production activities is collected. Farms are selected for analyses in a purposeful manner from a representative sample of farms observed in the Polski FADN system. Selection of farms every year is conducted independently.

When analyzing the results of activities (average from 2011-2013) that were "the starting point" for the projection, and the projection results anticipated in 2016, 2018 and 2020, the assessment covered the level of production, economic costs and effects, but, as the basic indicator of assessment of obtained effects, the level of income from activity without subsidies and income from activity (i.e. together with subsidies) were assumed. The mode of calculating particular income categories is presented below:

- (1) **gross margin without subsidies** =
= value of production – direct costs
- (2) **income from activity without subsidies** =
= value of production – (direct costs+ indirect costs)
- (3) **income from activity** =
=[value of production – (direct costs+ indirect)]+ subsidies

The calculation of income from activity includes direct and indirect costs. Direct costs are components of costs that, without doubts, can be attributed to given activity. Whereas, indirect costs are costs that, at the time of formation, cannot be divided into particular products (production activities); these are common costs for the whole farm. The structure of indirect costs is presented by diagram II.1.

¹³ *Wyniki ekonomiczne wybranych produktów rolniczych w 2012 roku* (scientific edition A. Skarżyńska), IERiGŻ-PIB, Warsaw 2014.

Diagram II.1. Structure of indirect costs of a farm

1. Indirect real costs

general economic costs

- electricity
- fuel for heating
- engine fuel
- repairs, maintenance, inspections
- services
- insurance (e.g. buildings, property, communication)
- other (e.g. fee for water, sewer, telephone)

taxes

- agricultural
- other (e.g. forest, special branches, real estate)

cost of external factors

- cost of hired labour
- lease payments
- interest

2. Estimated indirect costs - depreciation

- buildings and structures
- machines and technical devices
- means of transport
- other (e.g. irrigation, orchards and perennial plantations)

Source: L. Goraj, S. Mańko, *Systemy monitorowania sytuacji ekonomicznej i produkcyjnej gospodarstw rolnych*, [in:] *Rachunkowość rolnicza*, 2nd edition, Difin, Warsaw 2004.

Indirect costs incurred in operating activity of farm include all costs incurred under operation or only its existence. These costs are divided between conducted activities according to division keys. In the conducted tests, following the possibilities with regard to access and use of specified variable databases (base of the system AGROKOSZTY and Polski FADN), one division key of indirect costs was applied, i.e. share of the value of production of each of them in the value of total production of a farm. Data that were used to calculate indirect costs of the analyzed activities were taken from the accounting base Polski FADN, which identifies farms that run activities analyzed in the system AGROKOSZTY. The algorithm of division of indirect costs was applied individually for particular farms and activities.

According to the principles of the Common Agricultural Policy, an instrument of support and stabilization of farmers' income are direct payments. The new financial perspective provides opportunities and preferences for active farmers. The purpose is also to permit development of small or medium farms,

so that they could become commodity farms, producing not only for own needs. For this reason, the direct payment system in the years 2015-2020 is to be linked to agricultural production.

This system of subsidies will be possible, among others, as a result of shifting 25% of funds from the 2nd pillar of the Common Agricultural Policy (namely from the Rural Areas Development Program 2014-2020) to direct subsidies, namely to the 1st pillar of the Common Agricultural Policy¹⁴. These additional funds are to be targeted at active farmers and are to support development of small and medium agricultural farms. The distribution of 25% of funds allocated for direct subsidies is as follows: 2% – incurred direct payments for young farmers, 15% – payments related to production, provided that 2% of this amount will be allocated for supporting cultivation of high-protein plants and 8.3% – for the so-called additional payments.

The new system of direct payments, i.e. for the years 2015-2020 will enter into force from 2015 and is a continuation of the previously applied simplified SAPS (Single Area Payment System).

The direct payment system for the years 2015-2020 is composed of two components:

- mandatory – the same for all member states of the EU,
- voluntary – selected by a member state.

Mandatory direct payments include:

- single area payment (JPO)¹⁵,
- payment for greening¹⁶,

¹⁴ Marek Sawicki przedstawił nowy system płatności bezpośrednich na lata 2015-2020. *Preferencje dla aktywnych rolników*. <http://www.arimr.gov.pl/aktualnosci/artykuly/marek-sawicki-przedstawil-nowy-system-platnosci-bezposrednich-na-lata-2015-2020-preferencje.html> [accessed in: July 2014]. *System płatności bezpośrednich w Polsce w latach 2015-2020 – projekt do konsultacji*, Ministerstwo Rolnictwa i Rozwoju Wsi, Warszawa 17 czerwca 2014 r.

¹⁵ Single area payment is related to the tasks executed in a given area, rather than results from rights reflecting historical production volumes.

It will be fixed on the annual basis after determination of the total area of qualifying hectares declared by farmers to this payment. Estimated payment rate may amount to approx. 110 EUR/ha.

¹⁶ To receive payments for greening, which can constitute approx. 30% of direct subsidies, it will be necessary to introduce in a farm the following practices: diversification of cultivations, maintenance of permanent grasslands (TUZ) and maintenance of environmentally friendly areas (the so-called EFA). The obligation of diversification of cultivations will not relate to farms of total area of arable lands below 10 ha, which means that approx. 83% of farmers do not have to introduce it. Farms with total area of 10 ha to 30 ha must introduce at least 2 cultivations, and minimum 3 cultivations above 30 ha of arable lands. Maintenance of environmentally friendly areas (EFA) is the obligation of a farm whose area of arable land is at least 15 ha. A farm with greater area must allocate 5% of arable lands for environmentally - friendly areas, and 7% from 2017. Approx. 91% of farms are exempted from this obligation. To facilitate farmers execution of

- payment for young farmers¹⁷.

Voluntary payments include:

- payments for small farms¹⁸,
- payments related to production¹⁹,
- additional payments²⁰,
- temporary national support²¹.

In the prepared projection of income from production activities, the payment rate until 2020 was assumed at 240 EUR/ha. A factor that has a great impact on the level of subsidies is EUR/PLN exchange rate. It is fixed by the European Central Bank as of 30 September. The exchange rate adopted in the calculations is: EUR 1 = PLN 4.20. Based on the above, it was estimated that subsidies to 1 ha will be at the level of PLN 1008.

The purpose of the research was projection of income, namely identification of the direction of their change in the mid run. The first stage of work was appropriate processing of base data which then became the basis of preparing the projection. In the case of activities covered by research, i.e. winter wheat, winter rye, spring barley, winter rapeseed and sugar beets, particular variables, i.e. components of the value of production and costs of the years 2011-2013 were averaged. Thereby, the impact of accidental, e.g. annual deviations of the level of these variable on results was eliminated.

the condition, several farmers whose farms lie near – maximum 10 farmers who live within the radius of 15 km can make joint settlements.

¹⁷ In the new system, young farmers will be able to use two sources of support to develop their farms. Apart from aid from the Rural Areas Development Program 2014-2020, which can be received in the form of non-refundable bonus of PLN 100 000, paid in two installments: 80% and 20%, will be also able to receive direct subsidies greater by 25% (i.e. approx. 62 Euro/ha) than their older colleagues. It is necessary to add that the maximum area for which young farmers will receive increased subsidies is 50 ha.

¹⁸ Farmers who have small farms will be able to receive non-refundable aid in the amount of PLN 60 000 for at their restructuring under PROW 2014-2020. On the contrary, if they decide to cease agricultural activities and sell their farm, then they will be entitled to compensation of 120% of subsidies they would receive to 2020.

¹⁹ Payments in connection with production will be made to farmers who conduct activities in the following sectors: cattle, cows, sheep, goats, high-protein plants, hop, potato starch, sugar beets, tomatoes, soft fruit (strawberries and raspberries), and flax and fibrous hemp.

²⁰ Additional payment to hectares in the range as specified by a member state. A rate per hectare may amount to maximum 65% of the average national payment per hectare, i.e. 205 Euro/ha.

²¹ According to the EU regulations, this aid is degressive, i.e. every year acceptable percentage threshold is smaller by 5 percentage points. It is possible to use temporary national support in the tobacco sector.

The average from the years 2011-2013, termed further as "the level for 2013", namely the base year for the projection, was the basis for building the projection for 2020 (and the preceding years), i.e. it was subject to extrapolation to the future on the basis of trends observed for time series of the analyzed variables. Time series were determined for 1995-2013 on the basis of the public statistics data.

It means that for all components of costs (direct and indirect) and components of the value of production of each activity the models were selected that described well the variability of the analyzed phenomenon. Models to be used in the projection were selected on the basis of the coefficient of determination and experts' knowledge about shaping of a given phenomenon in time. In the projection model, invariability of structure and amount of outlays for particular activities in the production process was assumed. It means that outlays reflect the average level in base years (i.e. 2011-2013).

Manner of results presentation. The projection results show impact on the level of income of the forecasted pace of changes in prices and other factors forming the value of production (revenues) of particular activities and changes in prices of measures for rural production (among others, seeds, fertilizers, plant pesticides, fuels). As a result, they permit identification of the dynamics of anticipated changes in the level of production value, costs and income of the analyzed production activities.

When depicting the problem in more detail, they present a possible direction of changes, namely what may be expected in average, similar as in recent years conditions of operation of farms (i.e. market and climatic conditions). Agriculture is, however, a particular sector, results of plant production are largely dependent on weather conditions. Random events occur, such as droughts, floods, but also conditions favourable for agricultural production which cannot be foreseen, and whose impact on the amount of yield of plants may be significant.

Fluctuations may cover also the prices of products and particular cost components, dynamics of their changes does not have to reflect the trend observed in the last dozen or so years. Deviations from average figures may be significant, which in consequence, influences the level of income. In agriculture, however, it is not possible to prepare a reliable forecast of economic phenomena, however, it is possible to predict limits of variability and observe the direction of changes in the obtained results.

For a detailed analysis of this issue projection models were built; they will enable specifying:

- the impact of unit changes in yield, price and costs of cultivation of the analyzed activities on the change in economic performance in 2020 (unit changes mean deviations from results of projections resulting from the trend),
- the impact of variability in yield and price recorded in the years 1995-2013 on the basis of the public statistics data, on the size of deviations of income without subsidies of the analyzed production activities from results of the projection prepared for the year 2020 in the production and price conditions resulting from the trend,
- the scope of change in 2020 in production and price results, assuming that income without subsidies of the analyzed activities will remain at the level of the base year (i.e. it will reflect the average level in the years 2011-2013).

The results are presented graphically and in tables. They reflect the average level in the groups of farms where research was conducted and therefore they should not be translated directly in the results average for the country. However, they enable presenting some phenomena and dependencies and direction of changes (e.g. production profitability) and, in this context, provide the basis for formulation of conclusions relating not only to the analyzed sample.

III. Method of projecting income from agricultural products

In the chapter, there are presented manner (procedure) of income projection model construction in the mid run (until 2020) for plant production activities. The research covered five activities, i.e. winter wheat, winter rye, spring barley, winter rapeseed and sugar beets.

The basis for the projection model construction included data collected in the system AGROKOSZTY and Polski FADN. For the purpose of presenting results of production activities, they were processed according to the methodology used in the system AGROKOSZTY. Data that were subject to extrapolation to the future, are, in detail, components of the structure:

- ◆ value of production – yield and selling price of products,
- ◆ direct costs – cost of seed material, mineral fertilizers, plant pesticides, growth regulators, other direct costs,
- ◆ indirect costs – presentation on diagram II.1.

The empirical material for the examined activities came from the years 2011-2013. Such short time series prevent their modeling and obtaining, on its basis, a reliable projection of results in the perspective of a few years. For this reason, these data were only a starting point for the projection. However, to level

the impact of accidental fluctuations, for further calculations average values from the period of research were used. In addition, it has been assumed that in the projection model the structure and amount of outlays for particular actions in the production process are not changed. That means that in the projection time horizon they reflect the average level in the years 2011-2013.

To solve the problem of too short time series, when building the model of projecting income from production activities, data of public statistics were used. On their basis, time series were created, covering 19 years, i.e. the period from 1995 until 2013²². Data from before this period were often clearly different; the reason was denomination of zloty introduced on 1 January 1995. For this reason, bearing in mind quality and homogeneity of data, the decision was made to resign from construction of longer series.

To particular variables describing production activities in the research period (i.e. components of the structure of value of production and costs) relevant series were assigned, which characterized, as well as possible the variability of these phenomena (e.g. prices, yields). Example of assigning selected variables, i.e. variables coming from public statistics (showing long-term changes) to variables from the base AGROKOSZTY (being the starting point for the projection) is presented in diagram III.1.

After selecting time series, an attempt was made of their modeling and extrapolation to the future. For this purpose mathematical-statistical methods were used, based on classic trend models²³. These models describe forming of phenomena in time and they can be used to prepare average- and long-term forecasts²⁴. Forecasting on their basis takes place through extrapolation to the future of trends observed in the past. However, it is required to adopt an assumption that the analyzed phenomena will be affected by the same factors and in the same manner as so far. It means that structural relations included in the model, and observed on the basis of the empirical data from the past, will not change in the forecast horizon²⁵. In practice, this assumption is difficult to meet, in particular when describing such unpredictable phenomena as occurring in agriculture.

²² Sometimes shorter time series were used.

²³ The selection of this method was determined, first of all, by practical reasons as well as availability of data, horizon and depth of forecast and technical possibilities of using it. This method is relatively simple computationally, and the results are easily interpretable.

²⁴ E. Nowak, *Zaawansowana rachunkowość zarządcza*, wyd. PWE, Warsaw 2009.

²⁵ S. Bartosiewicz, *Ekonometria. Technologia ekonometrycznego przetwarzania informacji*, PWE, Warsaw 1989; M. Cieślak, *Organizacja procesu prognostycznego*, [in:] *Prognozowanie gospodarcze. Metody i zastosowania* (scientific edition M.Cieślak), PWN, Warsaw 1999.

Diagram III.1. Example of assigning variables in the projection model

<i>Variables from the base AGROKOSZTY</i>		<i>Public statistics variables</i>
Yields of winter rapeseed	←→	Yields of winter rapeseed on individual farms
Price of winter rye	←→	Average annual price of rye
Cost of spring barley seed material	←→	Price of spring barley seed material
Cost of mineral fertilizers	←→	Ratio of changes in prices of mineral fertilizers
Costs of plant pesticides	←→	Ratio of changes in prices of plant pesticides
Cost of electric energy	←→	Price of electric energy

Source: preparation on the basis of author's research.

Using models of development trend requires separation of a trend that is a primary component of a time series. It is done by the so-called smoothening a series, namely removing from it any periodical and accidental fluctuations. In the conducted research, this treatment was conducted using analytical method²⁶. This method consists in finding such a mathematical function, further termed as trend function (development trend), which describes, as exactly as possible, changes of a phenomenon in time. It is a special type of regression function, where independent (explanatory) variable is time (t), and dependent (explained) variable is the level of analyzed phenomenon. It is assumed that the effect of various factors affecting the course of the forecasted variable is already specified in changes observed in time. Using the analytical method, it is assumed that the level of the analyzed phenomenon is the function of time:

$$\hat{y}_t = f(t)$$

²⁶ E. Wasilewska, *Statystyka opisowa od podstaw*, SGGW, Warsaw 2011.

where:

t – time variable (number of period), $t = 1, 2, \dots, n$,

\hat{Y}_t – theoretical value (arising from the model) of dependent variable in time t .

The procedure of prediction on the basis of a regression model (trend) requires additionally adoption of two assumptions, i.e. the regression function will not be changed and accidental factors do not distort the analyzed phenomenon in the prediction horizon²⁷.

The analytical form of the trend function was selected using the heuristic method. It consists in estimating several forms of the regression function, and then selecting one of them according to the adopted criteria. The analysis covered seven functions: linear, second degree polynomial (square), exponential, exponent, logarithmic, hyperbolic and linear-hyperbolic. On the basis of these functions for each of the analyzed time series, models of development trend were created, in the following form²⁸:

$Y_t = \beta_0 + \beta_1 t + \varepsilon_t$ – model of linear trend,

$Y_t = \beta_0 + \beta_1 t + \beta_2 t^2 + \varepsilon_t$ – model of square trend (second degree polynomial),

$Y_t = \beta_0 e^{\beta_1 t} \cdot \varepsilon_t$ – model of exponential trend,

$Y_t = \beta_0 (t+2)^{\beta_1} \cdot \varepsilon_t$ – model of exponent trend,

$Y_t = \beta_0 + \beta_1 \ln(t+2) + \varepsilon_t$ – model of logarithmic trend,

$Y_t = \beta_0 + \beta_1 \frac{1}{t+2} + \varepsilon_t$ – model of hyperbolic trend,

$Y_t = \beta_0 + \beta_1 t + \beta_2 \frac{1}{t+2} + \varepsilon_t$ – model of linear-hyperbolic trend

where:

Y_t – value of explained variable in time t ,

t – explanatory variable (time) assumes the integers from 1 to n ,

β_0 – absolute term,

β_1, β_2 – directional coefficients of functions,

ε_t – random component.

²⁷ B. Pułaska-Turyna, *Statystyka dla ekonomistów*, issue III, Difin, Warsaw 2011.

²⁸ For numeric (methodical) reasons in models of exponent, logarithmic, hyperbolic trend and partially linearly-hyperbolic trend the time variable was shifted by 2.

Parameters of all models were estimated with the least square method²⁹. This method consists in finding such assessments of parameters for which the sum of squares of deviations of the values calculated from the model, from values observed actually will be the smallest.

The relevant model was selected for each variable on the basis of several adopted criteria. In the first place the decision was made to resign from models for which the parameters were statistically irrelevant. The significance of parameters was tested using the t-student test. This test checks the authenticity of a zero hypothesis about the lack of significance of the examined parameter (parameter is 0) towards an alternative hypothesis, which says that this parameter is statistically significant (different from 0). The significance level of this test was determined at 0.05. Verification of a zero hypothesis was selected comparing the adopted significance level with p-value. This value determines the likelihood that the tested parameter has value 0, namely is insignificant. If p-value is smaller than the assumed significance level, these are grounds for rejection of the zero hypothesis in favor of the alternative hypothesis. It means that the parameter was substantially different from 0. According to the assumption, the parameter standing at the explanatory variable t is statistically significant. In this case, it can be assumed that time affects significantly the level of a given phenomenon.

Another factor decisive for the selection of model, apart from significance of parameters, was adjustment of different models to empirical data³⁰. The quality of this match is proven by, among others, determination coefficient R^2 , which determines degree to which the estimated model explains variability of the analyzed phenomenon in time. It has, however, its defects and restrictions. First of all, we should not compare directly on its basis models with different number of explanatory variables. Models of square and linear-hyperbolic trend, as opposed to others, have more than one explanatory variable. In such cases, an additional variable, even if the parameter standing at it is statistically significant, may not significantly improve the model quality. A measure of match, which will prove more reasonable, is an adjusted determination coefficient \hat{R}^2 , and thus the value of this coefficient was the main criterion for selection of models for further research.

Following only the determination coefficient (classical or adjusted), we may commit an error when selecting the model. The value of this coefficient presents sometimes in a misleading manner match of the model to empirical

²⁹ Before estimation of parameters of the model of exponential and exponent trend, for both parts of equation logarithm was found.

³⁰ In order to improve quality of adjustment of the model to empirical data, in the case of, buying-price of sugar beets (chart B.9), to the model an additional explaining variable was introduced: it was a binary variable, which had the value of 1 in 2004-2005, and the value of 0 in other years.

data. Apparent regression may occur or not all assumptions of the adopted method of estimation of parameters, in this case least squares method, were met. For the purpose of the completed analyses, full verification of models was not conducted, the stationarity of time series was not tested, either.

Having some knowledge about shaping of a given phenomenon in time it can be seen that, theoretically, in some cases preferably matched model does not characterizes well variability of the analyzed series. This is manifested especially in the case of series whose models were of poor quality (coefficients R^2 and \hat{R}^2 were low). In addition, in the conducted research it happened a few times that the highest value of the adjusted determination coefficient was shown by the square trend model. Unfortunately, values forecasted using this model may be largely over- or underestimated, even if the model itself is well adjusted to data. Also in the case of the other models, there were cases when, in spite of high determination coefficient, the projection of results on their basis was hardly reliable. For this reason, to avoid mistakes related to mechanical approach to the model selection, it was often selected on the basis of available knowledge about the examined phenomenon, by following only the size of determination coefficient (i.e. attention was paid so that it would be possibly the highest, but not at the expense of quality of a forecast).

An example of selecting the model for further analyses may be presented for the time series containing data concerning prices of spring barley seed material. Table III.1 presents the results of estimation of all seven models for this variable.

Models of square and linear-hyperbolic trend had some statistically irrelevant parameters (p -value > 0.05) and for this reason were excluded from further discussion³¹. Other models met the criterion of significance of parameters, but their determination coefficients, both classical and adjusted, were significantly different. From the accepted models, the exponential trend model had the highest \hat{R}^2 (0.867). For this model R^2 is 0.875, namely it is relatively high, which may prove its good match with empirical data. A little smaller match was characterizing the linear trend model ($R^2 = 0.822$, $\hat{R}^2 = 0.811$). Considering only the amount of both coefficients, for further works it was necessary to select the exponential trend model. However, the selection was not as obvious after analyzing the charts of exponential and linear functions – chart III.1.

³¹ The importance of parameter β_0 (absolute term) was not taken into consideration.

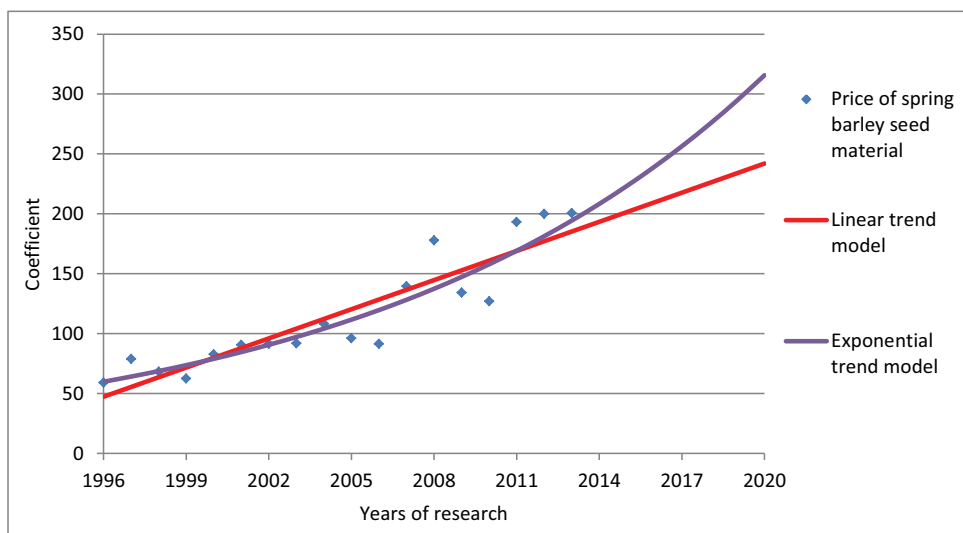
Table III.1. The results of estimation of selected trend models for prices of spring barley seed material

Type of model	R ²	\hat{R}^2	Parameter	Evaluation of parameter	P-value
Linear model	0.822	0.811	β_0	39.218	0.001437856
			β_1	8.112	2.13287E-07
Square model	0.872	0.855	β_0	66.600	0.000337026
			β_1	-0.103	0.976973173
			β_2	0.432	0.028837401
Exponential model	0.875	0.867	β_0	55.817	7.27581E-20
			β_1	0.069	1.27666E-08
Exponent model	0.767	0.751	β_0	22.096	1.2226E-09
			β_1	0.679	4.14584E-06
Logarithmic model	0.688	0.669	β_0	-47.165	0.114573694
			β_1	70.650	2.06748E-05
Hyperbolic model	0.495	0.463	β_0	166.901	7.48227E-09
			β_1	-434.342	0.001126573
Linear-hyperbolic model	0.854	0.835	β_0	-14.467	0.646964616
			β_1	10.980	2.07051E-05
			β_2	226.882	0.088295597

Source: prepared by the author on the basis of data from the Central Statistical Office (GUS).

Chart III.1 presents empirical data for the price of spring barley seed material in the period 1996-2013 and theoretical data calculated on the basis of linear and exponential model along with extrapolation into subsequent 7 years (until 2020). Both presented models are characterized by a relatively good match, but the values of projection for the exponential model are much higher. The figures forecasted for this model are hardly credible. On the basis of the analysis of real data from the years 1996-2013 and available knowledge it is difficult to expect so strong rise in price of spring barley seed material in the projection horizon. Finally, for analyses thus linear trend model was selected, which had the second largest determination coefficient value, however, the projection of price on its basis was more reliable.

Chart III.1. The price of spring barley seed material and selected functions of the model



Source: prepared by the author on the basis of data from the Central Statistical Office (GUS).

With the use of the above criteria, in a manner similar as in the example described above, the model was selected for each of the analyzed time series. Then, on the basis of selected models, theoretical values of particular variables were calculated and their values were extrapolated into subsequent 7 years (until 2020). On their basis, from year to year ratios of changes were calculated, where the previous year = 1.

Table III.2. The empirical and theoretical values of the price of spring barley seed material and ratios of changes for the years 2013-2020

Specification	2013	2014	2015	2016	2017	2018	2019	2020
Price of spring barley seed material in PLN/dt (GUS data)	200.69							
Theoretical values of the price of spring barley seed material calculated on the basis of the linear trend model	185.23	193.35	201.46	209.57	217.68	225.79	233.91	242.02
Ratios of changes (previous year = 1) on the basis of theoretical values	1.0458	1.0438	1.042	1.0403	1.0387	1.0373	1.0359	1.0347

Source: prepared by the author on the basis of data from the Central Statistical Office (GUS).

Table III.2 presents the price of spring barley seed material in 2013 according to the Central Statistical Office (GUS), theoretical values along with the projection until 2020 were calculated on the basis of a previously selected model (linear trend) and ratios of changes were calculated on the basis of theoretical data.

Table III.3. Output data and projection of prices of spring barley seed material

Specification	Average for 2011-2013*	2014	2015	2016	2017	2018	2019	2020
Ratios of changes (previous year = 1) on the basis of theoretical values		1.0438	1.042	1.0403	1.0387	1.0373	1.0359	1.0347
Projection of costs of spring barley seed material in PLN/ha (data of AGROKOSZTY)	167.49	174.83	182.16	189.5	196.83	204.17	211.51	218.84

*Starting point for the projection – reflects the average in the years 2011-2013, further is termed as the base year (2013).

Source: prepared by the author on the basis of data of the Central Statistical Office (GUS) and system AGROKOSZTY.

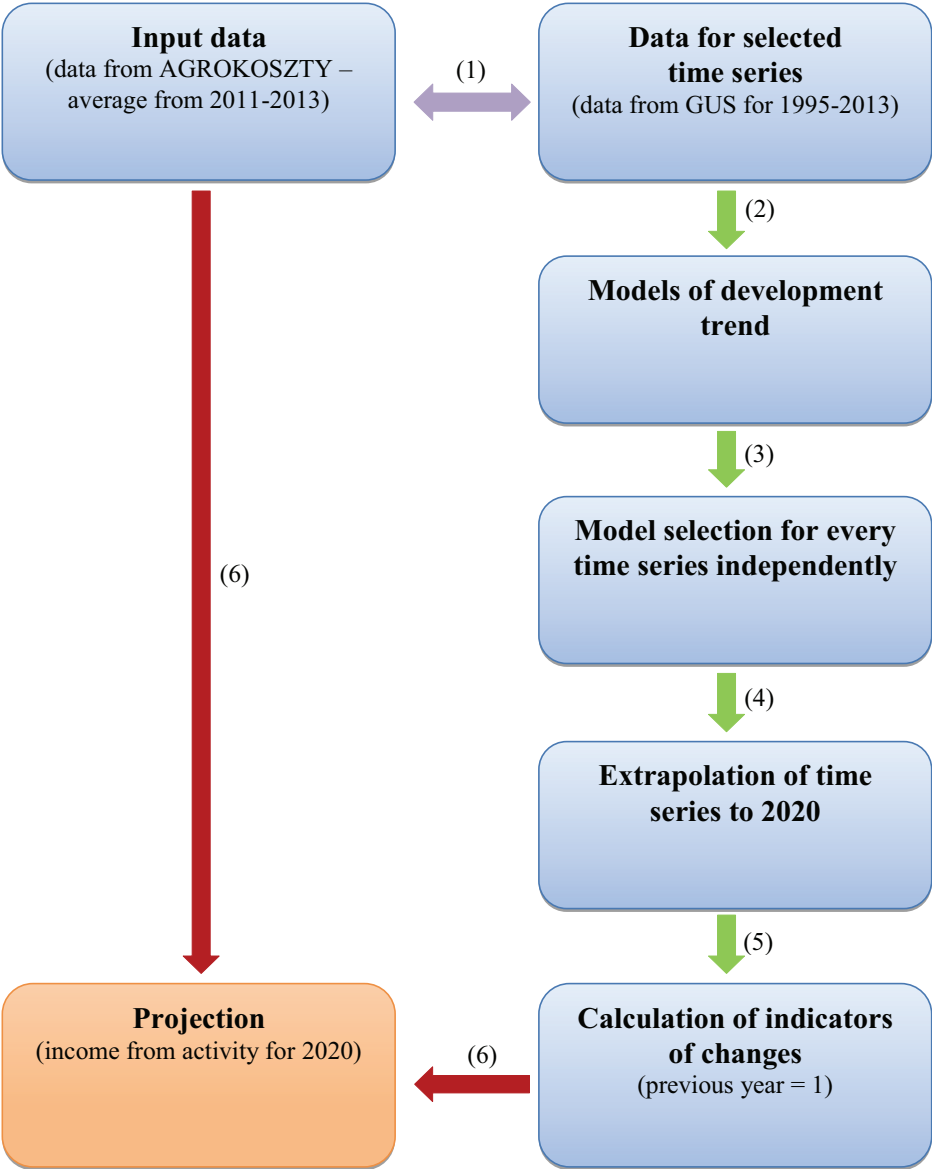
After calculation of ratios of changes for all series, we returned to the data from the database AGROKOSZTY, which describe particular production activities. As it has been mentioned at the beginning of the chapter, calculated on their basis average from the years 2011-2013 was used as the starting point for preparing the projection. Ratios of changes in the years 2014-2020 which were calculated on the basis of selected models with the use of data of the Central Statistical Office (GUS), were used to convert the value of the starting point for the projection years. An example of results received in this way for the cost of spring barley seed material is presented in table III.3.

The presented examples illustrate techniques of procedure, from selecting a model until obtaining the projection results. In this way, the projection of all components for the structure of values of production and costs was conducted, and then income from activity without subsidies for the years 2014-2020 was calculated for the analyzed production activities. To depict better particular stages of the projection model construction, they have been presented in a synthetic manner in diagram III.2.

The first stage of the model construction was preparation of output data which describe particular production activities. These were average values from the years 2011-2013 and constituted the starting point for the projection. Then, to each variable corresponding time series were assigned, with data from public statistics. For each of these series 7 development trend models were built. On the basis of the adopted criteria for further analyses one model was selected (for each series separately). Using selected models, theoretical values along with the projection for subsequent 7 years were calculated. These values were used for calculation of year to year ratios of changes. By using the calculated ratios the values of the starting point (averages from the years 2011-2013) were converted for the above components of the structure of values of production and costs. In this way,

expected values of these variables for the year 2020 were obtained. Then the anticipated level of income from activity without subsidies was calculated.

Diagram III.2. Stages of building the income projection model for agricultural production activities



Source: prepared by the author.

The procedure presents stages of projection model construction in average production and price conditions. However, yields and prices undergo certain fluctuations. Changes in yields are affected by, above all, weather factors, and the prices of agricultural products and means of production are affected by market conditions. Each their change has impact on the economic results. For this reason, an attempt was made to examine how unit changes can affect the level of income without subsidies from cultivation of the analyzed activities. The analysis covered the scope of change (deviations +/-) of income without subsidies from results of the 2020 projection, due to change in each of the income-forming factors independently, i.e.:

- yields in crops and rapeseed by +/-1 dt, and in the case of sugar beets by +/-10 dt,
- selling price of products by +/-1 PLN/dt, total costs by +/-100 PLN/ha.

Fluctuations in yields and prices of agricultural products may be relatively large. To analyze the volume of these changes, variability coefficient was calculated for yield and price of winter wheat, winter rye, spring barley, winter rapeseed and sugar beets. Like in the case of the projection model, calculations for these series were made on the basis of the data of the Central Statistical Office (GUS) from the years 1995-2013. The conducted analysis showed that yields and prices of the analyzed plants are subject not only to accidental fluctuations but also to long-term trends resulting from systematic changes (e.g. constantly improved production technology). In this situation, the use of classic variability coefficient (quotient of standard deviation to average) was not the best solution. For this reason, variability of particular yields and prices was calculated as a quotient of element of the sum of squares of residues from models (selected for building the projection) to the arithmetic average of subsequent variables:

$$V = \frac{\sqrt{\sum(Y - \hat{Y})^2}}{\bar{Y}}$$

where:

V – variability of the examined variable,

Y – empirical values of variable,

\hat{Y} – theoretical values of variable resulting from the model,

\bar{Y} – arithmetic average of variable value.

Considering observed in the years 1995-2013 variability of yield and price, the possible size of their deviations was calculated – for the analyzed agricultural products from the results of the 2020 projection, in average production and market

conditions. Then, it was analyzed how change in yield and price may affect the amount of income in 2020. In this way, the level of income and scope of its fluctuations in the level in the event of very favorable and unfavorable production and price conditions were determined. In the case of each activity, the impact of yield and price was analyzed separately. It was possible, because analyzing correlation between yields and prices of different activities showed no significant interrelations. Correlations were calculated using for each variable differences of logarithms between subsequent observations: $(\ln[Y_t] - \ln[Y_{t-1}])$. In this way, the impact of long-term changes, resulting from development trend, which could significantly affect correlation results, was eliminated.

An alternative depiction of the projection results may be a guideline as to the scope of changes in income from the analyzed production activities in the perspective of 2020. An attempt to determine precisely for a few years forward the amount of yield or selling price of agricultural products is rather doomed to failure. However, adopting some assumptions we can identify directions of the analyzed phenomena or the degree to which the expected results may change.

IV. The projection until 2020 of production costs and economic results of selected agricultural products – alternative depiction

The desire to get to know the future from the dawn of time was one of major human objectives. However, the future is unpredictable by nature and for this reason forecasting results in sometimes ironic smiles of reasonably thinking people. The development of civilization and science caused, however, appearance of methods based on searching for the associations between facts from the past that may determine the future. Such methods should be forecasting, defined by Cieślak³² as rational, scientific prediction of "future events". We speak about scientific predictions of the future when in the process of reasoning we use rules of science which differs from common knowledge by, among others, accurate language and determined research method.

Prediction of changes in the economic situation in agriculture is particularly difficult, mainly owing to strong dependence of production from natural conditions. For this reason, in agriculture it is not possible to obtain a correct forecast; there are too many factors which cannot be foreseen (e.g. hailstorm, droughts). However, forecasts fulfill an important information and warning role and therefore they should be an integral part of the process of managing a farm. It applies especially to the sphere of economic phenomena, in the case of which the result of

³² M. Cieślak, *Prognozowanie gospodarcze. Metody i zastosowania*, PWN, Warsaw 2004.

decisions taken today is largely dependent on what will be tomorrow. Forecasting reduces uncertainty and contributes to the growth in accuracy of decision-making, and hence to elimination of losses.

A farmer (entrepreneur) cannot take care only about production or restrict to solving only current problems. He should also think prospectively, specifying e.g. directions and scope of investment. To survive on the market the information is necessary, which, to a smaller or larger extent, would present future conditions. Preparation of forecasts is thus necessary for functioning of a farm. The directions of changes in CAP observed in recent years consist in limiting market regulation. It means that agriculture and its sectors will be subjected to a significantly greater impact of the rights of demand and supply and principles of competition. In these conditions, the need for producers' response to signals sent by the market will increase. It is:

- to make agriculture able to meet the requirements of market through adjustment of production to its needs,
- not to disturb competition in international trade,
- to strengthen competitiveness and innovation in the agricultural sector so that it would be able to face the global market challenges.

As a result of these directions in changes in the agricultural policy, we should expect greater demand for information about future market conditions (e.g. supply, prices) of agricultural raw materials³³.

Chapter IV, as compared to the data from previous years, presents results of the 2020 projection of cultivation profitability of **winter wheat, winter rye, spring barley, winter rapeseed and sugar beets** in average production and price conditions (namely resulting from the trend). Also projection models were built, making it possible to specify:

- impact of unit changes in yield, prices and costs of cultivation of the analyzed activities on change in the economic results in 2020,
- the impact of variability in yield and price recorded in the years 1995-2013 on the basis of the public statistics data, on the size of deviations of income without subsidies of the analyzed production activities from results of the projection prepared for the year 2020 in the production and price conditions resulting from the trend,

³³ S. Stańko, *Uwarunkowania prognozowania w agrobiznesie: teoria a decyzje gospodarcze*, [in:] *Zarządzanie ryzykiem cenowym a możliwości stabilizowania dochodów producentów rolnych – możliwości poznawcze i aplikacyjne*, (scientific edition M. Hamulczuk, S. Stańko), Seria Raporty Programu Wieloletniego no. 148, IERiGŻ-PIB, Warsaw 2009.

- the scope of change in 2020 in production and price results, assuming that income from activity without subsidies will be running at the level of base year (i.e. it will reflect the average level in the years 2011-2013).

The results of the calculations are presented in subsequent subchapters. The graphic annex presents charts showing applied in the projection models of the trend for variables typical of the analyzed activities.

When analyzing the impact of unit changes in yield and of prices of particular products, the determination of their variability in the years was considered as purposeful – table IV.1.

Table IV.1. Variability in yield and selling price of selected agricultural products in the years 1995-2013

Specification	Yield (%)	Selling price (%)
Winter wheat	6.1	19.8
Winter rye	7.9	23.9
Spring barley	8.3	19.0
Winter rapeseed	12.6	20.9
Sugar beets	7.6	7.9

Source: prepared by the author on the basis of data from the Central Statistical Office (GUS).

Calculations made on the basis of data of the Polish public statistics have shown that within analyzed 19 years (1995-2013) variability of yields selected for testing crops (winter wheat, winter rye, and spring barley) was similar with respect to each other. It was ranging from 6.1% for winter wheat to 8.3% for spring barley. Variability of yields of crops was approximately 2-times smaller than of rapeseed (12.6%). It means that rapeseed was a plant reacting significantly stronger to conditions of cultivation (environmental, agrotechnical conditions). On the contrary, variability of sugar beets yielding was running at the level of 7.6%, and was thus similar to crops and lower by 5.0 p.p. than in the case of rapeseed.

The research proved that in the years 1995-2013 variability of selling prices of grains of the analyzed crops were definitely greater than variability of their yields, ranging from 19.0 to 23.9%. It was similar to variability of the selling price of rapeseed determined at the level of 20.9%. On the contrary, the least variability of selling price (7.9%) was found in the case of sugar beets.

According to literature, yielding of cultivated plants is determined by many factors. Jasińska and Kotecki³⁴ state that it is affected, among others, by:

- hereditary characteristics of plants,
- environmental conditions (soil and climatic),
- agrotechnical factors, including:
 - ✓ structure of sowings,
 - ✓ crop rotation,
 - ✓ date of sowing,
 - ✓ volume and quality of used seeds,
 - ✓ mineral and organic fertilization,
 - ✓ plant protection manner.

Factors determining price variability include, first of all, situation on the national and foreign markets. The accession to the European Union involved incorporation of Poland to the common European market, in consequence the regulations of the Common Agricultural Policy became an important price-shaping factor. Customs and formal barriers between member countries were lifted. As a result, impact of the EU market on the domestic market was stronger. In practice, it means that since the accession to the EU, the volume of turnover of the Polish foreign trade in agricultural products is affected, apart from production and transport costs, also by the level of prices of products on markets of other EU countries and exchange rates³⁵. The level of prices of products is determined also by the supply and demand situation. The prices are stable, when the domestic or European market is characterized by a condition similar to balance, namely when the volume of supply and demand is similar. For more information about factors determining the level of prices of agricultural products in Poland, see the publication entitled: *Gross margin of selected agricultural products in 2012 and the projection of income for the year 2015*³⁶.

The basic branch of the world agriculture is **cereals**, and their economic importance is proved by the fact that they represent approx. 50% of the world plant production, are the main component of food, and, more and more, renewable raw material for industrial and power purposes. Data of the EU

³⁴ Z. Jasińska, A. Kotecki, *Szczegółowa uprawa roślin*. Volume I. 2nd issue revised and supplemented, Publishing House of the Agricultural University of Wrocław, Wrocław 2003.

³⁵ *Rynek zbóż w Polsce*, ARR, Warsaw 2013.

³⁶ A. Skarżyńska (scientific ed.), *Nadwyżka bezpośrednia z wybranych produktów rolniczych w 2012 roku oraz projekcja dochodów na 2015 rok*, Raport PW no. 88, IERiGŻ-PIB, Warsaw 2013.

statistics show that in terms of cultivation area of cereals Poland holds the second place (following France) among the European Union countries and, in terms of volume of harvest of their grains – the third place (following France and Germany). The data of the Central Statistical Office indicate, on the other hand, that in Poland for many years cereals have represented more than 70% of the total area of crops. The production of cereals is one of the basic directions of domestic agricultural production. According to experts of ARR (Agency for Agricultural Market), on average in the period 2008-2012, share of cereals in the value of total agricultural production in the country was 20%, and in the value of commercial agricultural production – 15%³⁷.

A large share of cereals in the national and world structure of sowings results mainly from simple technology of their cultivation, low production and storage costs, multi-directional use, easiness of transport and the possibility to use directly on agricultural farms for animal fodder and in households – for food products for people. During the last 15 years, however, clear changes in the structure of using grains have been visible. Its consumption increases for industrial purposes (for production of starch, malt, bioethanol), and decreases for consumption purposes. The share of grains intended for fodder and direct consumption decreases gradually, on the other hand the share of grains for export increases³⁸.

National demand for cereals in the last few years at least has been 27 and 28 million tons. Approximately 61% of this volume (17 million tons) are used for animal fodder, of which 80% are consumed directly on agricultural farms and 20% are used by the fodder industry. For consumer purposes approximately 19% of domestic demand for cereals is allocated, 10% to the brewing and distillery industry. Data of the Central Statistical Office (GUS) indicate that for many years the area of cereals in Poland has been decreasing gradually, and this process proceeds along with reduction in area of agricultural lands. The calculations of ARR prove that on average in the years 2008-2012 the national area of cereals (total) was 8 million 66 thousand ha and was it smaller by 3.1% than on average in the years 2003-2007 and by 7.2% than in the five-year period 1998-2002³⁹.

³⁷ *Rynek zbóż w Polsce*, ARR, Warsaw 2013.

³⁸ E. Arseniuk, T. Oleksiak, *Dlaczego zboża...*, Agro Serwis, 5th issue, May 2011.

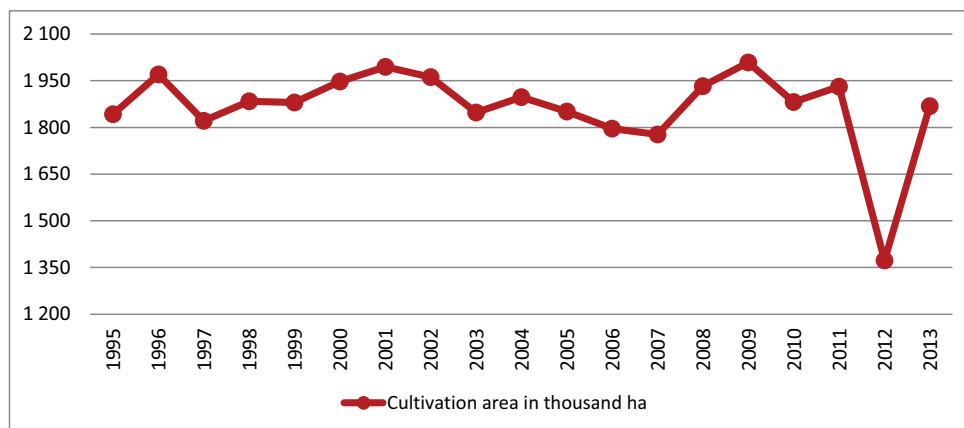
³⁹ *Rynek zbóż w Polsce*, ARR, Warsaw 2013.

1. Winter wheat

Winter wheat is a plant with the largest cultivation area in Poland. Over the last 19 years, the area intended for its sowing was undergoing some fluctuations. In the years 1995-2011, the acreage of this crop was ranging from 1.80 to 1.95 million ha. However, the year 2012 was characterized by a radical decrease in area (to 1.37 million ha) where winter wheat was cultivated (in consequence, the area of spring wheat sowings increased). It was a result of unfavourable meteorological conditions.

According to the data of the GUS, in 2013, the area sowed with winter wheat increased, as compared to 2012, by 35.9% and was close to the level recorded in 2010 – chart IV.1.1.

Chart IV.1.1. The cultivation area of winter wheat in the years 1995-2013, total in the country



Source: prepared by the author on the basis of data from the Central Statistical Office (GUS).

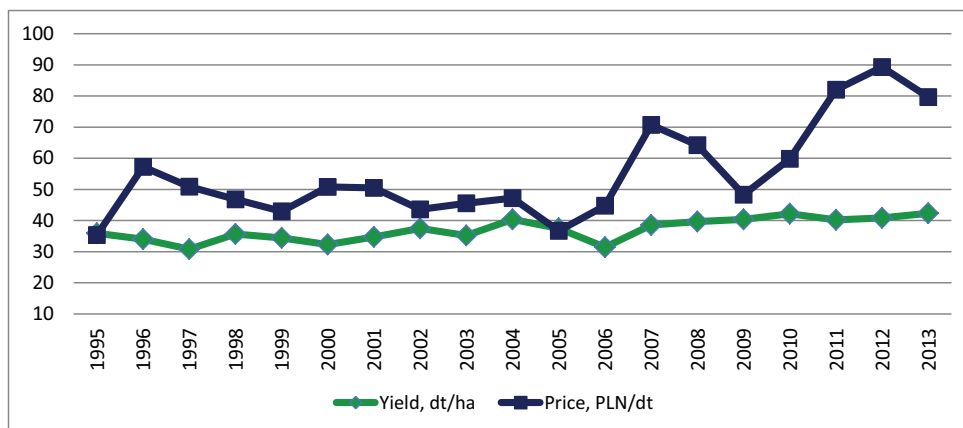
A relatively constant size of the area intended for cultivation of the concerned cereal results from large yielding potential as well as many-directional use of grains. Winter wheat is characterized by the highest yield from among basic cereals. In 2013, according to the data of the GUS, average yield of wheat was 44.4 dt from 1 ha⁴⁰. This is by 23.7% less than on average in EU member countries (58.2 dt/ha) where the largest producers of this cereal are France and Germany. In those countries, in 2013, the yield of wheat was more than 70 dt from 1 ha⁴¹. In Poland, over the last dozen or so years, a small growth in yield-

⁴⁰ *Produkcja upraw rolnych i ogrodnich w 2013 r.*, GUS, Warsaw 2014.

⁴¹ *Plony niektórych roślin uprawnych w Unii Europejskiej* <http://rme.cbr.net.pl/component/content/article/220-aktualnoci-z-zagranicy/526-produkcja-rolinna.html> [access: June 2014].

ing of wheat (chart IV.1.2) is noticed. In Eastern, Northern and Southern European countries yields are generally significantly lower than in Western European countries. Among the countries which along with Poland accessed the EU in 2004, the highest yields of wheat were obtained in the Czech Republic (in 2013 – 56.0 dt/ha)⁴².

Chart IV.1.2. Yield of winter wheat in individual farms and grain selling price in the years 1995-2013



Source: prepared by the author on the basis of data from the Central Statistical Office (GUS).

Level of grain selling prices is determined by many factors. One of them is demand and supply situation. Unfavourable since 2010 balance of crops resulting from low harvests, was reflected into a systematic growth in prices. In 2012, the price for 1 dt of wheat grain reached the record level of PLN 89.34. On the contrary, since the beginning of 2013, decrease in prices of wheat has been decreased. According to the data of the GUS in 2013, the average price for 1 dt of wheat grains was PLN 79.67, i.e. by 10.8% less than the year before – chart IV.1.2. It was determined, among others, by more beneficial situation for plant production.

The projection of results for winter wheat production to 2020 was made using data from the system AGROKOSZTY from 2011-2013. The research sample – on average in these years – was 161 individual agricultural farms cultivating this crop. These units were situated across the whole country, and the way of their selection was purposeful. The criterion qualifying units to the research sample was cultivation of winter wheat on an appropriate scale.

⁴² *Dobre plony pszenicy w Polsce*, <http://www.farmer.pl/produkcja-roslinna/zboza/dobre-plony-pszenicy-w-polsce,47164.html> [access: June 2014].

Table IV.1.1. Results of winter wheat cultivation in the base year 2013* and the projection until 2020 (in current prices)

Specification	Level for 2013*	Projection for			Indicator of changes year 2013 = 100		
		2016	2018	2020	2016	2018	2020
Number of surveyed farms		161			-	-	-
Growing area [ha]		23.84			-	-	-
Yield of grain [dt/ha]	56.3	58.4	59.7	61.1	103.6	106.0	108.4
Selling price of grain [PLN/dt]	79.13	85.26	89.34	93.42	107.7	112.9	118.1
Per 1 ha of growing area, in PLN							
Total value of production	4482	5001	5360	5731	111.6	119.6	127.8
Total direct costs	1420	1625	1762	1900	114.4	124.1	133.8
in this: sowing materials	231	271	298	325	117.2	128.8	140.5
fertilizers	845	986	1081	1176	116.6	127.8	139.1
plant protection products	303	324	338	352	106.9	111.5	116.1
Gross margin without subsidies	3062	3376	3598	3830	110.2	117.5	125.1
Total indirect costs	1690	1883	2013	2144	111.4	119.1	126.8
Income from activity without subsidies	1372	1493	1585	1686	108.8	115.5	122.9
Subsidies**	969	1008	1008	1008	104.0	104.0	104.0
Income from activity	2341	2501	2593	2694	106.8	110.8	115.1
TOTAL COSTS	3111	3508	3775	4044	112.8	121.4	130.0
Measuring the economic efficiency							
Indicator of profitability [%]	144.1	142.6	141.0	141.7	98.9	98.5	98.3
Total costs / 1 dt [PLN]	55.23	60.11	63.23	66.23	108.8	114.5	119.9
Income from activity without subsidies/ 1 dt of grain [PLN]	24.36	25.59	26.55	27.61	105.0	109.0	113.4
Total costs/1 PLN of income from activity without subsidies [PLN]	2.27	2.35	2.38	2.40	103.6	105.1	105.8
Subsidies per 1 PLN of income from activity without subsidies [PLN]	0.71	0.68	0.64	0.60	95.6	90.0	84.6
Share of subsidies in income from activity [%]	41.4	40.3	38.9	37.4	97.4	93.9	90.4

* 2013 – base for the projection model, the results reflect average values in the years 2011-2013.

** In the years 2011-2013, subsidies will include Complementary Area Payment and Single Area Payment, for the projection years subsidies were adopted at the level of 240 EUR/ha (according to the CAP assumptions for 2014-2020). In calculations the following exchange rate was adopted: EUR 1 = PLN 4.20.

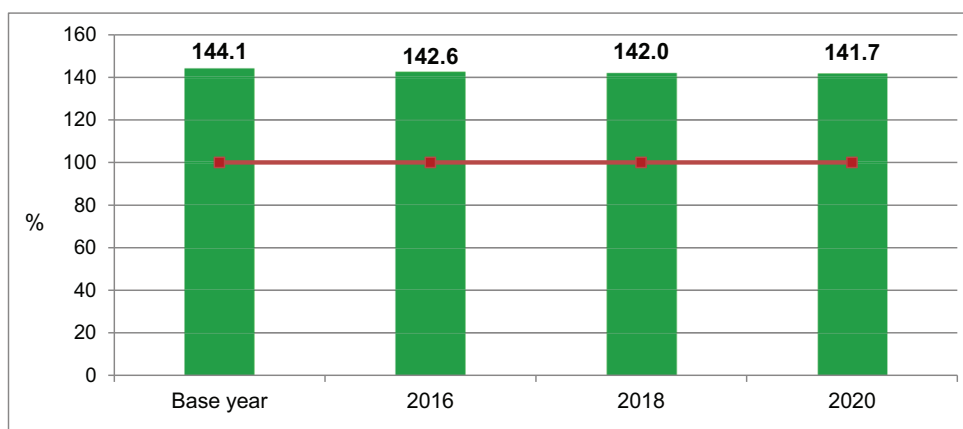
Source: preparation on the basis of author's research.

It is estimated that in the base year for projection, i.e. 2013 (average from 2011-2013), gross margin from 1 ha of winter wheat amounted to PLN 3062, and income without subsidies amounted to PLN 1372. After considering the support mechanism under CAP, income from activity together with subsidies (Complementary Area Payment + Single Area Payment) reached the level of 2341 PLN/ha. It is worth pointing out that share of subsidies in income was 41.4% – table IV.1.1.

Economic efficiency of wheat production is proved by the profitability ratio (expressed as a quotient of the value of total production to total costs), which, in 2013, amounted to 144.1% and, from among activities, was lower only than the ratio of spring barley profitability (151.3%).

Table IV.1.1 contains the projection of results of winter wheat for 2016, 2018 and 2020. It is envisaged that in the perspective of several years to come, yield of winter wheat will be increasing at the rate about 1.2% annually. As a result, in 2020, it can reach the level of 61.1 dt/ha, i.e. higher by 8.4% than in 2013. The forecasted annual rate of growth in grain selling price may range from 2.2 to 2.6%. In the target projection year (2020), the price of wheat will be probably higher by 18.1%. Growth in yield and prices will enable obtaining in 2020 revenues from 1 ha of winter wheat at the level of PLN 5731 – namely higher by 27.8% than in 2013, the base year for the projection.

Chart IV.1.3. Winter wheat cultivation profitability ratio in the base year (2013) and the projection until 2020



Source: preparation on the basis of author's research.

The conducted calculations enabled us to determine change in production costs. It is forecasted that direct costs in 2020, as compared to 2013, will grow by 33.8%. It is estimated that annual increase in direct costs within the next

7 years will be ranging from 3.8 to 4.8% and in 2020 will be at the level of 1900 PLN/ha. Among components of direct costs, the cost of seed material (from 4.4 to 5.7%) and the cost of mineral fertilizers (from 4.2 to 5.5%) will record the fastest growth.

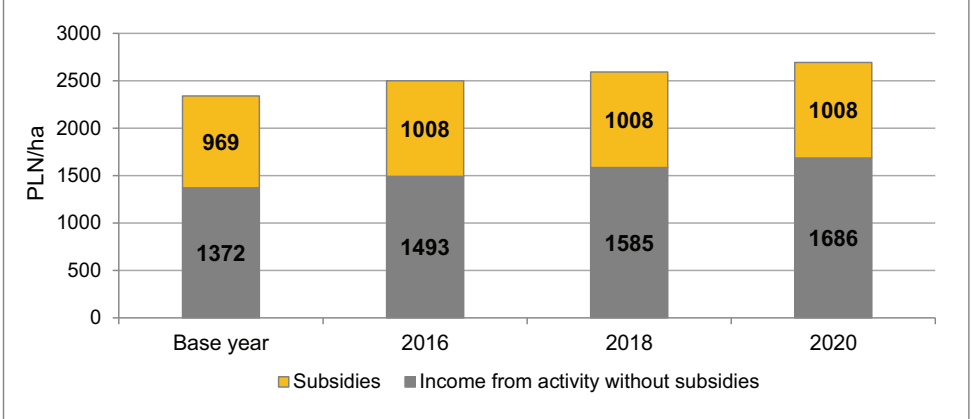
In the case of indirect costs the projection envisages much smaller growth than in the case of direct costs. It is forecasted that in 2020 total indirect costs will reach 2144 PLN/ha by 26.8% more than in 2013. In 2020, the greatest increase is envisaged for the cost of: lease rents, which, as compared to 2013, will be higher by 50.5%, services – increase by 43.0%, and engine fuel – increase by 28.8%. As a result, total costs incurred for 1 ha of winter wheat cultivation in 2020, reach PLN 4044, namely will be higher by 30.0% than in 2013.

It is envisaged that in 2020 the dynamics of growth in costs can be stronger than growth in the value of production by 2.2 p.p. In consequence, the profitability ratio will decrease to 141.7%, whereas in 2013 it was 144.1% – chart IV.1.3.

The projection shows that winter wheat cultivation will be profitable. Farmers in 2020 may expect income from the activity without subsidies higher by 22.9%. In the analyzed group of farms, at average cultivation area of 23.84 ha, this income should reach the level of 1686 PLN/ha – chart IV.1.4.

An important support for farmers' income are subsidies, and their amount for the years 2014-2020 has been adopted at 1008 PLN/ha.

Chart IV.1.4. Income from winter wheat cultivation without subsidies in the base year (2013) and the projection until 2020



Source: preparation on the basis of author's research.

The conducted calculations have proved that share of subsidies in income should decrease from year to year and in 2020 they may account for 37.4%, whereas in the base year (2013) they accounted for 41.4%. Decreasing share of

subsidies in income from activity results from the expected for the years 2014-2020 growth in income from activity without subsidies, supported by subsidies at a constant level. As a result, it is forecasted that in the target year (2020), per PLN 1 of income from activity without subsidies will fall PLN 0.60 of subsidies, i.e. by 5.5% less than in 2013.

Options of projection for the year 2020

To examine better the effect of changes in the main income-forming factors, the projection results for the year 2020 were presented in two options. In the first option the object of research was:

- **determination of the impact of unit changes in yield, prices and costs of winter wheat cultivation on change in economic results in 2020** (*unit changes mean deviations from the projection results resulting from the trend*).

Forecasting economic results from agricultural production is difficult, owing to its special character, which is based on work with living organisms. Factors having effect on the amount of income from plant production activity include yield and selling price and cost-intensive character of production. These are determinants, on which the agricultural producer has a limited impact, and their variability is often a result of unforeseeable events. Thus, it is worth looking at calculations, showing changes in economic results, depending on the direction of changes and factor subject to change.

Table IV.1.2. Percentage changes in results of the projection of winter wheat in 2020, assuming unit changes in yield, prices and total costs

Specification	Yield		Price		Total costs	
	+1 dt	-1 dt	+1 PLN	-1 PLN	+100 PLN	-100 PLN
Yield of grain	+1.6	-1.6				
Selling price of grain			+1.1	-1.1		
Total value of production	+1.6	-1.6	+1.1	-1.1		
Gross margin without subsidies	+2.4	-2.4	+1.6	-1.6		
Total costs					+2.5	-2.5
Income from activity without subsidies	+5.5	-5.5	+3.6	-3.6	-5.9	+5.9
Indicator of profitability	+1.6	-1.6	+1.1	-1.1	-2.4	+2.5

Source: preparation on the basis of author's research.

From the projection model it results (table IV.1.2) that unit changes in yield, price and total costs of winter wheat will cause in the perspective of 2020 the change *in plus* or *in minus* in economic results, i.e.:

- increase or decrease in yield by 1 dt (i.e. by 1.6%) – will result in increase or decrease in income from activity without subsidies by 5.5% (PLN 94), and production profitability by 1.6%; with an unchanged level of other factors,
- increase or decrease in price by 1 PLN/dt (i.e. by 1.1%) – will result in increase or decrease in income from activity without subsidies by 3.6% (PLN 61), and production profitability by 1.1%; with an unchanged level of other factors,
- increase or decrease in total costs by 100 PLN/ha (i.e. by 2.5 %) – will result in increase or decrease in income from activity without subsidies by 5.9%, and in production profitability by 2.4-2.5 %; with an unchanged level of other factors.

The calculations presented above show the impact of unit changes in yield, price and costs on profitability of winter wheat production. Based on the above, we can state that the level of income from activity without subsidies will be affected to a greater extent by unit change in yield, rather than change in selling price. Increase or decrease in yield by 1 dt will cause change in income greater by over 50% than in the case of increase or decrease in price by PLN 1.

However, taking into account variability of yield (6.1%) and price (19.8%), observed in the years 1995-2013 (table IV.1), we can foresee deviations from the 2020 projection results (drawn up at production and price results from the long-term trend). In the case of yield of winter wheat, change may be +/-3.7 dt, and in the case of price by +/-18.46 PLN.

The research has shown that the relation between yield and price is statistically insignificant. As a result, it is possible to determine the impact on the level of income for each of the factors independently:

- in the case of change in yield by 3.7 dt – fluctuations in income from activity without subsidies will amount to +/-350 PLN/ha, which, given the anticipated income for the year 2020 (PLN 1686) means increase to 2036 PLN/ha or decrease to 1336 PLN/ha (change by +/-20.8%),
- in the case of change in price by 18.46 PLN/dt – fluctuations in income from activity without subsidies will amount to +/-1127 PLN/ha, which, with given anticipated income for the year 2020 (PLN 1686), means increase to 2813 PLN/ha or decrease to 559 PLN/ha (change by +/-66.8%).

According to the calculations, in the last 19 years the level of prices underwent greater variability than yield. As a result, fluctuations in wheat grain selling prices had a significantly stronger impact on the amount of income. After considering price variability (from 1995-2013), in 2020 deviations from the level of income from the projection results may be 3.2-times greater than in the case of variability in yield. However, even in a pessimistic scenario the cultivation of winter wheat will remain profitable.

The second option of the projection of winter wheat results concerned:

- **determination of the scope of changes in 2020 in yield and price of winter wheat, with the assumption that income from winter wheat cultivation will remain at the level of the base year (i.e. will reflect average level in the years 2011-2013).**

The research was aimed to identify the level of yield and selling price of wheat grains in 2020 at which it will be possible to maintain income at the level of 2013, assuming increase in costs resulting from the trend (namely the expected level in 2020). To obtain the answer to the presented research problem, two accounts were made. In the first one the level of yield was determined, and price and costs for the year 2020 were as in the projection – table IV.1.3.

Calculations indicate that maintaining income from activity without subsidies at the level of the base year will be possible when yield in winter wheat does not fall below 58.0 dt/ha. It means that for income situation of farmers not to deteriorate, the deviation of yield *in minus* from the level expected for the year 2020 may amount to 3.1 dt (5.1%).

Table IV.1.3. Maximum deviation from the projection for the year 2020 in yield and price of winter wheat, assuming that income from activity without subsidies will remain at the level of the base year (2013)

Specification	Level for 2013*	Projection for 2020	Deviations from the projection for 2020	
			Yield	Price
Yield of grain [dt/ha]	56.3	61.1	58.0	61.1
Selling price of grain [PLN/dt]	79.13	93.42	93.42	88.70
Per 1 ha of growing area, in PLN				
Total value of production	4482	5731	5416	
Total costs	3111	4044	4044	
Income from activity without subsidies	1372	1686	1372	

* 2013 – base for the projection model, the results reflect average values in the years 2011-2013.

Source: prepared of on the basis of author's own research.

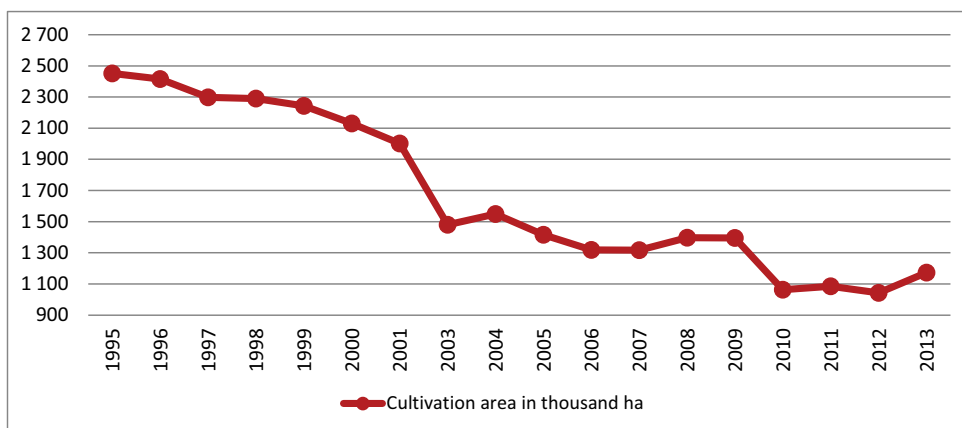
On the other hand, in the second account it was assumed that total costs and yield had figures forecasted for the year 2020, and the selling price of wheat grains was changing. The results presented in table IV.1.3 show that to maintain income from activity without subsidies at the level of the base year (2013), the price of wheat grains may not be lower than 88.70 PLN/dt. The in minus deviation of the price from the projection is 4.72 PLN/dt, i.e. 5.1%.

To sum up, it can be concluded that in the perspective of several years to come, the cultivation of winter wheat will be profitable. It is forecasted that in 2020, despite the growth in total costs (by 30.0%), the value of production will permit their full coverage. However, the dynamics of growth in costs will be stronger than the value of production, which will make the ratio of production profitability – as compared to 2013 – decrease by 2.4 p.p. The conducted tests indicated that change in yield by 1 dt will have a stronger impact on the level of income than unit change in price (by PLN 1). The impact of costs is also strong, the change by 100 PLN/ha can make income increase or decrease by 5.9%. In the years to come, it is planned to decrease the impact of subsidies on income. The share of subsidies in income from the activity will decrease by 9.6%, while the amount of subsidies per PLN 1 of income from the activity without subsidies will be lower by 15.4%.

2. Winter rye

Among Polish producers of cereals, in the recent dozen or so years, interest in rye has been decreasing, which reflects a regular decrease in area of its cultivation – chart IV.2.1. A decreasing winter rye cultivation area is caused mainly by much smaller importance of this cereal in the food economy. The utility value of rye grain is much smaller than of wheat and only a small part is allocated for human consumption. More than a half of harvests are used as fodder, although more and more often other applications are indicated, e.g. production of biomass for operation of a biogas plant⁴³.

Chart IV.2.1. Winter rye cultivation area in the years 1995-2013, total in the country

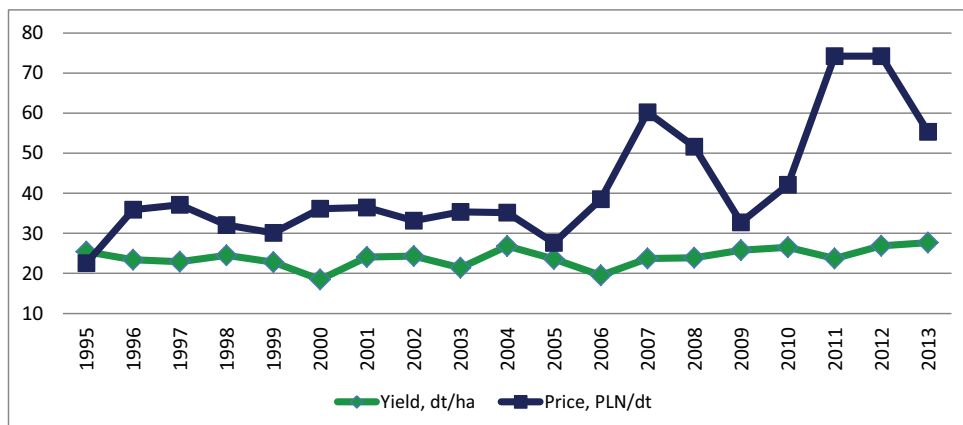


Source: prepared by the author on the basis of data from the Central Statistical Office (GUS).

Extensive manner of winter rye cultivation determines low yields obtained by farmers. In recent years, the average yield of winter rye according to the GUS has ranged from 20 to 30 dt/ha. Fluctuations in its level were small, which means that the main factor influencing variability in income from cultivation of this crop was price. In this case, in the recent ten years very high changes have been observed: both dynamic increases and sudden decreases. The first rapid growth in price was recorded in 2007 when the price for grain was approximately 60 PLN/dt. Then, the price returned to the previous level (approximately 30 PLN/dt) to rocket in 2011 and 2012 to more than 70 PLN/dt. The levels of yield and price of rye are presented in chart IV.2.2.

⁴³ *Nadwyżka bezpośrednia z wybranych produktów rolniczych w 2012 roku oraz projekcja dochodów na 2015 rok* (ed. A. Skarżyńska). Raport PW no. 88, IERiGŻ-PIB, Warsaw 2013.

Chart IV.2.2. Yield of winter rye in individual farms and selling price of grains in the years 1995-2013



Source: prepared by the author on the basis of data from the Central Statistical Office (GUS).

The projection of results of winter rye cultivation until 2020 was made on the basis of data collected on 118 individual agricultural farms cultivating this crop. Starting point for the projection were average results from 2011-2013. At this point, it is worth describing briefly the income situation which was recorded in these years and which determined the input values for the conducted projection.

In the analyzed group of farms, farmers cultivating winter rye in 2011 and 2012 obtained income even without support in the form of subsidies. Good results from cultivation of this crop were affected mainly by high grain price. It was only when the price significantly decreased in 2013 that support in the form of subsidies enabled obtaining income. The lowest grain yield was obtained by farmers in 2011, on average 28.9 dt/ha. In the years 2012-2013, yield was ranging from 33.3 to 34.3 dt/ha. Costs of winter rye cultivation increased significantly in 2012. As compared to the previous year, total costs were higher by 11.9%. In the subsequent year (2013), the increase in total costs was not high and amounted to only 1.7%. It should be pointed out that in both years (2012-2013) the increase in costs was caused mainly by increasing direct costs⁴⁴.

The results of the projection until 2020, in terms of value and as ratios of changes with regard to the base year, are presented in table IV.2.1.

⁴⁴ A. Skarzyńska, K. Jabłoński, *Wyniki ekonomiczne wybranych produktów rolniczych w 2011 roku*, IERiGŻ-PIB, Warsaw 2012; *Produkcja, koszty i dochody z wybranych produktów rolniczych w latach 2011-2012* (ed. I. Augustyńska-Grzymek). IERiGŻ-PIB, Warsaw 2013; *Produkcja, koszty i dochody z wybranych produktów rolniczych w latach 2012-2013* (ed. I. Augustyńska-Grzymek). IERiGŻ-PIB, Warsaw 2014.

Table IV.2.1. Results of winter rye cultivation in the base year 2013* and projection until 2020 (in current prices)

Specification	Level for 2013*	Projection for			Indicator of changes year 2013 = 100		
		2016	2018	2020	2016	2018	2020
Number of surveyed farms		118			-	-	-
Growing area [ha]		9.39			-	-	-
Yield of grain [dt/ha]	32.2	33.7	34.8	35.9	104.9	108.2	111.6
Selling price of grain [PLN/dt]	58.31	63.82	67.49	71.17	109.5	115.8	122.1
Per 1 ha of growing area, in PLN							
Total value of production	1890	2168	2364	2569	114.7	125.1	135.9
Total direct costs	665	760	825	889	114.4	124.0	133.7
in this: sowing materials	159	181	195	210	113.8	123.0	132.2
fertilizers	396	462	507	551	116.6	127.8	139.1
plant protection products	103	110	115	119	106.9	111.5	116.1
Gross margin without subsidies	1225	1407	1539	1680	114.8	125.6	137.1
Total indirect costs	850	944	1008	1072	111.1	118.6	126.2
Income from activity without subsidies	376	463	531	608	123.2	141.5	161.8
Subsidies**	970	1008	1008	1008	104.0	104.0	104.0
Income from activity	1345	1471	1539	1616	109.3	114.4	120.1
<i>TOTAL COSTS</i>	<i>1515</i>	<i>1705</i>	<i>1832</i>	<i>1961</i>	<i>112.5</i>	<i>121.0</i>	<i>129.5</i>
Measuring the economic efficiency							
Indicator of profitability [%]	124.8	127.2	129.0	131.0	101.9	103.4	105.0
Total costs / 1 dt [PLN]	47.10	50.54	52.66	54.65	107.3	111.8	116.0
Income from activity without subsidies/ 1 dt of grain [PLN]	11.68	13.73	15.27	16.94	117.5	130.7	145.0
Total costs/1 PLN of income from activity without subsidies [PLN]	4.03	3.68	3.45	3.23	91.3	85.5	80.0
Subsidies per 1 PLN of income from activity without subsidies [PLN]	2.58	2.18	1.90	1.66	84.3	73.5	64.2
Share of subsidies in income from activity [%]	72.1	68.5	65.5	62.4	95.1	90.8	86.5

* 2013 – base for the projection model, the results reflect average values in the years 2011-2013.

** In the years 2011-2013, subsidies included Complementary Area Payment and Single Area Payment, the subsidies adopted for the period of projection were at the level of 240 EUR/ha (according to the assumptions of CAP for the years 2014-2020). The exchange rate adopted in the calculations: EUR 1 = PLN 4.20.

Source: preparation on the basis of author's research.

On average, in the years 2011-2013, the winter rye cultivation area was 9.39 ha. In the base year for the projection (2013), the value of production from 1 ha was running at the level of PLN 1890, and income from activity without subsidies – PLN 376. Whereas, total costs amounted to PLN 1515/ha, including direct costs amounted to 665 PLN/ha.

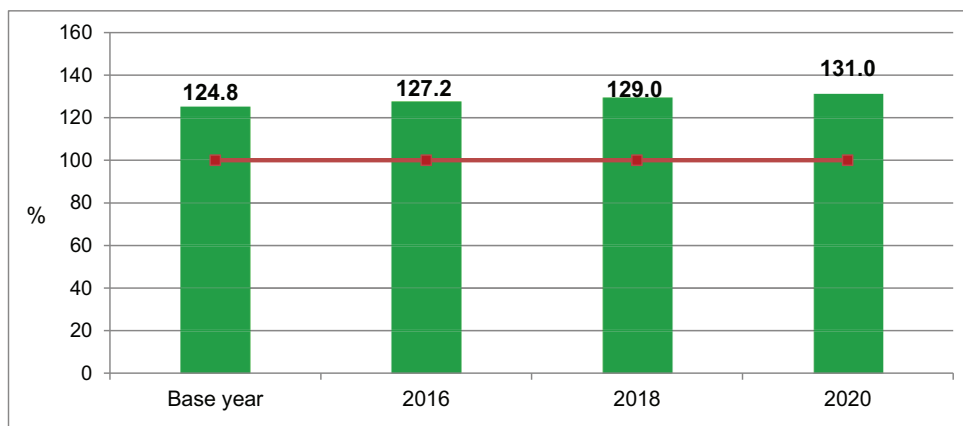
From the projection drawn up in average production and price conditions it may be concluded that yield of winter rye in the period covered by the research, i.e. in the years 2014-2020 will be increasing by about 1.6% annually. Thus in 2020, as compared to the output for the projection 2013, farmers can obtain yield higher by 11.6%. The grain selling price will be characterized by a stronger dynamics of growth. In the years 2014-2020, its annual increases will be ranging from 2.7 to 3.2%. Both these factors will favourably influence the level of revenues from cultivation of winter rye. According to the projection results, in 2020, we may expect increase in the value of production by 35.9%. This is the highest growth as compared to other activities covered by the forecast. Farmers cultivating winter rye have thereby wide opportunities to obtain economic results better than in the past.

The high level of income is also determined largely by cultivation costs. It is envisaged that in 2020 – as compared to the base year – they may be higher by 29.5%, including that indirect costs will grow by 26.2%, and costs directly related to activity – by 33.7%. Among direct costs, the largest growth can be expected definitely in the case of mineral fertilizers (39.1%) and seed material (32.2%). It means that the level of total costs will be affected to the greatest extent by direct costs, which, in turn, are affected to the greatest extent by a farmer.

As a result of the above described changes in the value of production and costs in 2020 as compared to the base year (2013), we may expect growth in gross margin without subsidies by 37.1% and in income from activity without subsidies by 61.8%. This is definitely the best result from among all the analyzed activities. That means that in the perspective of 2020 we should expect definitely better economic results from cultivation of winter rye. Owing to growth in costs of cultivation of 1 ha, also total costs of production of 1 dt of grains will increase – by 16.0% (PLN 54.65 towards PLN 47.10 in 2013), nevertheless the anticipated income without subsidies per 1 dt will be higher by 45.0% (PLN 16.94 towards PLN 11.68 in 2013). Thereby (total) costs of generation of PLN 1 of income from the activity will decrease by as much as 20.0% (PLN 3.23 towards PLN 4.03).

Below is presented a change in the level of profitability of winter rye cultivation in the base year for the projection (2013) and in the selected years of the period covered by the projection in average production and price conditions – chart IV.2.3.

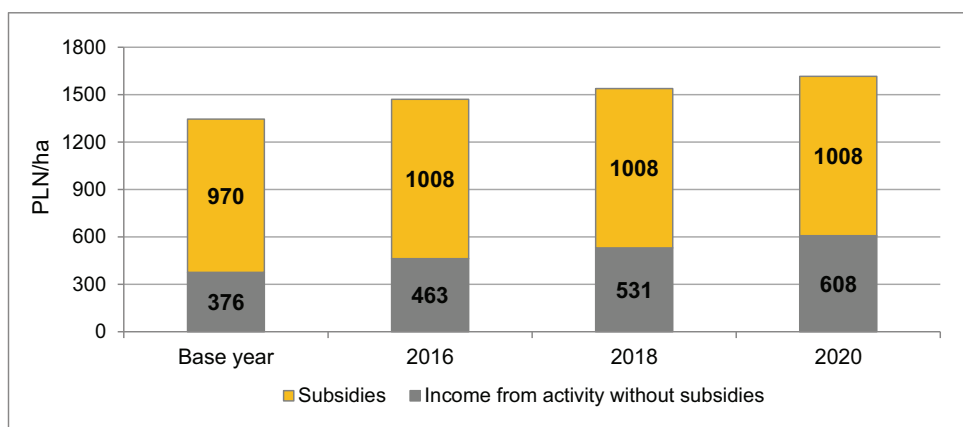
Chart IV.2.3. Ratio of profitability of winter rye cultivation in the base year (2013) and projection until 2020



Source: preparation on the basis of author's research.

In the perspective of 2020, the improvement of economic efficiency of winter rye cultivation should be expected. As compared to the base year, the profitability ratio may be higher by 6.2 p.p. It results from stronger rate of growth in the value of production than costs. Annual growth in the value of production will be ranging from 4.2 to 4.8%, whereas total costs will be growing at 3.4-4.2%.

Chart IV.2.4. Income from winter rye cultivation without subsidies in the base year (2013) and projection until 2020



Source: preparation on the basis of author's research.

It is envisaged that in 2020, as compared to the base year for the projection, income from the activity without subsidies will increase by 61.8%. In the research sample of farms, for the cultivation of rye in the area of 9.39 ha, this income will be running at the level of 608 PLN/ha. Meanwhile, considering the estimated amount of subsidies, we may expect income from activity (i.e. together with subsidies) higher by 20.1% (1616 PLN/ha towards 1345 PLN/ha) – Chart IV.2.4. Results of the calculations indicate that the importance of subsidies in shaping income from rye cultivation will decrease. In 2013, to PLN 1 of income from the activity fell PLN 2.58 of subsidies, while in the target projection year (2020) this amount was only PLN 1.66. Decreasing role of subsidies results from significantly higher income from rye cultivation and support in the form of subsidies at a level similar to the base year. It is planned that subsidies to 1 ha will grow by 4.0%, i.e. only by approx. PLN 38.

Options of projection for the year 2020

For the more detailed examination of factor-effect dependencies, the results of the projection for the year 2020 are presented in two options. The first option was aimed at:

- **determination of the impact of unit changes in yield, price and costs of cultivation of winter rye on change in economic results in 2020** (*unit changes mean deviations from the projection results resulting from the trend*).

Anticipating changes in the economic situation of products produced on an agricultural farm is difficult, especially in the long run. However, examination how different (factors) can affect results enable us to use the arising possibilities and to reduce the risk of made decisions. In the case of agricultural production, due to its biological character, it has particular importance. Table IV.2.2 presents the scope of changes in results of rye cultivation owing to unit changes in yield and prices, namely factors which are in principle independent from activities of a single farmer and also because of change in costs (total) of rye cultivation, whose level depends to a significant extent from the farmer's decision.

However, it should be noted that the scope of changes presented in table IV.2.2 is influenced by results that were the point of reference for unit changes. It means that the scope of changes refers solely to the research sample of farms.

The projection model shows that unit changes in yield, price and total costs of winter rye cultivation will cause in the perspective of 2020 change *in plus* or *in minus* in economic results, i.e.:

- increase or decrease in yield by 1 dt (2.8%) – will result in increase or decrease in income from activity without subsidies by 11.7% (71 PLN/ha), and production profitability by 2.8%; with an unchanged level of other factors,
- increase or decrease in grain price by 1 PLN/dt (1.4%) – will result in increase or decrease in income from activity without subsidies by 5.9% (36 PLN/ha), and production profitability by 1.4%; with an unchanged level of other factors,
- increase or decrease in total costs by 100 PLN/ha (5.1%) – will result in increase or decrease in income from activity without subsidies by 16.4%, and production profitability by 4.9-5.4%; with an unchanged level of other factors.

Table IV.2.2. Percentage changes in results of the projection of winter rye in 2020, assuming unit changes in yield, price and total costs

Specification	Yield		Price		Total costs	
	+1 dt	-1 dt	+1 PLN	-1 PLN	+100 PLN	-100 PLN
Yield of grain	+2.8	-2.8				
Selling price of grain			+1.4	-1.4		
Total value of production	+2.8	-2.8	+1.4	-1.4		
Gross margin without subsidies	+4.2	-4.2	+2.1	-2.1		
Total costs					+5.1	-5.1
Income from activity without subsidies	+11.7	-11.7	+5.9	-5.9	-16.4	+16.4
Indicator of profitability	+2.8	-2.8	+1.4	-1.4	-4.9	+5.4

Source: preparation on the basis of author's research.

According to the calculations – in the analyzed farms – unit change in yield has much greater impact on income, rather than grain selling prices. Increase or decrease in yield by 1 dt will cause change in income without subsidies almost two times greater than increase or decrease in price by PLN 1. Analyzing changes in income it is also worth paying attention to strong impact of (total) costs of rye cultivation. Their change by 5.1% will result in increase or decrease in income without subsidies by 16.4%. It means that a farmer, by correct managing resources and making rational decisions regarding production may affect significantly the level of income.

Notwithstanding determination of unit changes in research the variability in yield (7.9%) and price (23.9%) of rye, observed in the period 1995-2013 (table IV.1), was taken into account. This variability, expressed in absolute figures, served to determine deviations in income without subsidies from results of the 2020 projection, drawn up in production and price conditions resulting from the

long-term trend. In the analyzed farms, change in yield of winter rye can be +/-2.8 dt, and change in grain price can be +/-17.02 PLN.

According to the research, the relation between yield and its price is statistically insignificant. As a result, the impact on the level of income can be determined for each of factors, independently:

- in the case of change in yield by 2.8 dt – fluctuations in income from activity without subsidies will amount to +/-201 PLN/ha, which, at the anticipated income for the year 2020 (PLN 608) means increase to 809 PLN/ha or decrease to 407 PLN/ha (change by +/-33.0%),
- in the case of change in price by 17.02 PLN/dt – fluctuations in income from activity without subsidies will amount to +/-611 PLN/ha, which, at the anticipated income for the year 2020 (PLN 608), means increase to 1219 PLN/ha or unprofitability of cultivation, namely decrease to -3 PLN/ha (change by +/-100.5%).

Results indicate much greater variability of price rather than yield in the period, in connection with this, its impact on the level of income also turned out to be stronger. Variability of rye grain price was three times greater than yield which, in an extreme case, resulted in the unprofitability of cultivation of this crop. The analysis shows high risk of rye cultivation, related to large price fluctuations. Additionally, due to small, as compared to other crops, income from 1 ha of rye, farmers are not interested in its cultivation and larger expenses for improvement in the cultivation technology of this crop.

The second projection option was aimed at:

- **determination of the scope of changes in 2020 in production and price results, assuming that income from cultivation of winter rye will be at the level of the base year** (*i.e. will reflect average level in the years 2011-2013*).

When analyzing the impact of variability of yield and price of winter rye on economic results, the research covered the level of yield and selling price of grains at which income from activity without subsidies in 2020 will be at the level of 2013, which was adopted as the base year for the projection model. Assumptions for the second option of the projection include change in costs resulting from the trend, namely they remained at the level planned for the year 2020 – table IV.2.3.

The level of yield which will make it possible to maintain income from activity without subsidies at the level of the base year, given a change in selling price of grains and total costs is, in accordance with the projection for the year 2020, 32.8 dt/ha. Maximum deviation (*in minus*) of the level of yield from the level of projection is 3.1 dt (8.6%).

Table IV.2.3. Maximum deviation from the projection for the year 2020 of yield and price of winter rye, assuming that income from activity without subsidies will be at the level of the base year (2013)

Specification	Level for 2013*	Projection for 2020	Deviations from the projection for 2020	
			Yield	Price
Yield of grain [dt/ha]	32.2	35.9	32.8	35.9
Selling price of grain [PLN/dt]	58.31	71.17	71.17	65.12
Per 1 ha of growing area, in PLN				
Total value of production	1890	2569	2337	
Total costs	1515	1961	1961	
Income from activity without subsidies	376	608	376	

* 2013 – base for the projection model, the results reflect average values in the years 2011-2013.

Source: preparation on the basis of author's research.

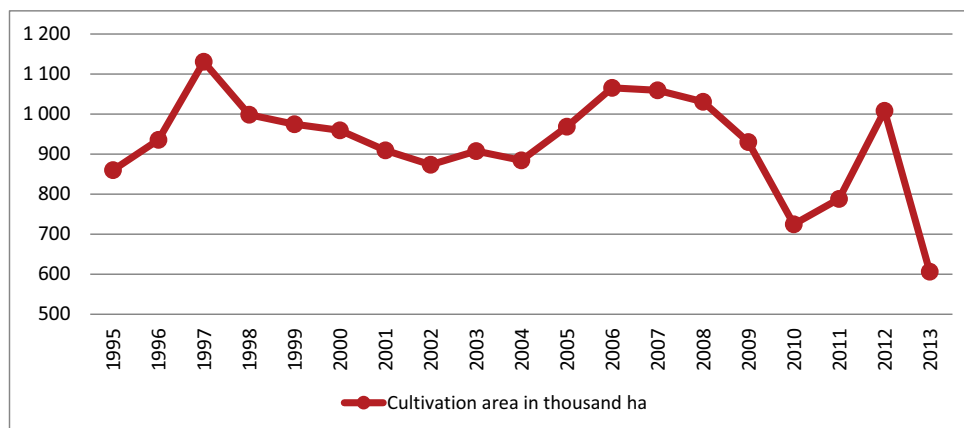
In the second approach the level of yield and total costs were adopted in accordance with the projection for the year 2020. On the contrary, the selling price of grains was subject to change. The results of the calculations show that maintenance of income without subsidies at the same level as in the base year will be possible in a situation when the price of rye does not fall below 65.12 PLN/dt. Maximum deviation downwards of the grain price from the value from the projection is PLN 6.05 (8.5%).

To sum up, cultivation of winter rye in the perspective of 2020 will be profitable activity. The expected increase in direct costs and indirect costs will be fully compensated by revenues. Dynamics of growth in the value of production will be stronger than of production costs (by 6.4 p.p.), as a result, profitability of rye – as compared to the base year (2013) – will be 5.0% higher. It is worth pointing out that the greatest impact on growth in total costs will be exerted by direct costs related to rye cultivation (particularly cost of fertilizers and seed material). It can be concluded from the analysis that change in the yield by 1 dt will affect stronger the level of income than unit change in price (by PLN 1). Substantial impact on income is exerted also by costs of cultivation. In the analyzed farms change in costs by 5.1% will have its effect on three times greater change in the level of income from activity without subsidies (16.4%). It is estimated that in the 2020 perspective the importance of subsidies in shaping income from activity will decrease, but will still be a very important factor that will stabilize income, particularly given a high variability of the rye selling price. The amount of subsidies per PLN 1 of income from activity without subsidies will increase by 35.8% and the share of subsidies in income from activity (i.e. together with subsidies) will be lower by 13.5%.

3. Spring barley

Barley is used mainly as fodder, to prepare mixes of feeding stuff on farms and in the fodder industry. Another significant way of use of barley grain is the food industry, mainly production of malt⁴⁵. In Poland, in the last 18 years (1995-2012), the total area of barley cultivation was 12-15% of the total acreage of cereals, and area of spring barley cultivation was approximately 80% of the area occupied for barley⁴⁶. A sudden decrease in spring barley cultivation area was observed in 2013. As compared to 2012, its cultivation acreage decreased by 40.0%⁴⁷ – chart IV.3.1.

Chart IV.3.1. Spring barley cultivation area in the period 1995-2013, total in the country



Source: prepared by the author on the basis of data from the Central Statistical Office (GUS).

In the examined period (1995-2013), the selling price of barley grains was characterized by a definitely greater changeability than yield. For 12 successive years (1995-2006) it was ranging from 30 to 51 PLN/dt, while in the years 2007-2008 it was higher than 64 PLN/dt. In 2009, the grain selling price fell down to approximately 41 PLN/dt, but within the following three years it was increasing gradually until achieving in 2012, unprecedented in the previous years level of 82 PLN/dt – chart IV.3.2.

The highest in the world barley yields (60-70 dt/ha) are obtained in Ireland, Belgium, France and Switzerland. In Poland, yielding of this cereal is much weaker. Chart IV.3.2 presents the level of yield of spring barley and grain selling

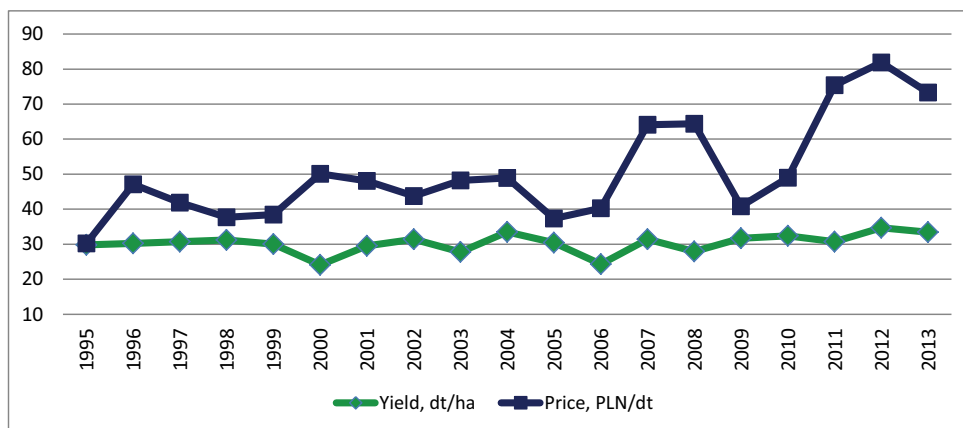
⁴⁵ A. Najewski, *Zboże wysokiej jakości*, 2nd issue, Agro Service, June 2005.

⁴⁶ *Rocznik Statystyczny Rolnictwa i Obszarów Wiejskich 2007*, GUS, Warsaw 2007; *Produkcja upraw rolnych i ogrodnich w 2006 r.*, GUS, Warsaw 2007; *Produkcja upraw rolnych i ogrodnich w 2010 r.*, GUS, Warsaw 2012; *Produkcja upraw rolnych i ogrodnich w 2012 r.*, GUS, Warsaw 2013.

⁴⁷ *Użytkowanie gruntów i powierzchnia zasiewów w 2013 r.*, GUS, Warsaw 2014.

price in the country in the years 1995-2013. The chart shows that in the whole concerned period yielding of barley was generally stable. The yield oscillated around 30 dt/ha, in 2000 and 2006 – when it was relatively the lowest – it was approximately 24 dt/ha, and in 2012, when it achieved the highest level – almost 35 dt/ha.

Chart IV.3.2. Yield of spring barley in individual farms and grain selling price in the period 1995-2013



Source: prepared by the author on the basis of data from the Central Statistical Office (GUS).

The projection of results of spring barley for 2020 was prepared on the basis of data collected on 142 individual agricultural farms cultivating these crops. A starting point for the projection was the average from 2011-2013. In the adopted for tests sample of farms the average selling price was 70.79 PLN/dt. The yield of spring barley was 43.3 dt/ha, namely it was definitely higher than the average yield in Poland. The value of production from cultivation of 1 ha of barley was running at the level of PLN 3079. Whereas, total costs amounted to 2035 PLN/ha, including indirect costs (total) – 1081 PLN/ha, and direct costs (total) – 954 PLN/ha. The greatest share in direct costs could be attributed to mineral fertilizers (65.0%), cost of seed material and plant pesticides had a definitely smaller share – 17.6% and 15.3%, respectively. In 2013, the base years for the projection (the average from 2011-2013), the income without subsidies from cultivation of spring barley was 1043 PLN/ha, and taking account of subsidies, the income from activity reached the level of 2013 PLN/ha.

The results from the 2020 projection, both in terms of values and ratios of changes, are presented in table IV.3.1.

Table IV.3.1. Results of spring barley cultivation in the base year 2013* and the projection until 2020 (in current prices)

Specification	Level for 2013*	Projection for			Indicator of changes year 2013 = 100		
		2016	2018	2020	2016	2018	2020
Number of surveyed farms		142			-	-	-
Growing area [ha]		11.09			-	-	-
Yield of grain [dt/ha]	43.3	43.9	44.4	44.8	101.5	102.5	103.5
Selling price of grain [PLN/dt]	70.79	76.52	80.33	84.15	108.1	113.5	118.9
Per 1 ha of growing area, in PLN							
Total value of production	3079	3376	3578	3784	109.7	116.2	122.9
Total direct costs	954	1091	1183	1275	114.3	124.0	133.6
in this: sowing materials	167	189	204	219	113.1	121.9	130.7
fertilizers	620	723	792	862	116.6	127.8	139.1
plant protection products	146	156	162	169	106.9	111.5	116.1
Gross margin without subsidies	2124	2285	2395	2509	107.6	112.8	118.1
Total indirect costs	1081	1207	1291	1377	111.6	119.4	127.3
Income from activity without subsidies	1043	1078	1104	1132	103.4	105.8	108.5
Subsidies**	969	1008	1008	1008	104.0	104.0	104.0
Income from activity	2013	2086	2112	2140	103.7	104.9	106.3
<i>TOTAL COSTS</i>	<i>2035</i>	<i>2298</i>	<i>2474</i>	<i>2652</i>	<i>112.9</i>	<i>121.6</i>	<i>130.3</i>
Measuring the economic efficiency							
Indicator of profitability [%]	151.3	146.9	144.6	142.7	97.1	95.6	94.3
Total costs / 1 dt [PLN]	47.01	52.29	55.76	59.19	111.2	118.6	125.9
Income from activity without subsidies/ 1 dt of grain [PLN]	24.10	24.54	24.88	25.27	101.8	103.3	104.9
Total costs/1 PLN of income from activity without subsidies [PLN]	1.95	2.13	2.24	2.34	109.2	114.9	120.1
Subsidies per 1 PLN of income from activity without subsidies [PLN]	0.93	0.93	0.91	0.89	100.6	98.3	95.8
Share of subsidies in income from activity [%]	48.2	48.3	47.7	47.1	100.3	99.1	97.8

* 2013 – base for the projection model, the results reflect average values in the years 2011-2013.

** In the years 2011-2013, subsidies will include Complementary Area Payment and Single Area Payment, for the projection years subsidies were adopted at the level of 240 EUR/ha (according to the CAP assumptions for 2014-2020). The exchange rate adopted in the calculations: EUR 1 = PLN 4.20.

Source: preparation on the basis of author's research.

From the completed calculations it results that yield of spring barley until 2020, as compared to 2013, will increase only by approx. 3.5%. It means that annual increases in yield will be in the following years only 0.5%. The grain selling price will be characterized by a definitely higher dynamics of growth. It is anticipated that for barley grain farmers will be able to obtain higher price, 2.3 to 2.7% than in the previous year. Therefore, the value of production from 1 ha of barley in 2020 can reach the level of PLN 3784. This is more by 22.9% than in the year 2013 adopted as the base for the projection.

Unfortunately, the costs of barley cultivation will be characterized by a definitely stronger dynamics. In the perspective of 2020, total costs higher by 30.3% should be expected. According to the projection model, dynamics of growth in direct costs will be stronger (33.6%) than for indirect costs (27.3%). It is anticipated that from among direct costs the greatest increase will be characterizing the cost of mineral fertilizers (39.1%) and seed material (30.7%). The growth in the cost of plant pesticides will be smaller (16.1%).

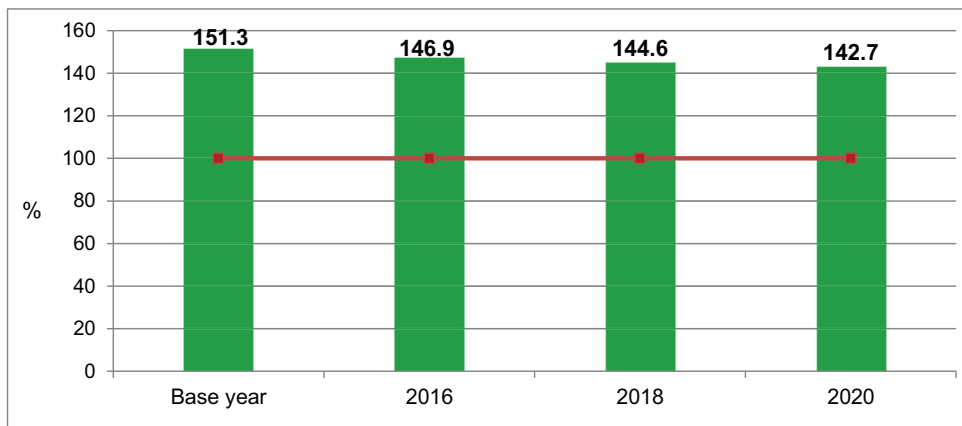
The above changes in the value of production and costs of spring barley cultivation will result – as compared to 2013 – in a growth in gross margin without subsidies by 18.1%, and income from activity without subsidies by 8.5%. In the analyzed farms at spring barley cultivation, on the surface area of approximately 11 ha the gross margin can reach the level of 2509 PLN/ha, and income without subsidies will reach 1132 PLN/ha. The anticipated annual income without subsidies growth rate will be only 1.1-1.3%. This result cannot be considered as satisfactory. In order to increase income from barley cultivation, farmers need to take actions stimulating increase in revenues or reducing cost intensity of production.

In the perspective of 2020, a quite strong increase in costs of cultivation of 1 ha of spring barley (by 30.3%) at a little higher yield (by 3.5%) will make costs of production of 1 dt – as compared to 2013 – grow by 25.9%. Deteriorated economic efficiency of barley production is proved also by other ratios. For example, cost of producing unit of income without subsidies probably will be higher by as much as 20.1%.

Despite that in 2020 income from production exceeds the level from the basic year for the projection (by 8.5%), the economic efficiency of barley production will worsen. It is determined by stronger by 7.4 p.p. dynamics of growth in costs than revenues. From the projection model it can be concluded that in the years 2014-2020 annual increases in the value of production can be ranging from 2.8 to 3.2%, whereas costs (total) will be growing at 3.5-4.3%. As a consequence,

in 2020 – as compared to 2013 – profitability of spring barley production will decrease by 8.6 p.p. – chart IV.3.3.

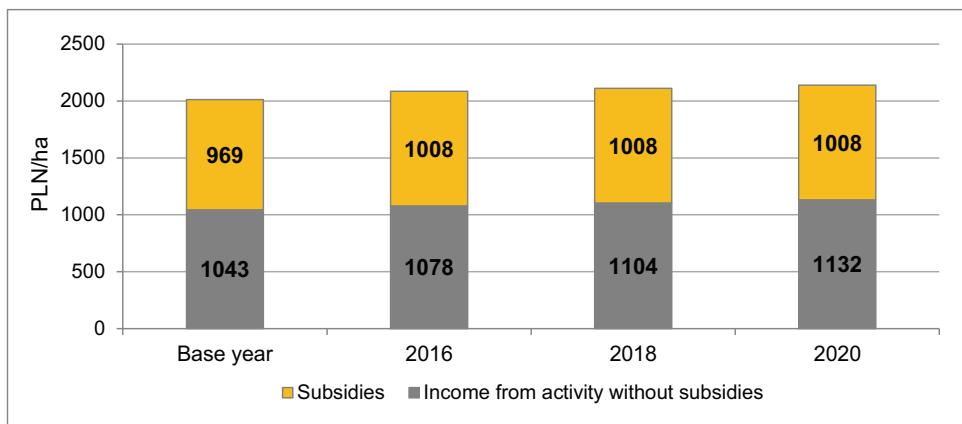
Chart IV.3.3. The ratio of spring barley cultivation profitability in the base year (2013) and the projection until 2020



Source: prepared by the author on the basis of own research.

Stronger rate of growth in costs than revenues from spring barley cultivation will make income from activity without subsidies grow just about 1% per year. In 2020, with regard to the base year, it will be higher by only 8.5% (1132 PLN/ha towards 1043 PLN/ha). Taking account of the amount of subsidies estimated for the years 2014-2020, we may expect income (together with subsidies) higher only by approx. 6.3% (2140 PLN/ha towards 2013 PLN/ha). This is the lowest growth as compared to other, covered by the forecast activities – chart IV.3.4.

Chart IV.3.4. Income from spring barley cultivation without subsidies in the base year (2013) and the projection until 2020



Source: prepared by the author on the basis of own research.

Options of projection for the year 2020

The purpose of the conducted research was also the presentation of the projection results in alternative depiction. The authors were followed by the idea to get to know the force of impact on change in income of each of the income-generating factors independently. Results of the 2020 projection are presented in two variants, the first was aimed at:

- **determination of the impact of unit changes in yield, prices and costs of spring barley cultivation on change in economic results in 2020** (*unit changes mean deviations from the projection results resulting from the trend*).

Table IV.3.2 presents the scope of changes in results of spring barley cultivation in the case of unit change in yield and price, namely the main factors which shape revenue from the conducted activities as well as in the event of change in costs (total) of this crop cultivation. It should be added that the scope of changes presented in the table is determined by the results of the research sample of farms that were the point of reference for unit changes. For this reason, you cannot translate them directly into total farms cultivating spring barley.

Table IV.3.2. Percentage changes in the spring barley projection results in 2020 assuming unit changes in yield, prices and total costs

Specification	Yield		Price		Total costs	
	+1 dt	-1 dt	+1 PLN	-1 PLN	+100 PLN	-100 PLN
Yield of grain	+2.2	-2.2				
Selling price of grain			+1.2	-1.2		
Total value of production	+2.2	-2.2	+1.2	-1.2		
Gross margin without subsidies	+3.4	-3.4	+1.8	-1.8		
Total costs					+3.8	-3.8
Income from activity without subsidies	+7.4	-7.4	+4.0	-4.0	-8.8	+8.8
Indicator of profitability	+2.2	-2.2	+1.2	-1.2	-3.6	+3.9

Source: preparation on the basis of author's research.

From the projection model it results that unit changes in yield, prices and total costs of spring barley cultivation will cause in the 2020 perspective change *in plus* or *in minus* in economic results, i.e.:

- increase or decrease in yield by 1 dt (2.2%) – will result in increase or decrease in income from activity without subsidies by 7.4% (84 PLN/ha), and production profitability by 2.2%; with an unchanged level of other factors,

- increase or decrease in grain prices by 1 PLN/dt (1.2%) – will result in increase or decrease in income from activity without subsidies by 4.0% (45 PLN/ha), and production profitability by 1.2%; with an unchanged level of other factors,
- increase or decrease in total costs by 100 PLN/ha (3.8%) – will result in increase or decrease in income from activity without subsidies by 8.8%, and in production profitability by 3.6-3.9%; with an unchanged level of other factors.

The above calculations show that, like in the case of wheat and rye, the force of impact on the level of income of unit change in yield was greater than of grain price. The second regularity observed for the analyzed crops is definitely the strongest effect on income by change in cultivation costs. These results suggest – taking into account unit variability – that aiming at high crop cultivation profitability should focus, first of all, on proper cost management, and strive to obtain the best production results.

Apart from the determination of the impact of unit changes on the level of income, the research included variability in yield (8.3%) and price (19.0%) of spring barley, observed in the period 1995-2013 (Table IV.1). This variability was used to identify deviations of income without subsidies from the 2020 projection results, prepared in the production and pricing conditions resulting from long-term trends. On the examined farms, change in spring barley yield can be +/-3.7 dt, and change in grain price +/-15.96 PLN.

According to the research, the relation between yield and price is statistically insignificant. For this reason, it is possible to specify the impact on the level of income of each of these factors independently:

- in the case of change in yield by 3.7 dt – fluctuations in income from activity without subsidies will amount to +/-313 PLN/ha, which, at the anticipated income for the year 2020 (1132 PLN) means growth to 1445 PLN/ha or decrease to 819 PLN/ha (change by +/-27.7%),
- in the case of change in price by 15.96 PLN/dt – fluctuations in income from activity without subsidies will amount to +/-715 PLN/ha, which, at the anticipated income for the year 2020 (1132 PLN), means growth to 1847 PLN/ha or decrease to 417 PLN/ha (change by +/-63.1%).

Research making use of variability in yield and price, observed in the last dozen or so years, indicated that larger fluctuations of income can be expected with regard to instability of the barley grain selling price. It means that, owing to great variability in grain prices, farmers can both gain and lose much. Decreases

in income may be eliminated by accordingly high yields and rational outlays of means of production.

The second variant of the spring barley projection results was aimed at:

- **determination of the scope of changes in 2020 in production and pricing results, assuming that income from spring barley cultivation will be at the level of the base year** (*i.e. it will reflect the average level in the years 2011-2013*).

Assuming that total costs of spring barley cultivation change according to the adopted trend in the projection, the research covered the level of selling price and yield of grain at which income from activity without subsidies in 2020 will be at the level of the base year 2013 – table IV.3.3.

It seems from the conducted analysis that when changing price and total costs in accordance with the 2020 projection, the minimum level of yield enabling achieving income from activity without subsidies at the level of 2013 is 43.9 dt/ha. It means that the maximum deviation (*in minus*) of the amount of yield from the projection level is only 0.9 dt (2.0%). In the years to come risk to obtain low income from activity, related to reduction in yield, will be high. Farmers have to include in their calculations that even a small decrease in yield may make income from 1 ha of spring barley cultivation lower than in 2013. For this reason, greater importance is attached to rational management of inputs of means of production on a farm.

Table IV.3.3. The maximum deviation from the projection for the year 2020 of yield and price of spring barley, assuming that income from activity without subsidies will be at the level of the base year (2013)

Specification	Level for 2013*	Projection for 2020	Deviations from the projection for 2020	
			Yield	Price
Yield of grain [dt/ha]	43.3	44.8	43.9	44.8
Selling price of grain [PLN/dt]	70.79	84.15	84.15	82.48
Per 1 ha of growing area, in PLN				
Total value of production	3079	3784	3695	
Total costs	2035	2652	2652	
Income from activity without subsidies	1043	1132	1043	

* 2013 – base for the projection model, the results reflect average values in the years 2011-2013.

Source: preparation on the basis of author's research.

In the second approach, change covered selling price of grain, whereas yield and total costs remained at the level of projection for the year 2020. The calculations indicated that the minimum selling price that enables earning income without subsidies at the level of 2013 is 82.48 PLN/dt, and that the maximum deviation (*in minus*) in this case is only 1.67 PLN (2.0%). Like in the case of minimum yield, possible deviation from the projection is minute, which again suggests growing importance of proper management of costs in the future.

To sum up, it should be concluded that in the 2020 perspective spring barley cultivation will be profitable activity. However, because of a stronger dynamics of growth in costs than revenues, decrease in barley production profitability can be expected – by 8.6 p.p., as compared to the base year (2013). Like in the case of other cereals, unit change in yield (by 1 dt) will have a stronger impact on the level of income without subsidies than change in price by one unit (by PLN 1). From the analysis, it can also be concluded that change in cultivation costs has also a strong impact on income. Their increase or decrease by PLN 100 (3.8%) may result in change in income without subsidies by 8.8%. Subsidies will still remain an important instrument supporting income of farmers. However, in the 2020 perspective their role will be probably smaller. We may expect that the amount of subsidies per PLN 1 of income without subsidies will decrease by 4.2%, while their share in income (together with subsidies) will drop by 2.2%. It will be determined mainly by the higher level of income: without subsidies 8.5%, and together with subsidies 6.3%. Higher income at drop in production profitability in the quantitative depiction, means that production will be generated too costly. The expected level of costs is probably too high to create the production volume resulting from the projection model.

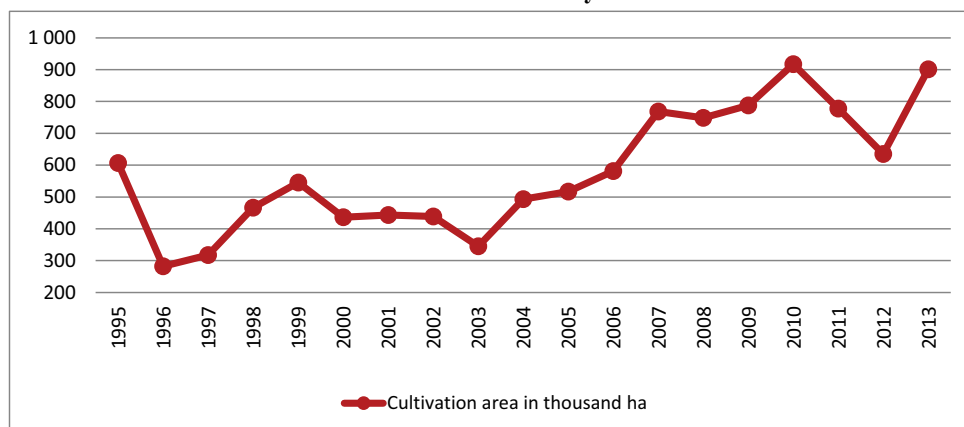
4. Winter rapeseed

The production of oil plants in the world shows systematic growth in response to dynamically growing demand for food and renewable energy sources. In the structure of the world production of oil seeds in the season 2012/2013 the greatest share was attributed to soya bean (55.9%), then rapeseed (13.4%), and sunflower (7.5%). The production of soya bean is concentrated mainly in the US, Brazil and Argentina, while the leader in production of rapeseed is the European Union where the estimated share in the structure of production of the EU of oil seeds in 2013 was 66.6%⁴⁸. The greatest share in rapeseed cultivation area have France, Germany, Poland and the Great Britain. Despite a dynamic development of rapeseed production, the European Union is not self-sufficient, and still considerable volumes of seeds, oils and ground grain are imported. It is worth pointing out that the use of rapeseed oil for production of biodiesel fuel will exceed significantly the use of this oil in the agricultural and food sector.

Rapeseed in Poland, whose share in the acreage of oil plants is 95-97%, has become most rapidly developing activity of plant production. This is closely related to the accession of Poland to the European Union in 2004, and the main stimulant of development of rapeseed production and processing is developing market of biofuels. In the previous years, rapeseed was cultivated, first of all, for the needs of the fat industry.

Changes in the cultivation area of winter rapeseed in the last 19 years are presented in chart IV.4.1. The size of the acreage of rapeseed, despite periodical fluctuations, is shown by long-term growth trend.

Chart IV.4.1. The cultivation area of winter rapeseed in the years 1995-2013, total in the country



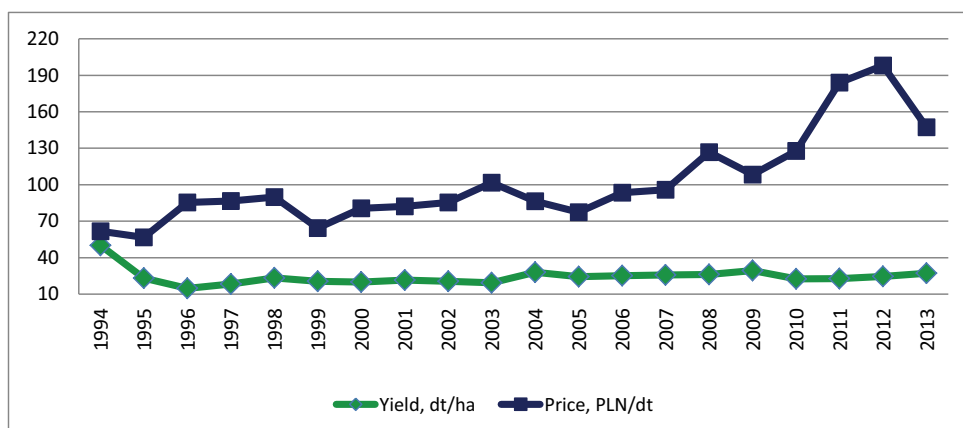
Source: prepared by the author on the basis of data from the Central Statistical Office (GUS).

⁴⁸ Rynek rzepaku. Stan i perspektywy. No. 45, IERiGŻ-PIB, ARR, MRiRW, Warsaw 2014.

In 2012, according to the data of the Central Statistical Office (GUS), as much as 88.2% of the national cultivation area of rapeseed and agrimony was occupied by winter form, which gives higher and more stable yields⁴⁹. However, in the climatic conditions of Poland winter rapeseed is burdened with a relatively large risk of freezing⁵⁰. Variable weather conditions caused substantial losses as a result of freezing out of crops in the season 1996/97 and in the years 2011-2012. Fluctuations in the acreage of rapeseed are determined also by variable profitability (mainly as a result of fluctuations in buying-in prices of raw material) and structural changes in the agricultural sector.

Chart IV.4.2 presents the levels of yield and selling price of rapeseed grains in the last years.

Chart IV.4.2. Yield of winter rapeseed in individual farms and grain selling price in the years 1994-2013



Source: prepared by the author on the basis of data from the Central Statistical Office (GUS).

The rapeseed yielding level is affected, among others, by quality of soils, inputs of means of production (e.g. consumption of fertilizers), cultivation of good quality varieties, and weather conditions. The climate of Poland is largely less favourable for rapeseed cultivation than the Western European climate. In the period of recent few years (since 2010), we have been observing in our country a lower level of yielding of winter rapeseed as compared to other countries of the European Union; in 2013 in Poland on average 26.5 dt/ha were obtained, while in France – 30.4 dt/ha, in Germany – 39.5 dt/ha, UK – 30.4 dt/ha, Czech Republic – 34.4 dt/ha⁵¹.

⁴⁹ Wyniki produkcji roślinnej w 2012 r., GUS, Warsaw 2013.

⁵⁰ W. Budzyński, *Efektywność wybranych czynników produkcji nasion rzepaku ozimego*, [in:] *Rzepak biopaliwa*, 2nd issue, Biznes-Press Sp. z o.o., Warsaw 2006.

⁵¹ *Rynek rzepaku. Stan i perspektywy*. No. 45, IERiGŻ-PIB, ARR, MRiRW, Warsaw 2014.

The level of grain selling prices is also determined by several factors. In the years 2009-2012, growth in prices was due to mainly a persisting large demand for raw material with detectable production stagnation. However, in 2013, rapeseed grain selling prices plummeted. This reduction was affected by exceptionally high crops of seeds (as a result of favourable weather conditions and improvement in rapeseed yielding), which increased to 2.7 million tons in respect of 1.9 million tons in the years 2011-2012. Negative impact was exerted also by increased supply of rapeseed on the European market and decrease in soya bean selling price in the world⁵².

The projection of results of winter rapeseed production until 2020 was prepared on the basis of the data collected in 149 individual farms cultivating this plant. The adopted starting point for the projection was the average from 2011-2013 which is reflected in research by the year 2013 termed as the base year for the projection. Initial values for the conducted projection were shaped by the income situation of rapeseed in those years.

In the analyzed group of farms, on average in the years 2011-2013, winter rapeseed was cultivated in the area of 16.29 ha, grain yield was 25.9 dt/ha, and their selling price – 173.99 PLN/dt. The value of production from 1 ha was running at the level of PLN 4499, and income from activity without subsidies was PLN 1125. Cultivation of rapeseed was thus profitable activity even without support by subsidies. Total costs (i.e. direct and indirect costs), incurred by farmers, amounted to 3374 PLN/ha, in this direct costs 1711 PLN/ha.

It is worth noting the results from rapeseed cultivation obtained in the years (2011-2013) being the basis for the base year of the projection (2013). The level of income in 2011 and 2012 was affected mainly by high grain selling price, which was 183.23 PLN/dt, 197.37 PLN/dt, accordingly⁵³. Farmers obtained in these years income without subsidies in the amount of 1055 PLN/ha and 1734 PLN/ha, respectively. On the contrary, a significant decrease in price in 2013, to the level of 141.37 PLN/dt, caused the lowest in the years 2011-2013 result in the form of income without subsidies – 484 PLN/ha. In the analyzed period, yielding of rapeseed increased by 25.0%, from the level of 22.8 dt/ha in 2011 to 28.5 dt/ha in 2013. Also costs of cultivation were growing systematically; in 2012, total costs were higher by 11.1% than in 2011, while in 2013 – higher by 2.2% than in 2012. Increase in costs (total) of rapeseed cultivation was caused by mainly increasing direct costs.

⁵² *Rynek rzepaku. Stan i perspektywy*. No. 45, IERiGŻ-PIB, ARR, MRiRW, Warsaw 2014.

⁵³ I. Augustyńska-Grzymek (ed.), *Produkcja, koszty i dochody z wybranych produktów rolniczych w latach 2011-2012*. IERiGŻ-PIB, Warsaw 2013; I. Augustyńska-Grzymek (ed.), *Produkcja, koszty i dochody z wybranych produktów rolniczych w latach 2012-2013*. IERiGŻ-PIB, Warsaw 2014.

Table IV.4.1. Results of winter rapeseed cultivation in the base year 2013* and the projection until 2020 (in current prices)

Specification	Level for 2013*	Projection for			Indicator of changes year 2013 = 100		
		2016	2018	2020	2016	2018	2020
Number of surveyed farms		149			-	-	-
Growing area [ha]		16,29			-	-	-
Yield of seeds [dt/ha]	25.9	26.8	27.3	27.9	103.6	105.8	107.8
Selling price of seeds [PLN/dt]	173.99	192.45	204.75	217.05	110.6	117.7	124.7
Per 1 ha of growing area, in PLN							
Total value of production	4499	5154	5600	6053	114.5	124.5	134.5
Total direct costs	1711	1953	2115	2278	114.1	123.6	133.1
in this: sowing materials	161	189	208	226	117.1	128.6	140.0
fertilizers	1086	1267	1388	1511	116.6	127.8	139.1
plant protection products	388	415	433	451	106.9	111.5	116.1
Gross margin without subsidies	2788	3201	3485	3775	114.8	125.0	135.4
Total indirect costs	1662	1849	1976	2103	111.3	118.8	126.5
Income from activity without subsidies	1125	1351	1509	1672	120.1	134.1	148.6
Subsidies**	970	1008	1008	1008	104.0	104.0	104.0
Income from activity	2095	2359	2517	2680	112.6	120.2	127.9
TOTAL COSTS	3374	3802	4090	4380	112.7	121.2	129.8
Measuring the economic efficiency							
Indicator of profitability [%]	133.4	135.5	136.9	138.2	101.6	102.7	103.6
Total costs / 1 dt [PLN]	130.47	141.98	149.57	157.08	108.8	114.6	120.4
Income from activity without subsidies/ 1 dt of seeds [PLN]	43.52	50.47	55.18	59.97	116.0	126.8	137.8
Total costs/1 PLN of income from activity without subsidies [PLN]	3.00	2.81	2.71	2.62	93.8	90.4	87.4
Subsidies per 1 PLN of income from activity without subsidies [PLN]	0.86	0.75	0.67	0.60	86.6	77.5	69.9
Share of subsidies in income from activity [%]	46.3	42.7	40.0	37.6	92.3	86.5	81.2

* 2013 – base for the projection model, the results reflect average values in the years 2011-2013.

** In the years 2011-2013, subsidies included Complementary Area Payment and Single Area Payment, the subsidies adopted for the period of projection were at the level of 240 EUR/ha (according to the assumptions of CAP for the years 2014-2020). The exchange rate adopted in the calculations: EUR 1 = PLN 4.20.

Source: preparation on the basis of author's research.

The projection of results of winter rapeseed cultivation until 2020 in terms of value and as ratios of changes with regard to the base year are presented in table IV.4.1. The projection prepared in average production and pricing conditions indicates that yield of winter rapeseed in the period covered by the research (2014-2020) will be growing by approx. 1.1% annually. As a result, in 2020, farmers can obtain yield higher by 7.8% as compared to the starting yield for the projection (base year 2013). On the contrary, the grain selling price will increase by 24.7%, at the annual pace of its changes of 2.9-3.5%. The anticipated increase in yield and grain selling price will affect favourably the level of revenues from winter rapeseed cultivation. According to the projection results, in 2020, the value of production may be higher by 34.5%. Thus, in the longer perspective, farmers cultivating rapeseed can anticipate significantly better economic results.

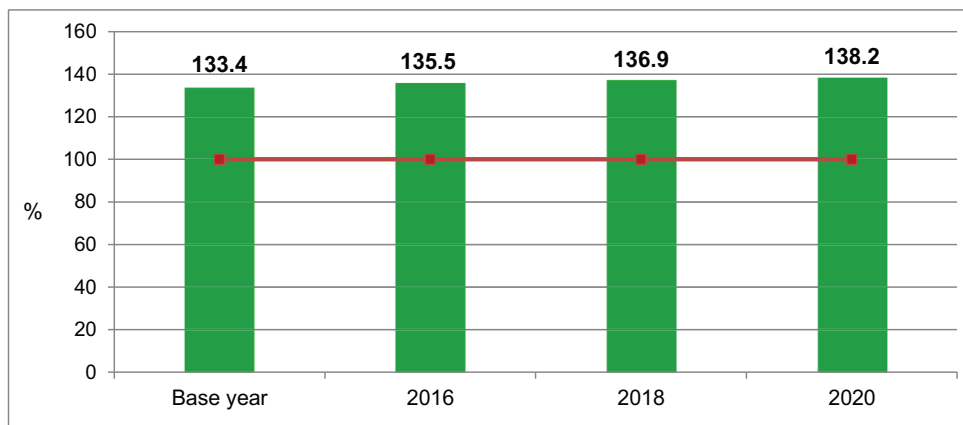
While shaping income, a large portion is attributed also to costs (total) of cultivation. It is anticipated that in 2020 – as compared to 2013 – their level may be higher by 29.8%. Particularly large growth will be characterizing direct costs (by 33.1%), and especially cost of seed material (by 40.0%) and of mineral fertilizers (by 39.1%). This is the valuable information for long-term planters of rapeseed who may, to a large extent, determine the level of direct costs through appropriate operating actions and therefore they will affect directly the obtained level of income from the activity.

In consequence of the discussed changes in the value of production and costs of rapeseed cultivation, a growth is anticipated in gross margin without subsidies by 35.4%, and of income from the activity without subsidies by 48.6%.

The results of projection justify taking an optimistic view on the economic situation of winter rapeseed cultivation. Despite that in the 2020 perspective we should expect higher by 20.4% costs of (total) production of 1 dt of grains (PLN 157.08 towards PLN 130.47 in 2013), the anticipated income without subsidies per 1 dt will also be higher – by 37.8% (PLN 59.97 towards PLN 43.52 in 2013). In this favourable system, costs (total) of production of PLN 1 of income from activity will fall by 12.6% (PLN 2.62 towards PLN 3.00).

Chart IV.4.3 presents change in the level of winter rapeseed cultivation profitability in the average production and pricing conditions in 2013 (the base year for the projection), and in the selected years of the projection period.

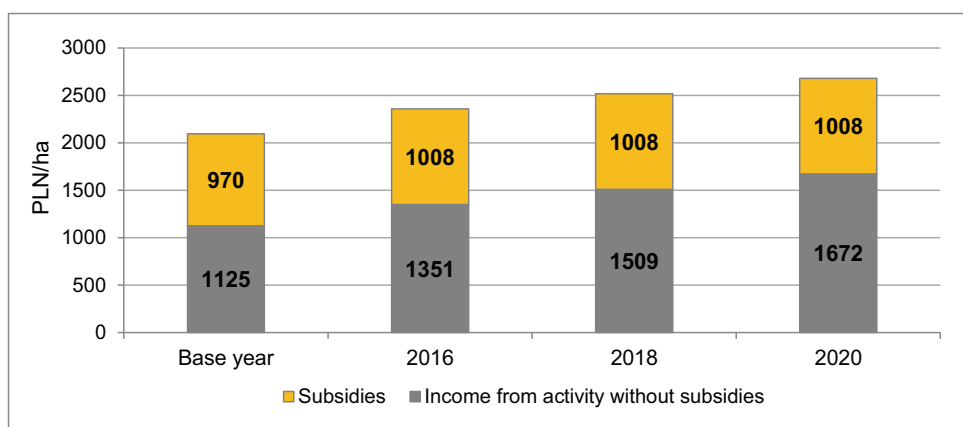
Chart IV.4.3. The ratio of winter rapeseed cultivation profitability in the base year (2013) and the projection until 2020



Source: preparation on the basis of author's research.

In the 2020 perspective, we may expect higher winter rapeseed cultivation profitability. As compared to the base year, the profitability ratio may be higher by 4.8 p.p. Favourable situation results from a stronger rate of growth in the value of production than costs – the expected annual growth in the value of production will be from 3.9 to 4.8%, while total costs will be growing at the rate of 3.4-4.2%. As a result of these changes in 2020, the dynamics of growth in the value of production will be stronger by 4.7 p.p., which will be reflected in the improvement in profitability.

Chart IV.4.4. Income from winter rapeseed cultivation without subsidies in the base year (2013) and the projection until 2020



Source: preparation on the basis of author's research.

In 2020, as compared to the base year for the projection, income from activity without subsidies will increase by 48.6% and in the analyzed farms it may be running at the level of 1672 PLN/ha. Meanwhile, considering the estimated amount of subsidies, we should expect income from activity (i.e. together with subsidies), higher by 27.9% (2680 PLN/ha towards 2095 PLN/ha) – chart IV.4.4.

The research results indicate that the impact of subsidies on the level of income from rapeseed cultivation will be decreasing. It results from the fact that the economic efficiency of its production will be increasing and, consequently, surplus from production at the disposal of farmers will be also increasing. The second reason is the scale of support by subsidies, and its level will be higher only by approx. 4.0% than in 2013. It means that in 2020, to PLN 1 of income from activity without subsidies farmers will receive PLN 0.60 of subsidies; thus, support will be smaller by 30.2%. On the other hand, taking account of the share of subsidies in income from activity (i.e. together with subsidies), it is assessed that in 2020 – as compared to 2013 – it will be smaller by 8.7 p.p.

Options of projection for the year 2020

For more detailed identification of factors determining income from winter rapeseed production, the results of the 2020 projection are presented in two versions. The first option was aimed at:

- **identification of the impact of unit changes in yield, price and costs of rapeseed cultivation on change in economic results in 2020** (*unit changes mean deviations from results of the projection resulting from the trend*).

Preparation of long-term forecasts concerning the economic situation of agricultural production activity is a great challenge. Despite obvious difficulties in predicting dynamically occurring changes in agriculture, forecasting is an important element of assessment of existing results as well as can indicate directions of their further changes. Assessment of the production and economic results in the long-run perspective may enable avoiding wrong, expensive for farmer decisions, and limit significantly the risk of activities on the farm and alleviate the effects of unfavourable trends in the economy.

Table IV.4.2. presents unit changes in yield and price, namely variables whose level is independent of operating activities of a farmer, and costs (total) of winter rapeseed cultivation, whose level can be reduced during the decision-making process at the level of a farm.

Table IV.4.2. Percentage changes in results of the projection of winter rapeseed in 2020, assuming unit changes in yield, price and total costs

Specification	Yield		Price		Total costs	
	+1 dt	-1 dt	+1 PLN	-1 PLN	+100 PLN	-100 PLN
Yield of seeds	+3.6	-3.6				
Selling price of seeds			+0.5	-0.5		
Total value of production	+3.6	-3.6	+0.5	-0.5		
Gross margin without subsidies	+5.7	-5.7	+0.7	-0.7		
Total costs					+2.3	-2.3
Income from activity without subsidies	+13.0	-13.0	+1.7	-1.7	-6.0	+6.0
Indicator of profitability	+3.6	-3.6	+0.5	-0.5	-2.2	+2.3

Source: preparation on the basis of author's research.

From the projection model it can be concluded (Table IV.4.2) that unit changes in yield, price and total costs of winter rapeseed cultivation will cause in the 2020 perspective change *in plus* or *in minus* in economic results, i.e.:

- increase or decrease in yield by 1 dt (i.e. 3.6%) – will result in increase or decrease in income from activity without subsidies by 13.0% (217 PLN/ha), and in production profitability by 3.6%; with an unchanged level of other factors,
- increase or decrease in grain prices by 1 PLN/dt (0.5%) – will result in increase or decrease in income from activity without subsidies by 1.7% (28 PLN/ha), and in production profitability by 0.5%; with an unchanged level of other factors,
- increase or decrease in total costs by 100 PLN/ha (2.3%) – will result in increase or decrease in income from activity without subsidies by 6.0%, and in production profitability by 2.2-2.3%; with an unchanged level of other factors.

Calculations indicate that unit change in yield has much larger impact on income from activity without subsidies, rather than grain selling price. Increase or decrease in yield by 1 dt will cause change in income without subsidies, more than 7-times higher than increase or decrease in price by PLN 1.

However, taking into account variability of yield (12.6%) and price (20.9%) observed in the years 1994-2013 (table IV.1.), we can anticipate size of deviations from the results of projection for 2020 (prepared for production

and price results from long-term trend). In the case of yield of winter rapeseed, a change may be +/-3.5 dt, and in the case of price +/-45.45 PLN.

The research has shown that the relation between yield and price is statistically insignificant. As a result, the impact on the level of income can be determined for each of factors, independently:

- in the case of change in yield by 3.5 dt, fluctuations in income from activity without subsidies amount to +/-761 PLN/ha, which, at the anticipated income for the year 2020 (PLN 1672), means increase to 2433 PLN/ha or decrease to 912 PLN/ha (change +/-45.5%),
- in the case of change in price by 45.45 PLN/dt, fluctuations in income from activity without subsidies amount to +/-1267 PLN/ha, which, at the anticipated income for the year 2020 (PLN 1672), means increase to 2939 PLN/ha or decrease to 405 PLN/ha (+/-75.8%).

The conducted analysis shows clearly that instability of the seed selling price may affect more significantly the results achieved by farmers than variable yielding of rapeseed. Planters of rapeseed in the perspective of 2020, even in the worst (pessimistic) relation of yield and seed selling price, will continue to earn income from rapeseed cultivation.

The second option of the projection was aimed at:

- **determination of the scope of changes in 2020, production and price results, assuming that income from rapeseed cultivation will remain at the level of the base year** (*i.e. will reflect average level in the years 2011-2013*).

Broadening the scope of analysis of the impact of variability of yield and price on economic results of rapeseed cultivation, it was analyzed at which level of yield and seed selling price it will be possible to obtain in 2020 income from activity without subsidies at the level of 2013 (the base year for the model). At the same time, it was assumed that total costs of production will be increasing according to the forecasts resulting from the projection for the year 2020.

Results in table IV.4.3 present two scenarios enabling farmers to obtain in 2020 income from activity without subsidies at the level of 2013. The first scenario contains the minimum level of yield of rapeseed, given unchanged price and costs, and the second contains the minimum seed selling price with unchanged level of yield and costs.

The conducted calculations indicate that the minimum amount of yield of rapeseed which will enable to achieve income from the activity without subsidies at the level of the base year, given price of seed and total costs according to the

results of the projection, is 25.4 dt/ha. Maximum deviation of yield from the projection value is 2.5 dt (9.0%).

Table IV.4.3. Maximum deviation from the projection for the year 2020 of yield and price of winter rapeseed, assuming that income from activity without subsidies will remain at the level of the base year (2013)

Specification	Level for 2013*	Projection for 2020	Deviations from the projection for 2020	
			Yield	Price
Yield of seeds [dt/ha]	25.9	27.9	25.4	27.9
Selling price of seeds [PLN/dt]	173.99	217.05	217.05	197.43
Per 1 ha of growing area, in PLN				
Total value of production	4499	6053	5505	
Total costs	3374	4380	4380	
Income from activity without subsidies	1125	1672	1125	

* 2013 – base for the projection model, the results reflect average values in the years 2011-2013.

Source: preparation on the basis of author's research.

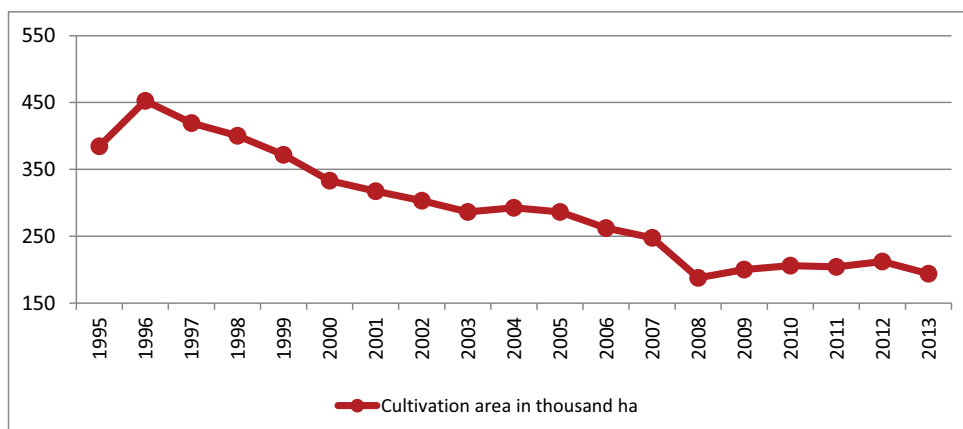
The result of the second calculation indicates that the minimum price of winter rapeseed guaranteeing income from activity without subsidies at the same level as in the base year would be 197.43 PLN/dt. Maximum deviation of price from the projection value is PLN 19.62 (9.0%).

In the summary of the discussion about the economic situation of winter rapeseed, forecasted in the perspective of 2020, it should be stated that it will remain profitable activity. The expected increase in total costs (by 29.8%) will be covered fully by expected revenues (increase by 34.5%). Dynamics of growth in the value of production will be stronger than total production costs, which will result in higher than in the base year for the projection profitability ratio – by 4.8 p.p. It is worth pointing out that increase in total cost will be determined, to the greatest extent, by direct costs (mainly the cost of seed material and fertilizers). It can be concluded from the analysis that unit change in yield has much larger impact on income from activity without subsidies, rather than seed selling prices – increase or decrease in yield by 1 dt will result in greater change in income without subsidies than increase or decrease in grain price by PLN 1. In the perspective of 2020, the impact of subsidies on the level of income from activity will decrease. Considering the share of subsidies in income from activity (i.e. together with subsidies), it is assessed that it will be smaller by 8.7 p.p.

5. Sugar beets

The research of the Central Statistical Office has shown that for many years the area occupied in Poland for sugar beets cultivation has been gradually decreasing. Over the last decade, a substantial effect on this change was exerted by related to the accession to the EU restriction in limits of sugar production, introduced under the reform of the EU sugar market on 1 July 2006. For example, in 2013, the acreage of sugar beets cultivation in Poland was 193.7 thousand ha and was lower by 8.6% than in 2012 year, when it was 212.0 thousand ha, and by 4.8% than in 2011, when it was 203.5 thousand ha – chart IV.5.1. This acreage was also smaller by 12.2% as compared to the 5-year period 2006-2010⁵⁴.

Chart IV.5.1. The area of sugar beets cultivation in the years 1995-2013, total in the country



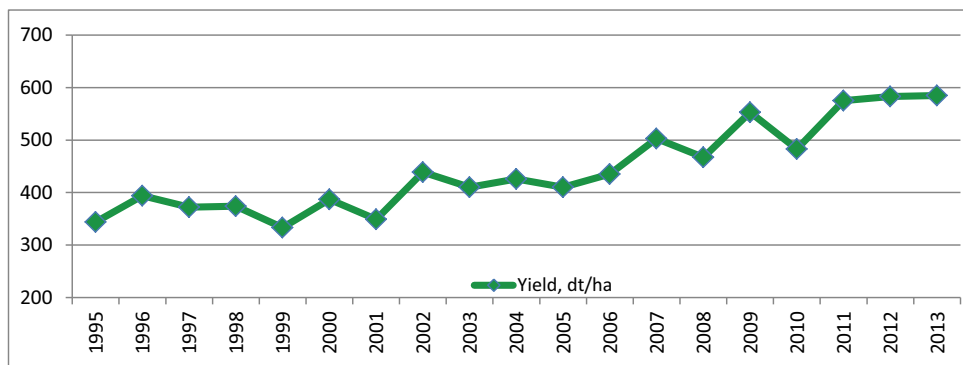
Source: prepared by the author on the basis of data from the Central Statistical Office (GUS).

Analyzing yielding of sugar beets it was noticed that – in illustrated in chart IV.5.2 – nineteen years (1995-2013), the yield of this agricultural products increased gradually. As a result, in 2013, as compared to 1995, in the case of individual farms this change was 70.1%. The difference between the highest level of yield (585 dt/ha) in 2013 and the lowest level (333 dt/ha), recorded in 1999, was 252 dt. On the other hand, taking into account the last three years (which were used in the projection of effects of beets cultivation until 2020 to determine the results for the base year, i.e. 2013), it has been determined that in 2013, on

⁵⁴ A. Artyszak, K. Kucińska, *Zmiany w produkcji cukru i buraka cukrowego w Polsce i w Unii Europejskiej spowodowane reformą rynku cukru*, Zesz. Nauk. SGGW w Warszawie, Ekon. i Organ. Gosp. Żywn., no. 68, Warsaw 2008; *Produkcja upraw rolnych i ogrodnich w 2011 r.*, GUS, Warsaw 2012; *Wynikowy szacunek produkcji głównych ziemiopłodów rolnych i ogrodnich w 2013 r.*, GUS, Warsaw 2013; *Użytkowanie gruntów i powierzchnia zasiewów w 2013 r.*, GUS, Warsaw 2014.

average from 1 ha of this agricultural product 585 dt of roots were obtained, i.e. by 0.3% more than in 2012 and by 1.7% than in 2011⁵⁵.

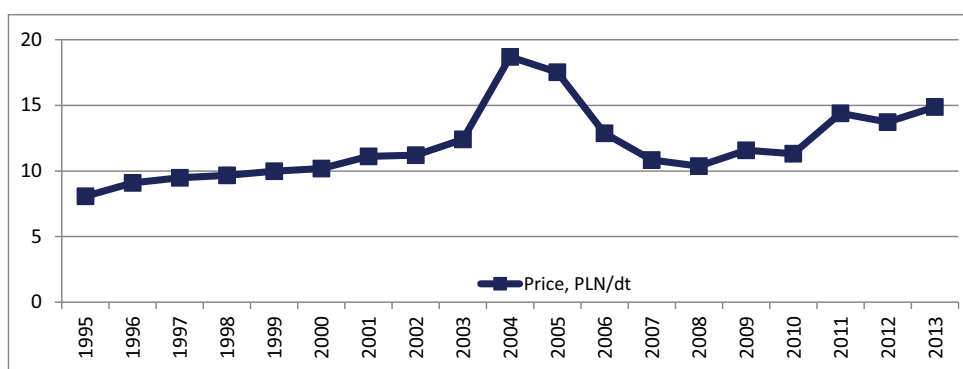
Chart IV.5.2. Yield of roots of sugar beets in individual farms in the years 1995-2013



Source: prepared by the author on the basis of data from the Central Statistical Office (GUS).

Analyzing sugar beets buying-in prices it was determined that during presented in chart IV.5.3 nearly 20-year period, exceptionally high level was recorded in the first two years after Poland's accession to the European Union. In 2004 and 2005, the price for 1 dt of sugar beets roots on average in the country was PLN 18.70 and 17.53, whereas in 1995 – PLN 8.08. However, it should be added that starting from the season 2006/2007, i.e. from the implementation of the EU reform of the sugar market regulation, the level of buying-in prices for beets roots depends on set for a given season minimum price and on quality of raw material supplied to sugar factories.

Chart IV.5.3. Buying-in price for sugar beets roots in the years 1995-2013



Source: prepared by the author on the basis of data from the Central Statistical Office (GUS).

⁵⁵ *Produkcja upraw rolnych i ogrodnich w 2011 r.*, GUS, Warsaw 2012; *Produkcja upraw rolnych i ogrodnich w 2012 r.*, GUS, Warsaw 2013; *Produkcja upraw rolnych i ogrodnich w 2013 r.*, GUS, Warsaw 2014.

It is worth mentioning that in the season 2013/2014 the buying-in price for sugar beets with sugar of 16.0% was EUR 26.29 for 1 ton of roots – identically like in the four previous seasons. The average EUR exchange rate of September 2013 was: EUR 1 = PLN 4.2371, as a result for the season 2013/2014 the minimum national buying-in price of roots was set at the level of 11.14 PLN/dt⁵⁶. Finally, however, in 2013 average annual buying-in price for sugar beets (taking account of the minimum price and quality of roots) was higher than 14 PLN/dt⁵⁷.

The projection of results of sugar beets cultivation until 2020 was executed on the basis of data from the period 2011-2013, coming from 140 individual agricultural farms running this activity. These units were selected in a purposeful manner for research from farms of Polski FADN.

The results of analyses prove that in 2013 (showing averages for 2011-2013), which, in the further part of the subchapter was termed as the base year for the projection, cultivation of sugar beets was profitable activity even at the level of income from activity without subsidies. Obtained from 1 ha of beets roots value of production was in total PLN 8754 and ensured complete coverage of (total) cultivation costs of PLN 6189. As a result, income from activity without subsidies was 2564 PLN/ha. In the base year for the projection, economic efficiency of sugar beets cultivation was high, the profitability ratio – i.e. percentage ratio of the value of production to total costs was 141.4% – table IV.5.1.

In the base year (2013) for 1 ha of beets roots both sugar payment⁵⁸ and Complementary Area Payment were granted. As a result, obtained from beets cultivation income from activity (i.e. together with subsidies) was running at the level of 6401 PLN/ha. The share of subsidies in income was 59.9%.

⁵⁶ *KURS EURO – Kurs euro i cena minimalna*, <http://kzpb.com.pl/aktualnosci,2,pl,news,2,1,78.html> [accessed in April 2014].

⁵⁷ *Skup i ceny produktów rolnych w 2013 r.*, GUS, Warsaw 2014.

⁵⁸ The rate of sugar payment expressed in euro is calculated for Poland by dividing total amount allocated for a country by the quantity of sugar beets covered by quota, resulting from submitted by producers applications for sugar payment. Necessary to determine this rate of payment in PLN, EUR to PLN exchange rate is defined on the basis of data of the European Central Bank of 30 September of a specific year. For 2013, this exchange rate was adopted at the level of 1 EUR = 4.2288 PLN. As a result, in 2013 for 1 ton of roots of sugar beets, sugar payment was granted in the amount of PLN 54.10 (in 2012 and 2011 this amount was PLN 52.44 and 56.00, respectively). Prepared on the basis of: *EUR EXCHANGE RATE – EUR exchange rate and minimum price*, <http://kzpb.com.pl/aktualnosci,2,pl,news,2,1,78.html> [accessed in April 2014]; *Rozporządzenie Ministra Rolnictwa i Rozwoju Wsi z dnia 14 listopada 2013 r. w sprawie stawki płatności cukrowej za 2013 r.* (DzU z 2013 r., poz. 1338); *Rozporządzenie Ministra Rolnictwa i Rozwoju Wsi z dnia 23 listopada 2012 r. w sprawie stawki płatności cukrowej za 2012 r.* (DzU z 2012 r., poz. 1164); *Rozporządzenie Ministra Rolnictwa i Rozwoju Wsi z dnia 4 listopada 2011 r. w sprawie stawki płatności cukrowej za 2011 r.* (DzU z 2011 r., nr 238, poz. 1424).

Table IV.5.1. Results of sugar beets cultivation in the base year 2013* and projection until 2020 (in current prices)

Specification	Level for 2013*	Projection for			Indicator of changes year 2013 = 100			
		2016	2018	2020	2016	2018	2020	
Number of surveyed farms		140			-	-	-	
Growing area [ha]		8.91			-	-	-	
Yield of roots [dt/ha]		611	653	682	710	106.9	111.5	116.1
Selling price of roots [PLN/dt]		14.30	15.10	15.63	16.16	105.5	109.2	112.9
		Per 1 ha of growing area, in PLN						
Total value of production		8754	9875	10660	11475	112.8	121.8	131.1
Total direct costs		2600	2961	3214	3477	113.9	123.6	133.8
in this: sowing materials		740	862	954	1056	116.4	128.9	142.6
fertilizers		1133	1322	1448	1576	116.6	127.8	139.1
plant protection products		668	714	745	776	106.9	111.5	116.1
Gross margin without subsidies		6154	6914	7446	7997	112.4	121.0	130.0
Total indirect costs		3590	4014	4302	4593	111.8	119.8	128.0
Income from activity without subsidies		2564	2900	3145	3404	113.1	122.6	132.8
Subsidies**		3836	4097	4230	4363	106.8	110.3	113.7
Income from activity		6401	6997	7374	7767	109.3	115.2	121.3
TOTAL COSTS		6189	6975	7515	8070	112.7	121.4	130.4
Measuring the economic efficiency								
Indicator of profitability [%]		141.4	141.6	141.8	142.2	100.1	100.3	100.5
Total costs / 1 dt [PLN]		10.12	10.67	11.03	11.37	105.4	108.9	112.3
Income from activity without subsidies/ 1 dt of roots [PLN]		4.19	4.44	4.61	4.80	105.8	110.0	114.4
Total costs/1 PLN of income from activity without subsidies [PLN]		2.41	2.40	2.39	2.37	99.6	99.0	98.2
Subsidies per 1 PLN of income from activity without subsidies [PLN]		1.50	1.41	1.35	1.28	94.4	89.9	85.7
Share of subsidies in income from activity [%]		59.9	58.6	57.4	56.2	97.7	95.7	93.7

* 2013 – base for the projection model, the results reflect average values in the years 2011-2013.

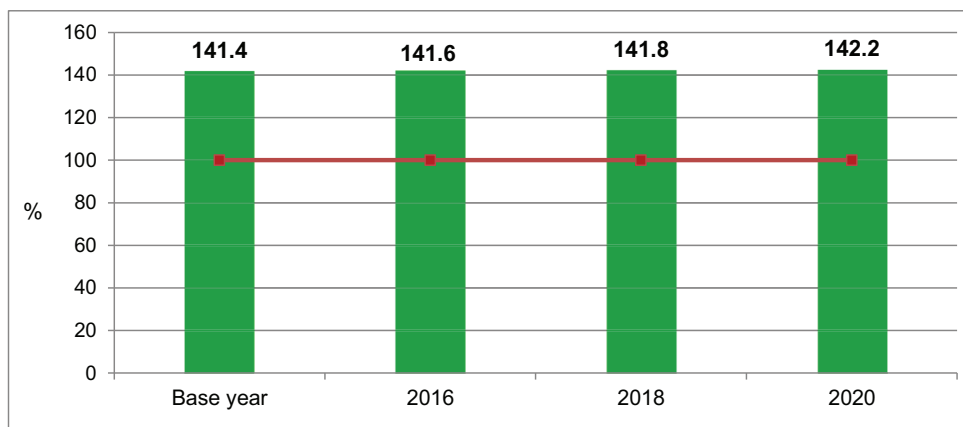
* In the years 2011-2013, subsidies included sugar payment and Single Area Payment, for the period of the projection (2014-2020), it was assumed that for sugar beets cultivation sugar payment will still be granted, and, in addition – subsidies at the level of 240 EUR/ha will be granted (according to the CAP assumptions for 2014-2020). The exchange rate adopted in the calculations: EUR 1 = PLN 4.20.

Source: preparation on the basis of author's research.

According to the projection in 2020, in average production and price conditions (resulting from the trend), the income situation of sugar beets cultivation will be favourable and, at the same time, better than in the base year for the projection (i.e. 2013). There will also be as a result of growth in yield along with buying-in price for sugar beets. It is planned that – as compared to the base year – until 2020 yield for sugar beets will increase by 16.1%, and annual increase in yield will be from 2.0 to 2.3%. The buying-in price for roots will increase until 2020 by 12.9%, and its annual increases will be around 1.7%. Finally, until 2020, as compared to the base year, the value of production will increase by 31.1%. Also costs of cultivation will increase (by 30.4%), including direct costs – by 33.8%, and indirect costs – by 28.0%, the annual pace of their growth will be: 4.0-4.5% and 3.3-3.9%. However, despite higher costs of sugar beets cultivation, in the course of the entire examined period gross margin without subsidies may increase by 30.0%, and income from activity without subsidies will increase by 32.8% – table IV.5.1.

In particular years of the projection – like in the base year (i.e. 2013) – the result of profitability ratio will be favourable, may be more than 140%. Furthermore, it is planned that from the base year with each next year of the projection it will be increasingly higher. It will be determined by stronger dynamics of growth in the value of production, than increase in total costs – chart IV.5.4.

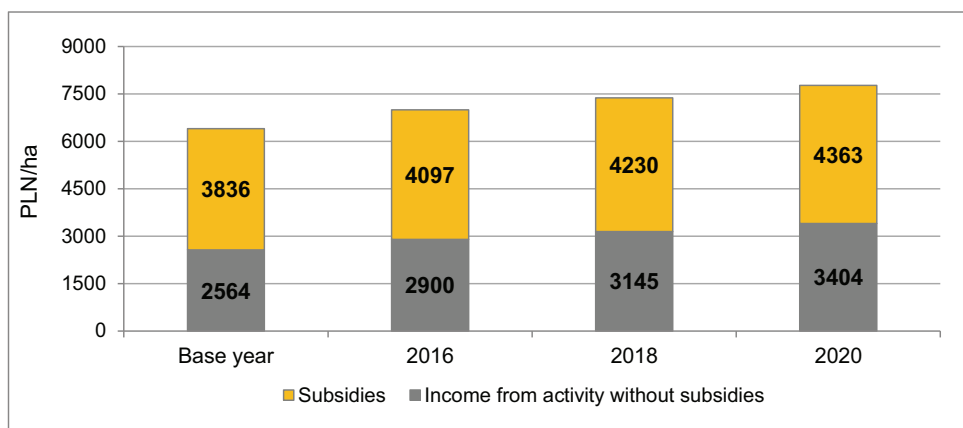
Chart IV.5.4. Ratio of sugar beets cultivation profitability in the base year (2013) and projection until 2020



Source: preparation on the basis of author's research.

It is assumed that – as compared to the base year – subsidies (the sum of sugar payment and Single Area Payment) will increase, until 2016, by 6.8%, and until 2020 by 13.7%. In consequence – in the years to come – income from activity (together with subsidies) will be gradually increasing – at the rate of 2.6-3.7% annually. The effect of these changes is illustrated in chart IV.5.5. It is expected, however, that the share of subsidies in income from activity will be in subsequent years of the projection smaller – in the base year it was 59.9%, and in the target year (i.e. 2020) may amount to 56.2%. The fact is determined – despite the annual growing amount of subsidies – by gradually increasing income from production (i.e. income from activity without subsidies), whose level will be determined by increasingly higher yield and selling price for beets roots.

Chart IV.5.5. Income from sugar beets cultivation without subsidies in the base year (2013) and the projection until 2020



Source: preparation on the basis of author's research.

Analyzing attainable – in subsequent years of the projection, level of income from activity we should, however, mention that – according to the sugar market experts' opinions – such a scenario that – starting from the season 2015/2016 – the sugar beets cultivation will no longer be covered with sugar payment, is also possible. In this situation income from activity (taking into account subsidies) will be clearly lower than it can be concluded from the conducted projection. However, it does not change the fact that in the next years of the projection the share of subsidies in income from activity will be more and more smaller. Calculations indicate that in the described case this share may be in 2016 – 25.8%, in 2018 – 24.3%, and in 2020 – 22.8%.

Options of the projection for the year 2020

In pursuit of determination of the impact on income from sugar beets cultivation of major factors determining its level, the results of the projection for the year 2020 were presented in two options. The first of them was aimed at:

- **determination of the impact of unit changes in yield, price and costs of sugar beets cultivation on change in economic results in 2020** (*unit changes mean deviations from results of the projection resulting from the trend*).

Anticipating changes that may take place in economic results of sugar beets cultivation creates many difficulties, especially due to the fact that agricultural production depends to a great extent upon agro-weather conditions. Anticipating is even more difficult, if it is to include the perspective of a few years, as in the described case. Table IV.5.2 presents the scope of changes in effects of sugar beets cultivation in the research sample (140 farms), depending on changes in yield and selling price for roots, namely factors determined to a limited extent by farmers, and changes in costs of cultivation, whose level depends mainly on the decisions of farmers.

Table IV.5.2. Percentage changes in results of the projection for sugar beets in 2020, assuming unit changes in yield, price and total costs

Specification	Yield		Price		Total costs	
	+1 dt	-1 dt	+1 PLN	-1 PLN	+100 PLN	-100 PLN
Yield of roots	+1.4	-1.4				
Selling price of roots			+6.2	-6.2		
Total value of production	+1.4	-1.4	+6.2	-6.2		
Gross margin without subsidies	+2.0	-2.0	+8.9	-8.9		
Total costs					+1.2	-1.2
Income from activity without subsidies	+4.7	-4.7	+20.8	-20.8	-2.9	+2.9
Indicator of profitability	+1.4	-1.4	+6.2	-6.2	-1.2	+1.3

Source: preparation on the basis of author's research.

From the projection model it results (table IV.5.2) that unit changes in yield, price and total costs of sugar beets cultivation will cause in the perspective of 2020 change *in plus* or *in minus* in economic results, i.e.:

- increase or decrease in yield by 10 dt (i.e. by 1.4%) – will result in increase or decrease in income from activity without subsidies by 4.7% (by 161 PLN/ha), and production profitability by 1.4%; with an unchanged level of other factors,

- increase or decrease in selling price for roots by 1 PLN/dt (i.e. by 6.2%) – will result in increase or decrease in income from activity without subsidies by 20.8% (by 709 PLN/ha) and production profitability by 6.2%; with an unchanged level of other factors,
- increase or decrease in total costs by 100 PLN/ha (i.e. by 1.2%) – will result in increase or decrease in income from activity without subsidies by 2.9%, and production profitability by 1.2-1.3%; with an unchanged level of other factors.

The conducted analysis demonstrated thus that in the perspective of 2020, in the case of sugar beets from among examined factors, i.e. yield, price and total costs, the greatest impact on change in the level of income from activity without subsidies and production profitability ratio will be exerted by change in selling price for roots, and the smallest impact was exerted by change in costs of cultivation. In the analyzed farms, increase or decrease in selling price for roots by 1 PLN/dt – will result in the percentage perspective – in more than 7-times higher change in the aforementioned income and about 5-times higher change in production profitability than increase or decrease in total cultivation costs by 100 PLN/ha.

Bearing in mind agreed for the years 1995-2013 variability in yield (7.6%) and selling price for roots of sugar beets (7.9%) – presented in Table IV.1 – deviations were determined of income from activity without subsidies from results of the projection for the year 2020, conducted for average production and price conditions resulting from the trend.

Calculations indicate that in the perspective of 2020, in the covered by research sample of 140 farms cultivating sugar beets, change in yield for roots may be +/-53.6 dt/ha, while change in their selling price +/-1.28 PLN/dt. The relation between yield and selling price for sugar beets roots is statistically insignificant, it was thus possible to determine the impact of each of these factors on the level of income from activity without subsidies, regardless of the second factor:

- in the case of change in yield by 53.6 dt – fluctuations in income from activity without subsidies will amount to +/-866 PLN/ha, which, at the anticipated income for the year 2020 (3404 PLN/ha), means increase to 4270 PLN/ha or decrease to 2539 PLN/ha (change by +/-25.4%),
- in the case of change in price by 1.28 PLN/dt – fluctuations in income from activity without subsidies will amount to +/-908 PLN/ha, which, at the anticipated income for the year 2020 (3404 PLN/ha), means increase to 4313 PLN/ha or decrease to 2496 PLN/ha (change by +/-26.7%).

The research proved that variability of selling price for beets roots (7.9%) was slightly greater than variability of yield (7.6%), in consequence the impact of prices on the level of income was also a slightly stronger than yield. Moreover, calculations presented that in the perspective of 2020 even at unfavourable for the producers of sugar beets direction of change in yield and price (i.e. *in minus*), income from activity without subsidies will be earned. It should be also noted that if we take into consideration variability of price, the risk of sugar beets cultivation is clearly smaller than of cereals and rapeseed discussed in previous chapters.

The second projection option was aimed at:

- **determination of the scope of changes in 2020 in production and price results, assuming that income from sugar beets cultivation will remain at the level of the base year (i.e. will reflect average level in the years 2011-2013).**

In the second option of the projection the impact of variability of yield and price for roots of sugar beets on income from activity without subsidies was examined. As a result, yield and price for which, in 2020, income will remain at the level of the base year, were calculated. At this point, we should mention that in this option it was assumed that total costs of cultivation will be running at the level anticipated for the year 2020 – table IV.5.3.

Table IV.5.3. Maximum deviation from the projection for the year 2020 of yield and price of sugar beets with the assumption that income from activity without subsidies will remain at the level of the base year (2013)

Specification	Level for 2013*	Projection for 2020	Deviations from the projection for 2020	
			Yield	Price
Yield of roots [dt/ha]	611	710	658	710
Selling price of roots [PLN/dt]	14.30	16.16	16.16	14.98
Per 1 ha of growing area, in PLN				
Total value of production	8754	11475	10635	
Total costs	6189	8070	8070	
Income from activity without subsidies	2564	3404	2564	

* 2013 – base for the projection model, the results reflect average values in the years 2011-2013.

Source: preparation on the basis of author's research.

Results of the projection presented that if price of roots and total costs of sugar beets cultivation remain at the level anticipated for the year 2020, yield enabling obtaining income from activity without subsidies at the level of the base year will have to be at least 658 dt/ha. In this situation, maximum deviation in yield *in minus* from the level of the projection may be 52 dt/ha (7.3%).

On the other hand, apart from total cultivation costs, if yield remains at the level anticipated for the year 2020, the selling price for roots of sugar beets that enables earning in 2020 income from activity without subsidies at the level of the base year will have to be at least 14.99 PLN/dt. Maximum deviation of price of roots down from the level expected for the target year of projection (i.e. 2020) may amount to 1.17 PLN/dt (7.3%).

To sum up the above discussion, it should be stated that in the perspective of 2020 in average production and price conditions, cultivation of sugar beets will be profitable. In spite of expected costs of cultivation higher by 30.4%, the dynamics of growth in the value of production (31.1%) will be stronger than in the case of costs. As a result, income from activity without subsidies will increase by 32.8%, ratio of cultivation profitability will also be high (142.2%) – higher by 0.8 p.p. than in the base year.

Analyzing the effect of unit changes in yield of sugar beets, selling prices of roots and costs of cultivation, it has been stated that the greatest impact on the level of income from activity without subsidies and on ratio of production profitability will be exerted by the change in price of roots, and the smallest impact will be exerted by the change in costs of cultivation.

Considering variability in yield and price in the last 19 years, it is assessed that in the perspective of 2020 change in yield of roots may be +/-53.6 dt/ha, and in their selling price +/-1.28 PLN/dt. Variability of yield (7.6%) was slightly smaller than variability of price of roots (7.9%), therefore the impact of yield on the level of income was slightly smaller than on price.

Results of the projection indicate also that to maintain in 2020 income from activity without subsidies at the level of the base year, yield may not fall below 658 dt/ha, and price – below 14.99 PLN/dt, given variability of costs of cultivation resulting from the trend.

It is estimated that share of subsidies in income from activity in 2020 will be lower than in the base year. However, subsidies will still improve clearly the income situation of producers of sugar beets.

V. Elements of time series' variability

The analysis of a time series may apply to all possible components and measurement of their sizes. The effect of impact of particular factors makes clarification of the course of a time series require analysis of its particular components. While modeling the behaviour of a time series with monthly or quarterly frequency, the following components may be separated in it: trend or constant level of phenomenon, cyclical fluctuations, seasonal fluctuations, irregular fluctuations, random fluctuations. All listed components of variability can occur with each other in any configurations or penetrate one another, which usually happens. In the analytical papers, one of the first stages is to separate particular components of a time series and measure their sizes.

The development trend refers to the presence of systematic, one-way changes (increase or decrease) in the level of analyzed phenomenon, taking place in the long run⁵⁹. The trend indicates long-term development direction of phenomenon, provides strategic, long-term information. The trend is usually permanent, and inversion of the direction involves new conditions, changing the previous strength and direction of impact of long-term factors on a given phenomenon. The development trend should be interpreted as overall direction of changes in the analyzed phenomenon in the long run⁶⁰.

The cyclicity manifests itself in regular recurrence of a certain scheme of fluctuations around the trend, or average level, and the period of fluctuations is longer than one year. Cyclicity is caused by changing economic conditions, related to business cycles in the economy⁶¹. Opinions on reasons for cyclical fluctuations in agriculture and its environment are different. Usually they indicate economic factors, biological and external reasons, e.g. droughts, which stimulate the presence of cycles. We should bear in mind that these fluctuations may be connected both with the general economic situation and occur in the form of commodity (special) cycles.

In practice, cyclical fluctuations and trends are difficult to distinguish if they co-occur and are predominantly estimated together as a component of the trend-cycle. Research on cyclicity of economic phenomena indicate that in time series several cycles of different period may occur at the same time. This is due to the fact of overlapping of different types of cycles.

⁵⁹ G. Józwiak, J. Podgórski, *Statystyka od podstaw*, PWE, Warsaw 1998.

⁶⁰ *Prognozowanie gospodarcze. Metody i zastosowania* (ed. M. Cieślak), PWN, 4th issue revised, Warsaw 2005.

⁶¹ As above.

Seasonal fluctuations are fluctuations in the value of variable around its trend or permanent (average) level, recurring within period that does not exceed one year. Most often annual fluctuations are observed. The reason for fluctuations with annual period covers usually natural factors, therefore they are termed as seasonal fluctuations⁶². Seasonality involves similar effects in supply of products, level of their prices, income, period of sustaining outlays, etc. Often the scale and character of seasonal changes are so big that hinder effectively analysis of long-term changes.

Irregular, accidental fluctuations are always occurring component of time series' variability. Among irregular changes we can distinguish effects caused by random factors, impossible to predict, such as: natural calamities, sudden changes in policy of the state, strikes and non-standard observations, among which, due to the character changes, the following changes can be separated:

- one-time (*additive outliers*), i.e. constituting an important deviation from the envisaged value of analyzed phenomenon only in one period, which do not affect the value of series in the next periods,
- long-term (*level shift*), i.e. causing permanent change in the variable level,
- causing temporary change in the variable level (*temporary change*), provided that return to the initial condition occurs predominantly in accordance with the exponential or linear function,
- innovative (*innovation outliers*), which, as opposed to the above concerned, cause change in the data generating process, in particular change in the form of trend. An innovative event may be, e.g. application of new production technology.

VI. Identification of the periodical structure of time series

Research on changes in prices of agricultural products provides various conclusions concerning periodical nature of fluctuations. Certainly, in this case we can refer to the presence of seasonal fluctuations. However, conclusions concerning fluctuations with longer cycle are encumbered with a great subjectivity. Although it may be assumed that cyclical fluctuations occur in the course of prices of agricultural products, some difficulties arise in the case of determining length of cycles, or the dominant cycle in total variance of prices. This situation results, among others, from overlapping periodical fluctuations of different lengths and various amplitude. For this reason, more and more often in quantitative

⁶² G. Józwiak, J. Podgórski, *Statystyka od podstaw*, PWE, Warsaw 1998.

research related to the examination of dynamics the spectral analysis is applied, which permits detection of the periodical structure of time series⁶³.

Application of the spectral analysis will permit identification of dominant periodical components in variability of the analyzed time series. Therefore, the assessment of presence of cyclical and seasonal fluctuations will be impartial. This analysis will eliminate also often adopted assumption as to the existence of a specified, non-random length of cycles of fluctuations. The *a priori* adoption of a specified length of the cycle may often result in drawing false conclusions with regard to the length of cycles of periodical fluctuations. In addition, the theory of stochastic approximation provides arguments holding that if we do not have non-stochastic information, a clear solution to this issues using only means of formal analysis is much hindered.

The spectral analysis reveals a complex structure of periodical fluctuations of time series by examination of their harmonics structure in partial aspect. The purpose of this analysis is decomposition of time series containing cyclical components into several basic sinusoidal functions (sinus and cosinus) with specific wavelengths. The spectral analysis permits identification of the correlation of sinus and cosinus functions with different frequency with observed data. This is the basis for concluding about periodicity of a given frequency. Indeed, using this technique we can identify and separate components of different lengths of period of fluctuations, and, at the same time, assess the importance of basic periodical components. A detailed test of spectral density may indicate the existence of various cycles, e.g. quarterly, annual or long-term⁶⁴.

The spectral analysis model comes down to the issues of multiple regression, in which a dependent variable is observed time series, and independent variables are sinus functions with all possible frequencies⁶⁵.

Since the sinus and cosinus functions are mutually independent, we can sum up squares of coefficients for each frequency, receiving values of the periodogram, which represent variance of fluctuations with specific frequency or period. The trend is the sum of all harmonics movements with a period no shorter than

⁶³ S. Drosiewicz, T. Michalski, *Analiza spektralna wybranych mierników aktywności gospodarczej*, Fundacja Promocji Rozwoju im. E. Lipińskiego, Warsaw 1996; W. Łuczyński, Z. Matkowski, *Analiza spektralna syntetycznych wskaźników koniunktury dla gospodarki polskiej, Z prac nad syntetycznymi wskaźnikami koniunktury dla gospodarki polskiej*, IRG SGH Warsaw 1997.

⁶⁴ M. Idzik, S. Gędek, *Analiza widmowa szeregów czasowych cen produktów rolnych*, Przegląd Statystyczny PAN, Volume 49, Warsaw 2002.

⁶⁵ Description of the method can be found in the papers: Bloomfield (1976), Jakubczyc (1984), Talaga, Zieliński (1986), Shumway (1988), Wei (1989), Drosiewicz, Michalski (1996), Radzikowska (1999).

the period covered by the analysis. The trend will be defined as fluctuations from the scope of frequencies close to zero, while seasonal component will be defined as fluctuations with frequencies from the scope $(\pi/6, \pi)^{66}$.

Values of the periodogram are subject to random fluctuations. More clear image of hidden periodicities appears often only when we examine spectral density, namely areas of frequency which have the greatest contribution in general harmonic structure of a time series. If there are no significant cyclical fluctuations in the time series, the distribution of values of the periodogram corresponds to the exponential distribution. Therefore, when testing the distribution of the periodogram in respect of exponential distribution, we can check whether the time series differs from white noise. Additionally, we can calculate statistics d Kolmogorov-Smirnov for one sample. In addition, the significance of components of harmonics can be tested using F -Snedecor statistics and t -Student test.

In this paper time series of monthly data were subject to spectral analyses for the purpose of identification of dominant cyclical components. The functions of spectral density were determined after elimination of trend and average⁶⁷. The analysis is based on the results obtained by means of Parzen window⁶⁸. Charts of spectral density present spectra of series removed from data throughout the entire compartment of the analyzed frequencies covering also low frequency equal to 0 per time unit, corresponding to length of cycle equal to the number observations in the examined time series. This presentation of charts of spectral density does not facilitate interpretation of spectral peaks at high frequencies, however, in the case of extrapolative nature of this analysis has a great cognitive value, as we are interested in full scope of possible fluctuations.

The values of spectral density are presented usually in respect of frequencies, however, to increase legibility of charts, they are presented in respect of periodicity (reverse frequencies). Since values of functions of spectral density can be

⁶⁶ S. Drosiewicz, T. Michalski, *Analiza spektralna wybranych mierników aktywności gospodarczej*, Fundacja Promocji Rozwoju im. E. Lipińskiego, Warsaw 1996.

⁶⁷ In order to identify periodical fluctuations in a time series, it is advisable to remove trend and average. If the average is not removed, it will be disclosed as a high coefficient of cosine at 0 frequency (the process average can be treated as a cycle with frequency of 0 per time unit). Often, it is a reason for exceptionally high value of the periodogram at this frequency, which makes it difficult to identify other local maxima on the periodogram or charts of spectrum density. In the case of lack of elimination of the trend, the periodogram assumes exceptionally high values for the lowest frequency different from zero, which also makes it difficult to identify other local maxima.

⁶⁸ Detailed information on the selection criteria of particular spectral windows can be found in the paper by Jakubczyc (1984, pp. 17-29) and Łuczyński (1998, p. 179).

interpreted for particular frequencies as share of harmonic fluctuations with a given frequency in the overall variance of the process, we can assume as Zieliński⁶⁹ the following principles of interpretation of the spectral density curve:

- high values of the spectral density function for low (close to zero) frequencies prove the presence of a strong trend. The more flat the curve, the less clear the trend;
- presence of peaks (for frequency different than relevant for the trend) of the curve proves the presence of cyclical fluctuations. The more steep the tops, the more clear the cyclicity;
- the course of the curve of the periodogram parallel to the X-axis implies the lack of trend and cyclical and seasonal fluctuations.

VII. Methods of the analysis of changes of time series in time

The theory of analyzing time series makes use of many different statistical methods, starting from the simplest methods through different analytical models. In the analysis the following was made:

- seasonal adjustment by means of the method Census II X-11,
- detrendization by means of Hodric-Prescot filter,
- derandomnalization to eliminate the impact of random factors, using a moving average, using MCD method (months of cyclical dominance),
- identification of turning points according to the assumptions of Bry-Boschan method,
- identification of descriptive statistics typical of the examined time series.

1. Seasonal adjustment by means of the method Census II X-11

One of methods that enables determining changes in seasonality is a multi-stage procedure of seasonal decomposition Census X-11⁷⁰. Analysis with the use of Census II X-11 is the basis for restoration of an empirical image of fluctuations which cover the analyzed phenomena. It is a necessary element of evaluation of properties of the examined time series in terms of their usefulness in

⁶⁹ Z. Zieliński, *Metody analizy dynamiki i rytmiczności zjawisk gospodarczych*, PWN Warsaw 1979.

⁷⁰ The Census-X11 method was developed by the US Bureau of Census in the 1960s and gained wide recognition among practitioners. It is applied mainly in the analysis of production changes, where adjustment due to the number of working days and non-standard events is significant. The description of the method can be found in the paper by: Wheelwright, S. Makridakis (1989).

short-term forecasts. It is commonly considered as one of the best tools used in analyzing economic phenomena in the world⁷¹. The method is based on the assumption that in the dynamics of economic processes three or four dynamics components can be separated: seasonal fluctuations (S), irregular changes, expressing certain one-time disorders (I), cyclical fluctuations, included together with trend or separately (TC, or C) and long-term linear or non-linear trend (T). Components (S), (I) and (TC) are separated using Census II X-11 and for separation of trend and cycle (TC) and (C), Hodric-Prescott (HP) filter is used most often.

In the analysis of cyclical changes the concept of cycle based on analysis of deviations from trend was used. In the course of empirical analysis a positive or negative verification can be conducted of hypotheses about the presence in a given process of components of particular dynamics, their relative independence and required stability of the distribution. Only after examination of empirical distributions of variability, we can resign from separation of insignificant or too irregular dynamics components (e.g. seasonal changes) and include them together with irregular changes. The use of techniques of decomposition of time series is thus purposeful not only in the cases of obvious seasonality, but also when we want only to be ensured that the discussed process is not burdened with a significant seasonality.

Seasonal adjustment⁷² is conducted through an iterative procedure of smoothing time series, based on moving averages and covering the following steps⁷³:

1. calculation of 12-term (in the case of monthly data) moving average as the first approximation of the trend-cycle, receiving the coefficient (S and I);
2. from calculated in the previous step coefficients S and I, expressing the sum of seasonal and irregular component, 5-periodical moving average is determined as an initial estimation of seasonal component for each month;

⁷¹ S.C. Wheelwright, S. Makridakis, *Forecasting Methods for Management*, John Wiley, New York 1989.

⁷² The seasonal adjustment procedure Census II X-11 was developed in 1980 and improved in 1988 by Dagum in the Statistical Office of Canada as development of the method II/X11 of the earlier used in the US Bureau of Census. The procedure Census II X-11 performs three basic functions – according to B. Dagum, X11-ARIMA/88. *Seasonal Adjustment Method – Foundations and User's Manual*, Ottawa 1988, tj. seasonal adjustment of time series, decomposition of time series into irregular, seasonal, cyclical component and trend, and extrapolation forecast with 12-month horizon.

⁷³ E.B. Dagum, X11-ARIMA/88, *Seasonal Adjustment Method – Foundations and User's Manual*, Ottawa 1988; I. Kudrycka, R. Nilsson, *Cykle koniunktury w Polsce analiza wstępna*, Z prac Zakładu Badań Statystyczno-Ekonomicznych GUS i PAN, Volume 209, Warsaw 1993; OECD 1987: *Leading Indicators and Business Cycles in Member Countries*. Sources and Methods 1960-1985 NO-39.

3. results of preliminary estimation of seasonal components are adjusted by means of 12-periodical centered moving average;
4. coefficients S and I, calculated in item 1, are divided by adjusted by initial estimates of seasonal component to determine irregular component;
5. extreme values of irregular component are eliminated or adjusted on the basis of analysis of 5-periodical moving standard deviations of irregular component;
6. to coefficients SI cleared from extreme values 5-periodical moving average is applied, to re-estimate seasonal components;
7. seasonal indicators determined in this way are re-adjusted by means of centered moving average;
8. preliminary estimation of the seasonally leveled time series proceeds by dividing the primary time series by seasonality factor obtained in item 7;
9. in order to separate growth-cyclical factor from the time series cleaned in this way, the so-called Henderson filter is used in the form of 9-, 13-, or 23-term moving average, with length selected according to the ratio of irregular component to trend⁷⁴. By dividing the output time series by the trend-cycle estimated in this way, we obtain the second approximation of the estimations of seasonality coefficients and irregular changes SI;
10. from coefficients SI calculated for each month separately 7-periodical weighed average is determined, with specification dependent on general value of SI, obtaining in this way the second approximation of the estimation of seasonality coefficients;
11. step 3 is conducted again, by calculating 12-month centered moving average from seasonality coefficients and by adjusting them by this average;
12. the output time series is divided by designated in item 11 seasonality coefficients, obtaining the final seasonally leveled time series.

⁷⁴ Depending on the size of I/C quotient, the following Henderson moving averages are applied: Quotient I/C (0.00-0.99), 9-term Henderson moving average, I/C (1.00-3.49), 13-term Henderson moving average and I/C \geq 3.5 accordingly 23-term Henderson moving average according to I. Kudrycka, R. Nilsson, Cykle koniunktury w Polsce: *analiza wstępna*. Z prac Zakładu Badań Statystyczno-Ekonomicznych GUS i PAN, Volume 209, Warsaw 1993.

Due to multiple estimation of results, the received estimators of seasonal fluctuations (ratios) for homologous periods do not accept equal values in particular years, both in the additive model and multiplicative model. We are, therefore, dealing with the possibility of presenting variable type of seasonality that is most often present in business practice.

Statements contain characteristics of the most important features of variability of the examined time series analyzed with the use of Census II X-11. The following was specified: average length of one-way changes (ADR average duration of run) of irregular, cyclical and cyclical component together with irregular component, number of months necessary to ensure that changes observed in the time series are cyclic, rather than irregular, namely MCD (months for cyclical dominance), share of irregular component I, seasonal component S of trend T and cycle C in the observed variability. It shows relative sizes of components in changes in prices depending on duration of changes and their significance in explanation of price variance and relations between components.

2. Detrending by Hodric-Prescot filter

An important stage of the empirical analysis of series is to separate long-term trends from cyclical fluctuations. This is a starting point for determination of cyclical components of changes in the examined time series. The trend and cyclical fluctuations were separated by means of Hodric-Prescot filter (HP) whose smoothed values were the level of trend (T). Filtration is the second, apart from analytical, method of evaluation of development trend related to some forms of local data averaging. These methods are intended to obtain approximate image of trend, and the effect depends on the nature of filter that will be used. In our case, maximum level of the value of smoothing parameter (9999) was used, which enabled to obtain quite smoothed level of trend not containing condition-dependent variability⁷⁵.

It is important to remember that, regardless of the method of substantiation and technique of determining development trend (T), the procedure of separation of "pure trend" and "pure cycle" was often criticized as artificial and risky. Substantive reservations raises, first of all, underlying grounds of this concept, assumption of mutual independence of long-term dynamics and short-term fluctuations. The separation of "upward" and "cyclical" element of the development process is, in the light of this criticism, a conventional and insufficiently justified

⁷⁵ H. Ongena, *Seasonal Adjustment of European Community External Trade Statistics: Application of X11-ARIMA/88*, Workshop on Opinion Surveys for Business and Consumers and Time Series Analysis, Munich 1991.

action, exactly because of dependence of the trend and cyclical fluctuations as phenomena based on similar or identical set of factors.

3. Derandomisation using the concept Months of Cyclical Dominance

The accidental component was removed by means of moving average with width of smoothing window equal to MCD, namely number of months necessary to extraction of cyclical changes (MCD-Month for Cyclical Dominance). MCD is used to test relations between systematic and random changes in the evaluation of suitability of time series when testing the business situation. It consists in estimating the period of units of time that are, at the same time, the basis for the shortest moving average, for which average absolute change in elements of the trend and cycle in a given period is equal to or greater than average absolute change in irregular elements. The lowest obtained value for which this condition is met is MCD⁷⁶.

In practice, the obtained MCD is the number of months that on average must "merge" until the development of systematic elements, namely until the trend and condition-dependent fluctuations, has exceeded the development of irregular elements, which is reflected in the I/TC relation, lower than one. This measure shows thereby the duration of period for which it is necessary to wait so that the observed on the curve of empirical values change in shaping these values could be with all confidence considered as a new phase of the cycle⁷⁷. MCD equal to e.g. 3, means that already after 3 months of one-way upward or downward change of the analyzed variable, we can assume that it characterizes a new phase of the cycle, rather than temporary irregular fluctuations.

4. Identification of turning points according to the assumptions of Bry-Boschan method

The basis for determining turning points and identifying main cyclical fluctuations in time series is a method based on the concept of trend determined based on Bry-Boschan procedure⁷⁸. It consists in using a set of moving averages to determine trend and then to determine turning points. For this purpose moving averages are calculated of different lengths, starting from the most smoothed long-term curves, e.g. 75-month average, Spencer's curve and

⁷⁶ R. Barczyk, Z. Kowalczyk, *Metody badania koniunktury gospodarczej*, PWN Warsaw-Poznań 1993.

⁷⁷ The moving average with the period equal to MCD is of fundamental importance in the cycle analysis and in the identification of turning points.

⁷⁸ R. Nilsson, *OECD Leading Indicators and the Phase Average Trend Method*. OECD Economic Studies no. 9, 1991.

12-month average, to short-term, 3-5 month average, and finally a series of raw data without trend⁷⁹. The procedure of searching turning points is repeated on various types of smoothed curves in order to find turning points that correspond preferably to variability observed in the output series, from which seasonal fluctuations were eliminated⁸⁰. Turning points are those which meet the following conditions⁸¹:

1. have extreme sizes obtained on the curve of empirical values, from which seasonal, accidental fluctuations and also development trend were eliminated;
2. top turning point – initial point of phase of continuous slope lasting minimum five months;
3. bottom turning point – final point of the phase of slope, and, at the same time, initial point of the phase of growth lasting minimum five months;
4. turning points on the curve of empirical values, after eliminating seasonal, accidental fluctuations and development trend, are to be in a direct neighborhood of points separated on the MCD curve;
5. the first and the last isolated top (bottom) point must achieve at least as high (low) value as any element of the series, located at the beginning or at the end of the series, relatively as elements between the turning points;
6. turning points lying in the radius of a five-month period from the beginning and from the end of the analyzed period are eliminated;
7. turning points at both ends of the series with values higher (lower) than values recorded closer the edge are eliminated;
8. economic cycles shorter than fifteen months are eliminated;
9. cyclical changes include only these, in the case of which at least four turning points can be determined, which means the occurrence of at least two full cycles;
10. peaks and troughs must be alternate.

⁷⁹ R. Nilsson, *OECD Leading Indicators and the Phase Average Trend Method*. OECD Economic Studies no. 9, 1991.

⁸⁰ R. Barczyk, Z. Kowalczyk, *Metody badania koniunktury gospodarczej*, PWN Warsaw-Poznań 1993.

⁸¹ OECD 1987: *Leading Indicators and Business Cycles in Member Countries*. Sources and Methods 1960-1985 NO-39; Z. Matkowski, *Problemy identyfikacji cykli koniunkturalnych, Z prac nad syntetycznymi wskaźnikami dla gospodarki polskiej*. Volume 51, IRG SGH Warsaw 1997; Z. Matkowski, *Cykle w rozwoju gospodarki polskiej. Barometry koniunktury dla gospodarki polskiej*, IRG SGH Warsaw 1999.

Some of these criteria (especially 6 and 9) are considered, however, as too restrictive with regard to the economy with a less regular course and not fully shaped mechanism of cyclical changes, such as the Polish economy at the present stage of development⁸².

5. Determination of descriptive statistics characterizing of the examined time series

Apart from the estimation of principal components of time series, various descriptive statistics were calculated:

- percentage monthly changes in time series and its particular components, depending on duration of changes,
- percentage share of selected components of time series of prices in their total variability, depending on duration of change,
- MCD values that indicate period that is necessary so that changes resulting from action of long-term component (TC) would equal changes resulting from action of accidental component. It is also consistent with the fact that after such a period of one-way changes in moving average (from the turning point) we can be sure as to the correctness of long-term trend.

VIII. Empirical analysis of price changes in the years 2001-2014

Formal and statistical characteristics of the examined time series made it possible to specify their structure and indicate special characteristics of dynamics of the examined prices from the point of view of short-term forecasting. Charts and tabular specifications present:

- the process of shaping prices and their particular components in time;
- the share of particular components in variability, depending on duration of changes;
- percentage changes in particular components, depending on time horizon;
- share of seasonal component and stability of seasonality pattern;
- the number of months necessary for disclosure of condition-dependent changes (MCD).

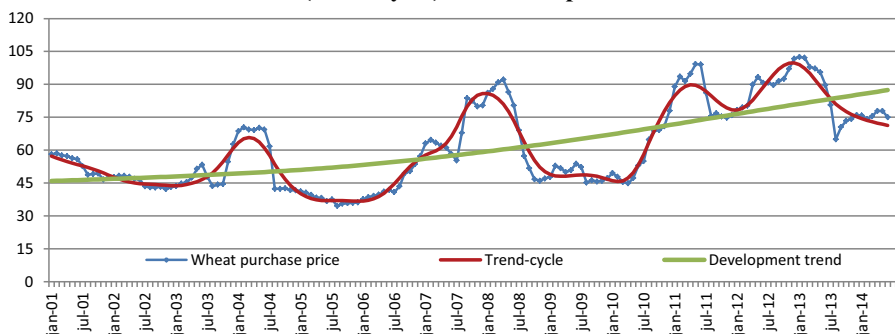
⁸² R. Barczyk, Z. Kowalczyk, *Metody badania koniunktury gospodarczej*, PWN Warsaw-Poznań 1993; Z. Matkowski, *Problemy identyfikacji cykli koniunkturalnych, Z prac nad syntetycznymi wskaźnikami dla gospodarki polskiej*. Volume 51, IRG SGH Warsaw 1997; Z. Matkowski, *Cykle w rozwoju gospodarki polskiej. Barometry koniunktury dla gospodarki polskiej*, IRG SGH Warsaw 1999.

The analysis was conducted for nominal prices according to the projection assumptions presented in subsequent chapters.

1. Analysis of changes in wheat buying-in prices

Testing the course of the time series of wheat buying-in prices indicates the presence of all four main variability components, i.e. development trend, cyclical fluctuations, seasonal fluctuations and accidental fluctuations (Chart VIII.1.1).

Chart VIII.1.1. Prices of wheat buying-in prices in PLN/100 kg along with long-term trend (trend-cycle) and development trend

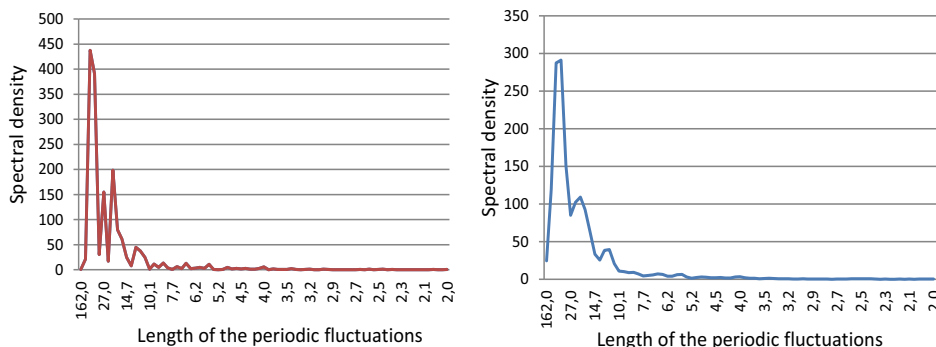


Source: prepared by the author on the basis of data of the Central Statistical Office (GUS).

Cyclical fluctuations become visible as recurring oscillations around the trend lines. Another phenomenon disclosing in the case of the time series of wheat buying-in prices is overlapping of different kinds of variability. Cyclical fluctuations run around the trend line, on the other hand seasonality is disclosed as deviations in respect of the so-called trend-cycle line. The outlined development trend is determined substantially by inflationary factor.

In the course of the time series of wheat buying-in prices periodical changes occur, and we may notice that the meaning of cyclical component is greater than of seasonal component (Chart VIII.1.3 and Chart VIII.1.4). Similar conclusions can be drawn from the analysis of spectrum density values (Chart VIII.1.2). The dominating values of spectral density were identified for fluctuations with cycle of 44, 20 and 12 months. It means presence of cyclical fluctuations as well as seasonal fluctuations. Average length of cyclical changes is 3.7 years, and cycles have different length and amplitude of changes. It is confirmed by turning points of cyclical changes. Distribution of the bottom turning points of wheat buying-in prices is: January 2003, January 2006, April 2010, January 2012. On the other hand, distribution of top turning points of wheat buying-in prices is: March 2004, December 2007, April 2011, November 2012.

Chart VIII.1.2. Periodogram (left) and smoothed with Bartle weights (65) periodogram (right) of spectral density of the time series of wheat buying-in prices

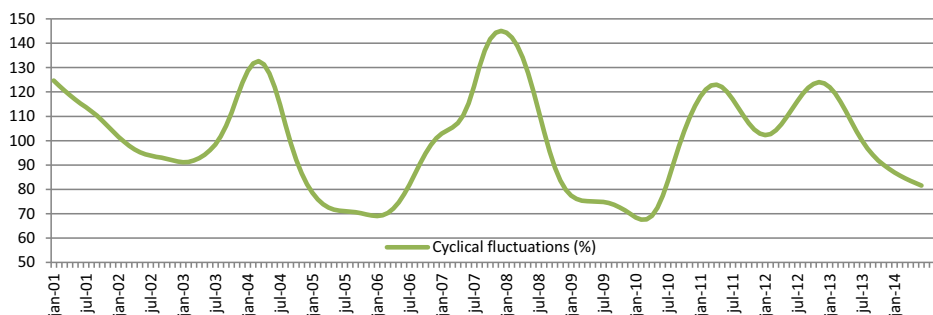


Source: prepared by the author on the basis of data of the Central Statistical Office (GUS).

The pattern of cyclical changes, provided that is periodical than each sequence of changes shows another intensity of particular phases, different distribution of turning points and different characteristics of the so-called troughs and peaks of different cycles (Chart VIII.1.3).

A characteristic feature of the course of wheat buying-in prices is a significant modification of the pattern of course of cyclical fluctuations (Chart VIII.1.3). Since 2011, another, as compared to the previous years, morphology of cyclical fluctuations has been visible. A consequence of this condition is the limited possibility of using the previous pattern of the course as determinant of building forecasts for the next periods.

Chart VIII.1.3. Cyclical fluctuations in wheat buying-in prices as % of deviations of the long-term trend

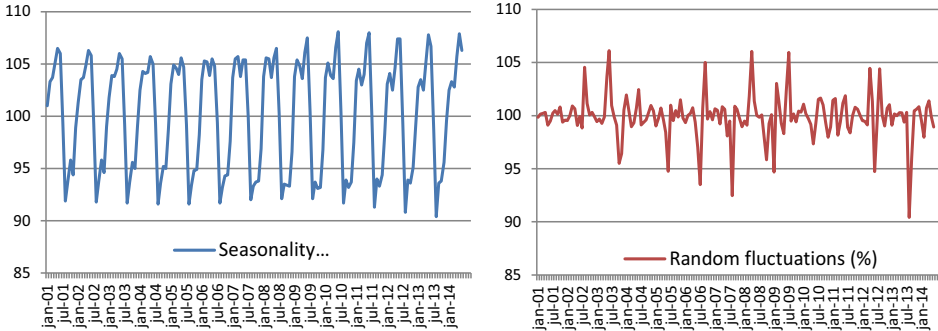


Source: prepared by the author on the basis of data of the Central Statistical Office (GUS).

The scale of cyclical fluctuations is diverse, and the maximum amplitude over the whole analyzed period was 79 p.p. In the case of cyclical component, maximum change amplitude was between 68% and 143% of the value of the

long-term trend, which is a deviation of ± 37.5 PLN/dt in respect of the average price resulting from the long-term trend.

Chart VIII.1.4. Seasonal and accidental fluctuations in wheat buying-in prices as % of deviations of the long-term trend



Source: prepared by the author on the basis of data of the Central Statistical Office (GUS).

In the case of seasonal fluctuations, we can observe growth in the amplitude of seasonal changes over the analyzed years (Chart VIII.1.4). For example, at the beginning of the analyzed period in 2001, the value of multiplicative seasonality ratios was 106.5% in May, 91.9% in August with respect to the trend-cycle values. In 2013, in May deviation was 107.8% and in August 94.20%, respectively. The modification covers also the pattern of seasonality, starting from 2009, seasonal growth in prices can be observed in May, whereas in the previous years it could be observed also in February.

Relative share of trend and cycle (TC) of wheat prices in its total variance on average in a year is 72.67%, while seasonality explains on average 17.82% of variability of the time series. In turn, the share of accidental component in the variance of the time series of wheat buying-in price is 9.51% (Table VIII.1.1). The value of MCD for wheat buying-in prices is 3.75, which means that after almost 4 months of one-way changes, long-term component (TC) became equal to changes resulting from accidental component. Maximum change amplitude amounted to 28 p.p. In relation to the last year, the value of the aforementioned statistics did not change.

Apart from the average values, from the point of view of risk and forecasting, the share of particular fluctuations (components) depending on time horizon of changes is significant. For example, when forecasting three months in advance, we need to bear in mind that long-term changes (TC) determine in more than 64% the correctness of such a forecast, while seasonal fluctuations only in 26.55%, but already by formulating the annual forecast key importance is

attained to long-term changes – their significance is 98.94%, respectively. On the whole, the regularity is such that along with increasing horizon of examined changes, the significance of long-term component increases, while the significance of short-term fluctuations (seasonal and accidental) decreases.

Table VIII.1.1. Relative share of selected components of the time series of wheat prices in their total changes, depending on their duration

Share of particular components of wheat prices in its total variance, depending on duration of changes (%)			
Months	I	TC	S
1	27.10	42.87	30.02
2	16.35	54.92	28.73
3	8.79	64.66	26.55
6	2.63	76.65	20.72
9	1.17	97.97	0.86
12	1.04	98.94	0.01
Average	9.51	72.67	17.82

Source: prepared by the author on the basis of data of the Central Statistical Office (GUS).

Also the nature and the scale of accidental changes are important (Table VIII.1.1). In the case of wheat buying-in price, accidental fluctuations are on average 9.51% of total variability of this time series, which is a relatively small part of total fluctuations.

Table VIII.1.2. Average percentage changes in the time series of wheat prices and their selected components, depending on duration of change

Change in particular components of the time series of wheat prices, depending on duration of change (%)					
Months	Nominal prices	TCI	I	TC	S
1	4.61	4.05	2.50	3.15	2.64
2	8.24	7.41	3.38	6.20	4.49
3	11.35	10.36	3.35	9.08	5.82
6	18.88	17.43	3.09	16.65	8.66
9	25.16	24.10	3.29	23.25	5.85
12	29.05	29.09	2.96	28.89	0.35

Source: prepared by the author on the basis of data of the Central Statistical Office (GUS).

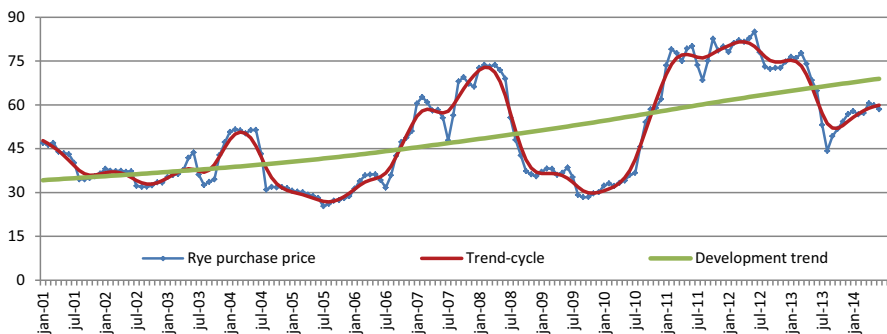
From the point of view of evaluation of variability as one of elements used for risk assessment, the analysis can cover also the character of changes in percentage perspective (Table VIII.1.2). The average change in prices within one year is nearly 30%, and is the result of long-term changes in components forming trend and cycle. On the other hand, within 6 months, prices change on average by 18.88%. In the same period, a component of the long-term trend (TC)

changes by 16.65%, and seasonal fluctuations change by 8.66%. The longer the forecast horizon, the greater the significance of changes in the form of trend-cycle. This conclusion justifies the assumptions adopted in the previous parts of the paper regarding forecasts formulated on the basis of development trends.

2. Analysis of changes in rye buying-in prices

The course of the time series of rye buying-in price in the sense of directions and sequences of changes in time is very similar in relation to morphology of changes in wheat buying-in prices. The main difference applies to the level around which fluctuations oscillate. Like in the case of wheat buying-in price, we can observe the presence of development trend, cyclical fluctuations, seasonal fluctuations and accidental fluctuations (Chart VIII.2.1). A characteristic feature of the course of cyclical fluctuations is a multiplicative dependence, in accordance with which, along with growth in the trend, the amplitude of cyclical fluctuations increases. This nature of development of the phenomena should be taken into account when formulating forecasts on the basis of the development trend itself, as accuracy of such reasoning decreases clearly with increasing forecast horizon. Then we say that a prognostic model becomes outdated.

Chart VIII.2.1. Rye buying-in prices in PLN/100 kg along with the long-term trend (trend-cycle) and the development trend

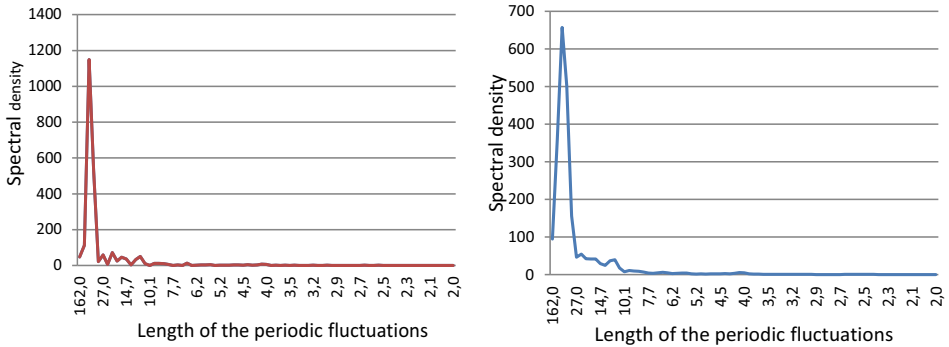


Source: prepared by the author on the basis of data of the Central Statistical Office (GUS).

The mid-term variability of the time series of rye buying-in price is determined by the occurrence of periodical fluctuations. Testing the periodogram of spectral density values of the time series of rye buying-in price confirms the presence of variability in the form of periodical fluctuations with a cycle of 40 months (Chart VIII.2.2). Critical importance is attained to cyclical fluctuations, which, with regard to morphological properties, are very similar to fluctuations observed in the case of changes in wheat prices. Also in this case, the

amplitude of cyclical changes is almost five times greater in relation to the amplitude of seasonal fluctuations in rye prices (Chart VIII.2.3 and Chart VIII.2.4).

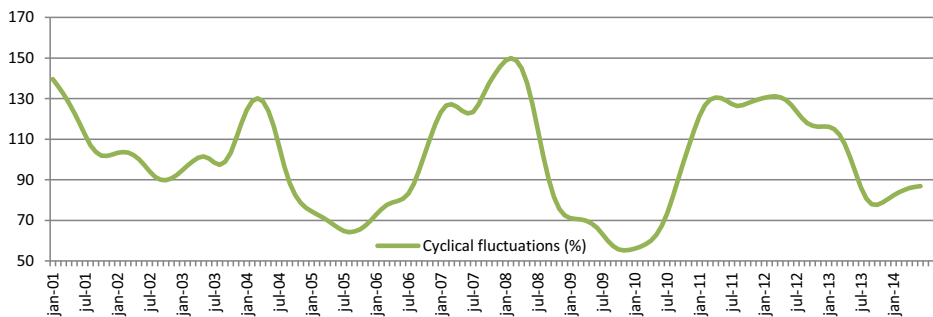
Chart VIII.2.2. Periodogram (left) and smoothed Bartlett weights (65) periodogram (right) of spectral density of the time series of rye buying-in prices



Source: prepared by the author on the basis of data of the Central Statistical Office (GUS)

In the analyzed period, changes covered the pattern of cyclical changes, morphology of particular cycles differs in intensity of particular phases, distribution of turning points or characteristics of the so-called troughs and peaks of particular cycles (Chart VIII.2.3). Average length of cyclical changes is the same as in case of wheat prices and is approximately 3.7 years. Distribution of the bottom turning points of rye buying-in prices is: October 2002, October 2005, November 2010, December 2013. On the other hand, distribution of the upper turning points of rye buying-in prices is: April 2004, May 2008, April 2011.

Chart VIII.2.3. Cyclical fluctuations of rye buying-in prices as % of deviations of the long-term trend

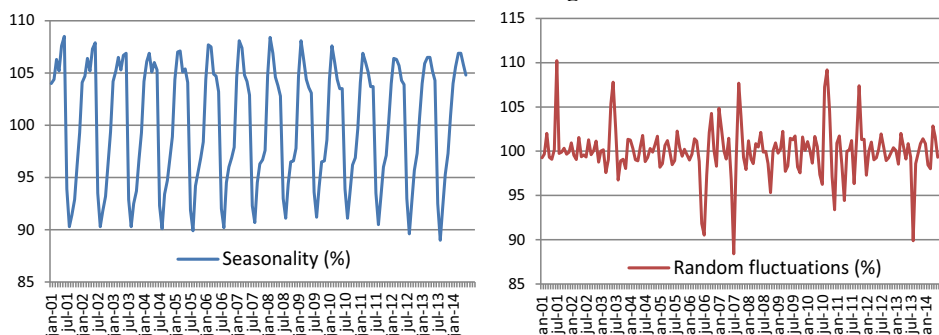


Source: prepared by the author on the basis of data of the Central Statistical Office (GUS).

The scale of cyclical fluctuations is diverse, and their maximum amplitude over the whole analyzed period was 48.14 p.p. In the case of cyclical component, the maximum change amplitude was between 55% and 150% of the values of the long-term trend.

In the case of seasonal fluctuations, we can observe a relatively stable amplitude of seasonal changes from the beginning of 2010 (Chart VIII.2.4).

Chart VIII.2.4. Seasonal and accidental fluctuations of rye buying-in prices as % of deviations of the long-term trend



Source: prepared by the author on the basis of data of the Central Statistical Office (GUS).

Relative share in trend and cycle (TC) of wheat prices in its total variance on average in a year is 65.73%, while seasonality explains on average 23.52% of variability of the time series. In turn, the share of accidental component in the variance of the time series of rye buying-in price is 10.74% (Table VIII.2.1). When forecasting based on the time series of rye buying-in prices with an annual horizon, we need to bear in mind that long-term changes (TC) determine in more than 98.9% the correctness of such a forecast, while seasonal fluctuations determine the correctness only in 1.08%.

Table VIII.2.1. Relative share of selected components of the time series of rye prices in their total changes, depending on their duration

Share of particular components of wheat prices in its total variance, depending on duration of changes (%)			
Months	I	TC	S
1	29.68	34.00	36.32
2	18.89	44.28	36.83
3	10.45	52.61	36.95
6	2.98	67.03	29.99
9	1.37	97.57	1.06
12	1.08	98.90	0.01
Average	10.74	65.73	23.52

Source: prepared by the author on the basis of data of the Central Statistical Office (GUS).

The value of MCD of rye buying-in prices is 3.4, which means that after 3 months of one-way changes, long-term component (TC) became equal to changes resulting from accidental component.

Table VIII.2.2. Average percentage changes in the time series of rye prices and their selected components, depending on duration of change

Change in particular components of the time series of rye prices, depending on duration of change (%)					
Months	Nominal prices	TCI	I	TC	S
1	5.48	4.29	2.94	3.14	3.25
2	9.56	7.62	4.04	6.18	5.64
3	12.99	10.48	4.04	9.07	7.60
6	21.31	18.18	3.65	17.29	11.57
9	28.00	26.24	3.72	25.47	7.64
12	33.74	33.76	3.49	33.34	0.40

Source: prepared by the author on the basis of data of the Central Statistical Office (GUS).

In the general variability in rye prices accidental fluctuations are more important as compared to wheat buying-in price, on the other hand the role of trend-cycle decreases. Despite this, long-term changes surpass seasonal changes already after two months of observation (Table VIII.2.1). In such a horizon, long-term changes in price (TC) are on average 6.18%, while seasonal changes are 5.64%. Average changes in the prices during the annual period are 33.74% and result mainly from trend-forming factors and cyclical fluctuations.

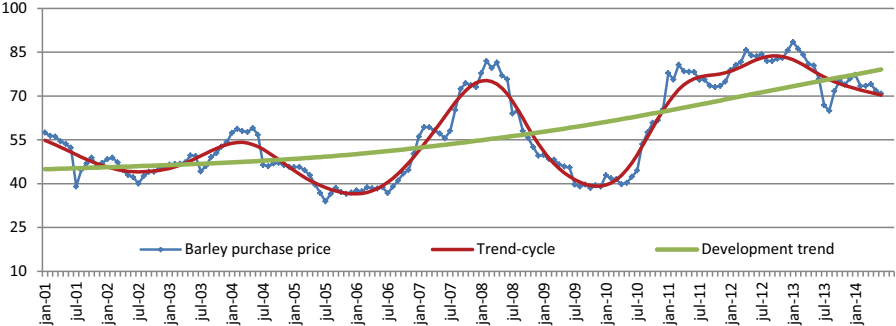
3. Analysis of changes in barley buying-in prices

Testing of the course of the time series of barley buying-in price indicates the presence of all four main variability components, i.e. development trend, cyclical fluctuations, seasonal fluctuations and accidental fluctuations (Chart VIII.3.1). A characteristic feature of the course of barley buying-in prices, like in the case of wheat buying-in prices, is the modification of the pattern of course of cyclical fluctuations (Chart VIII.3.3).

The analysis of value of spectral density of the time series of barley buying-in prices shows similar types of variability as in the observed case of rye buying-in prices. From among periodical fluctuations, critical importance can be attained to cyclical fluctuations, dominant in the cycle of 54 months (Chart VIII.3.3). Like in the case of rye buying-in prices, modification of the pattern of changes can be observed in time. Each cycle shows a different intensity of particular phases and a different distribution of cycles' turning points (Chart VIII.3.3). Average length of cyclical changes is approx. 4 years, and cycles have different length and amplitude of changes. It is confirmed by turning points of cyclical changes. Distribution of bottom turning points of the barley buying-in prices is: July 2002, January 2006, January 2010. On the other hand,

distribution of top turning points of the barley buying-in prices is: April 2004, March 2008, October 2012.

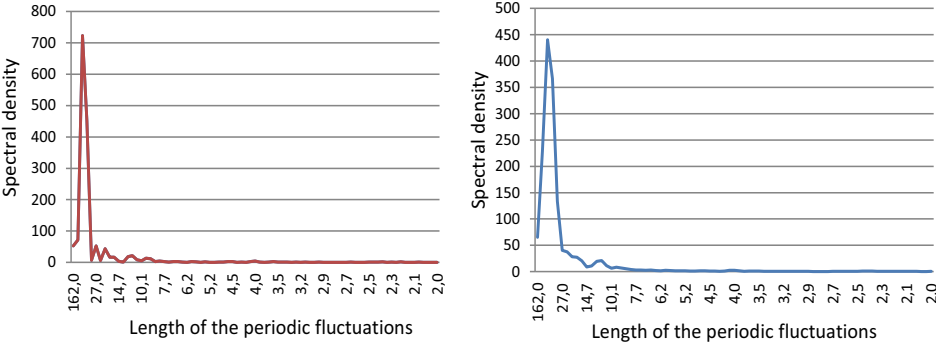
Chart VIII.3.1. Barley buying-in prices in PLN/100 kg along with long-term trend (trend-cycle) and development trend



Source: prepared by the author on the basis of data of the Central Statistical Office (GUS).

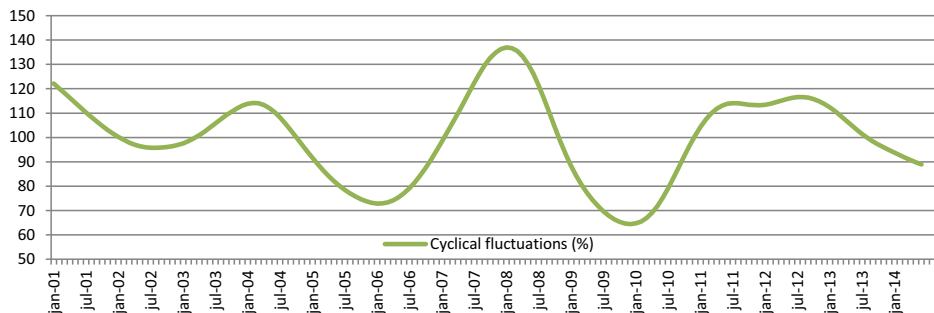
The scale of cyclical fluctuations is diverse, and the maximum amplitude over the whole analyzed period was 76.6 percentage points. In the case of cyclical component, the maximum amplitude of changes was between 63.1% to 139.7%, with respect to the average price resulting from a long-term trend.

Chart VIII.3.2. The periodogram (left) and smoothed with Bartle weights (65) periodogram (right) of spectral density of the time series of barley buying-in prices



Source: prepared by the author on the basis of data of the Central Statistical Office (GUS).

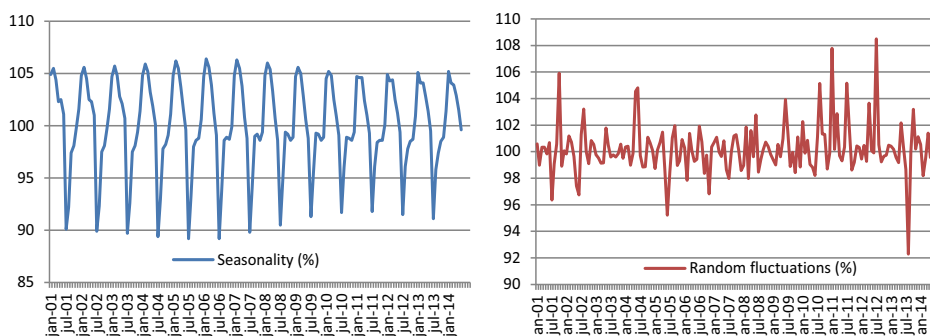
Chart VIII.3.3. Cyclical fluctuations of the barley buying-in prices as % of deviations of long-term trend



Source: prepared by the author on the basis of data of the Central Statistical Office (GUS).

In the course of the time series of barley buying-in prices, the impact of seasonality is also visible and, on the basis of the range of amplitudes we may notice that the meaning of cyclical component is a few times greater than of seasonal component (Chart VIII.3.4). In the case of seasonal fluctuations, after the period of growth in the amplitude of seasonal changes in the years 2005-2006, we can notice a return to the amplitude observed in 2001 (Chart VIII.3.4). For example, in 2001, the value of multiplicative seasonality indicators was in January 105.5%, in July 90.1% with respect to the trend-cycle values. In 2013, in January, deviation was 105.1%, in July 91.1% of the average level of prices in the year.

Chart VIII.3.4. Seasonal and accidental fluctuations in barley buying-in prices as % of deviations of long-term trend



Source: prepared by the author on the basis of data of the Central Statistical Office (GUS).

Table VIII.3.1. Relative share of selected components of the time series of the barley buying-in prices in their total changes, depending on their duration

Share of particular components of barley prices in its total variance, depending on duration of changes (%)			
Months	I	TC	S
1	25.39	35.85	38.75
2	11.19	52.48	36.33
3	6.52	62.77	30.71
6	1.69	80.35	17.96
9	0.64	98.25	1.11
12	0.71	99.28	0.01
Average	7.69	71.50	20.81

Source: prepared by the author on the basis of data of the Central Statistical Office (GUS).

Relative share of trend and cycle (TC) of barley prices in total price variance was, on average, 71.50%, and seasonality explains on average 20.81% of variability of the time series, and accidental fluctuations account for 7.69%. When forecasting the time series of barley buying-in prices with an annual horizon, we need to bear in mind that long-term changes (TC) determine in 99.28% the correctness of such a forecast, while seasonal fluctuations determine it only in 0.01%. However, the forecast formulated with a quarter horizon will depend in 30.71% on the impact of seasonal factors (Table VIII.3.1).

Table VIII.3.2. Average percentage changes in the time series of barley prices and their selected components, depending on duration of changes

Change in particular components of the time series of barley prices, depending on duration of change (%)					
Months	Nominal prices	TCI	I	TC	S
1	4.01	3.24	2.02	2.40	2.49
2	6.73	5.50	2.19	4.75	3.95
3	9.08	7.66	2.26	7.03	4.91
6	15.41	13.82	1.94	13.40	6.34
9	20.66	19.71	1.91	19.49	4.90
12	25.70	25.69	2.14	25.30	0.24

Source: prepared by the author on the basis of data of the Central Statistical Office (GUS).

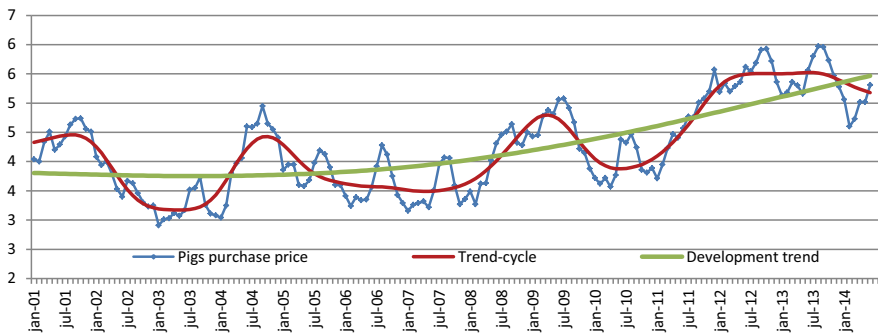
Average changes in prices during one year are 25.70%. These changes are largely a result of impact of long-term factors. Changes in prices resulting from seasonality have much smaller meaning. Due to seasonality, prices undergo the greatest change after 6 months, and the change itself is, on average, 6.34% (Table VIII.3.2). The value of MCD for barley buying-in prices is 2.8, which means that after 3 months of one-way changes, their permanent nature can be concluded.

4. Analysis of changes in live pigs buying-in prices

Analysis of variability of the time series of live pigs buying-in prices pointed to the presence of upward trend of live pigs buying-in prices in the examined period. In the course of live pigs buying-in prices, apart from the development trend, there are clear periodical fluctuations, both seasonal and cyclical (Chart VIII.4.1).

The peaks of value of spectral density visible in the chart of the periodogram and smoothed periodogram (Chart VIII.4.2) inform about dominant fluctuations in the analyzed time series. The main variability component remain periodical fluctuations with the cycle of 40 months, i.e. 3.3 years. Apart from cyclical fluctuations, the impact of seasonality becomes evident, for the cycle of fluctuations of 12 months.

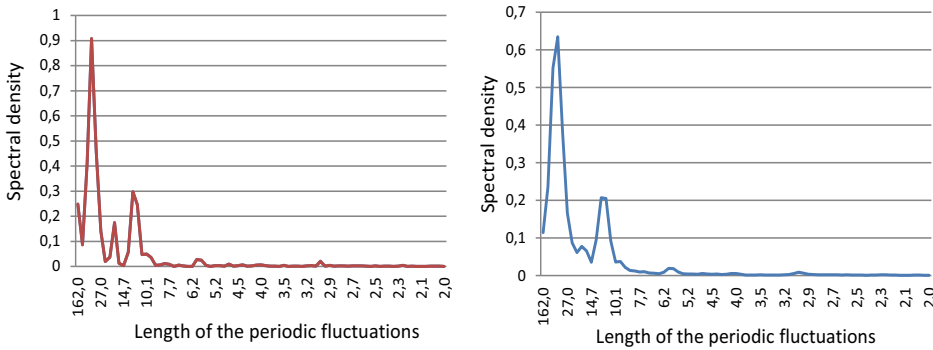
Chart VIII.4.1. Live pigs buying-in prices in PLN/kg along with long-term trend (trend together with cycle) and development trend



Source: prepared by the author on the basis of data of the Central Statistical Office (GUS).

Maximum amplitude of cyclical fluctuations over the whole analyzed period is 33%. Visible cycles have irregular course (Chart VIII.4.3). The distribution of bottom turning points of live pigs buying-in prices is: June 2003, August 2007, August 2010. The distribution of top turning points is: September 2001, October 2004, April 2009, May 2012. The distribution of turning points indicates diverse length of particular cycles.

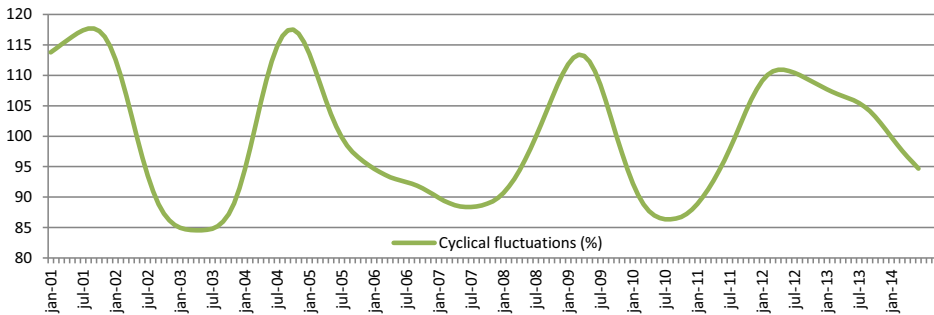
Chart VIII.4.2. The periodogram (left) and smoothed with Bartle weights (65) periodogram (right) of spectral density in the time series of live pigs prices



Source: prepared by the author on the basis of data of the Central Statistical Office (GUS).

The time series of live pigs buying-in prices includes changes being both seasonal and cyclical fluctuations. Seasonality explains on average 38.49% of variability of this time series. Over the analyzed period, however, an explicit change in morphological features of cyclical fluctuations is evident (Chart VIII.4.4). In particular, the amplitude of fluctuations decreased, however, invariably, the highest prices in the year are quoted in September, and the lowest in January.

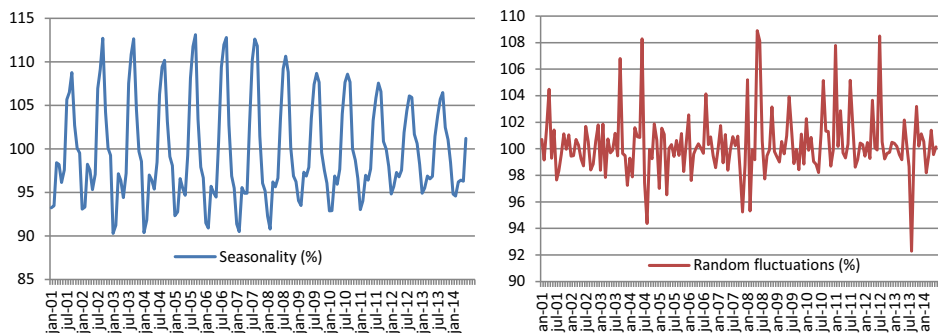
Chart VIII.4.3. Cyclical fluctuations in live pigs buying-in prices as % of deviations of long-term trend



Source: prepared by the author on the basis of data of the Central Statistical Office (GUS).

The share of particular fluctuations (components), depending on time horizon of changes, indicates that only when forecasting with six-month horizon, long-term changes (TC) determine in 51.17% the correctness of such a forecast, and seasonality determines it in 45.98%. However, forecasting for a quarter, the decisive factor is seasonality with the share of 59.91% (Table VIII.4.1).

Chart VIII.4.4. Seasonal and accidental fluctuations in live pigs buying-in prices as % of deviations of long-term trend



Source: prepared by the author on the basis of data of the Central Statistical Office (GUS).

Relative share of trend and cycle (TC) of live pigs prices in variance is on average 54.40%. Slightly smaller meaning is attributed to seasonal fluctuations that are responsible for 38.49% of changes (Table VIII.4.1). The share of accidental component in variance of live pigs buying-in prices is on average 7.11%. The value of MCD of live pigs prices is 3.22, which means that after 3 months of one-way changes, their permanent nature can be deducted.

Table VIII.4.1. Relative share of selected components of the time series of live pigs buying-in prices in their total changes depending on the time of their duration

Share of particular components of live pigs buying-in prices in its total variance, depending on duration of changes (%)			
Months	I	TC	S
1	31.38	17.71	50.91
2	13.09	25.38	61.53
3	6.66	33.43	59.91
6	2.85	51.17	45.98
9	1.91	79.48	18.61
12	1.95	97.96	0.09
Average	7.11	54.40	38.49

Source: prepared by the author on the basis of data of the Central Statistical Office (GUS).

From the point of view of forecasting, the most important conclusion is that in the time horizon up to 6 months the most important is to guess the proper course of seasonality, rather than trend and cyclical fluctuations. On the contrary, along with growing time horizon a growing importance is attached to correct guessing of long-term trend (TC), which, over a year, changes on average by 20.34% (Table VIII.4.2).

Table VIII.4.2. Average percentage changes in the time series of live pigs buying-in prices and their selected components depending on duration of change

Change in particular components of the time series of live pigs buying-in prices depending on duration of change (%)					
Months	Nominal prices	TCI	I	TC	S
1	4.68	3.51	2.66	2.00	3.39
2	8.02	5.28	2.84	3.95	6.15
3	10.67	7.08	2.59	5.79	7.76
6	15.79	11.35	2.51	10.62	10.07
9	18.16	15.79	2.37	15.26	7.39
12	20.31	20.34	2.80	19.81	0.59

Source: prepared by the author on the basis of data of the Central Statistical Office (GUS).

Average change that is made within one year is nearly 15% and it is the result of long-term changes (TC) which change over this period by 14.37%. On the other hand, within 6 months, prices change on average by 20.31%. In the same period, long-term component of trend and cycle (TC) changes by 20.34%, and seasonal fluctuations by 0.59% (Table VIII.4.2).

IX. Summary

Forecasting is one of the forms of cognitive activity, aiming at indication of the most probable future events. Proper prediction requires the application of a suitable method. In the conducted analyses quantitative methods (termed as mathematical-statistical), based on classic trend models, were applied. Forecasting on the basis of these models proceeds through projection (extrapolation) to the future of a trend observed in the past.

The paper presents a forecast of economic results for five plant production activities (i.e. winter wheat, winter rye, spring barley, winter rapeseed and sugar beets), given, resulting from the forecasting model, changes in production results, prices of products and prices of means of production and PLN/EUR exchange rate of 4.20.

High variability of the conditions of development and emergence of new qualities make running a farm and selecting relevant variants of actions more and more difficult. More and more often different tools are used, helpful in the decision-making process. Also demand for forecasts increases and this research topic should not be ignored, although forecasts in agriculture, due to biological character of production, are burdened with a larger or smaller error. For this reason, the ability to use forecast is important. The primary importance in the prepared forecasts is attached to the direction of changes, rather than absolute

sizes, which should be approached with certain caution. The purpose of the forecast is inspiration to undertaking actions aiming at fixing a direction of development that is considered favourable or at counteracting an unwelcome direction of development.

The forecast for the year 2020 of the results of the analyzed production activities shows that in the case of some of them the dynamics of growth in revenue per 1 ha (i.e. value of production) is higher than growth in costs, and in the case of other it is lower. However, differences will not be large. In spite of that, it is envisaged that gross margin remaining at the disposal of farmers, i.e. income from activity without subsidies in 2020, exceeds the level from the basic year for forecast (the average from 2011-2013), however, economic efficiency of production may be lowered. It should be added that rate of growth in direct costs will always be stronger than in the case of indirect costs. As a result in 2020 – as compared to the base year for forecast – direct costs, depending on activity, will increase from 33.1 to 33.8%, and indirect costs will increase from 26.2 to 28.0%.

In the case of **winter wheat**, annual increases in revenues (value of production) will be ranging from 3.4 to 3.8%, whereas costs (total) can increase at the rate of 3.4-4.2%. As a result, in 2020, rate of growth in the value of production (27.8%) will be weaker than growth in total costs (30.0%) by 2.2 p.p. In consequence, the ratio of profitability will decrease to level of 141.7%, whereas in 2013 it amounted to 144.1%. In the years 2011-2013, winter wheat was profitable activity and, as indicated by the forecast results, it will remain such also in the near future. In 2020, income from activity without subsidies will exceed the level from the base year by 22.9%.

From the model it can be concluded that revenues from cultivation of **winter rye** until 2020 will be increasing annually by 4.2 to 4.8%, whereas costs by 3.4 to 4.2%. The results in the target forecast year (2020) indicate a weaker by 6.4 p.p. dynamics of growth in costs (by 29.5%) than value of production (by 35.9%). This is a favourable situation for farmers, meaning that economic efficiency of rye production will improve. The ratio of profitability will reach probably the level of 131.0%, namely it will be higher than in the base year for the forecast by 6.2 p.p. On the contrary, income without subsidies may be higher by 61.8%. Despite such a strong growth, the income level will remain much lower than obtained from wheat and barley cultivation.

Until 2020, annual growth rate of revenues from cultivation of **winter barley** can be 2.8-3.2%, while costs (total) will be increasing within the range of 3.5-4.3%. It means that in 2020 – as compared to 2013 – revenues will be higher

by 22.9%, whereas costs by as much as 30.3%. Although the dynamics of growth in costs will be stronger than revenues, it is envisaged that in 2020 income from activity without subsidies will be 108.5% of the level obtained in 2013. However, economic efficiency of production will worsen. The ratio of profitability, i.e. percentage relation of the value of production to total costs will decrease by 8.6 p.p. (from 151.3% to 142.7%). The decrease in profitability means that increase in the value of production will be too costly. In spite of that, barley still may be profitable activity, and farmers will have at their disposal surplus in the form of income from activity without subsidies.

In recent years, **winter rapeseed** has been profitable activity, assuming for measure both gross margin which may be used by a farmer and the ratio of profitability. In the prospect of 2020, we should expect that revenues from rapeseed cultivation will be increasing annually from 3.9 to 4.8% and in 2020 they will reach a higher level – as compared to the base year for the forecast – by 34.5%. Whereas, costs at annual growths of 3.4-4.2% can increase by 29.8%. It means that in the prospect of 2020 we should expect a stronger by 4.7 p.p. dynamics of growth in the value of production than costs. In consequence, the ratio of profitability will increase by 4.8 p.p. and will reach the level of 138.2%. In the conditions that were defined by means of the forecasting model, income from activity without subsidies attainable for farmers in 2020 – as compared to 2013 – may be higher by as much as 48.6%. It is estimated that its level will be similar to income from winter wheat cultivation.

In recent years, business performance of **sugar beets** cultivation were favourable. Production profitability in the quotient depiction reached 141.4%. However, the future is "a great unknown" and is associated with reform of the sugar market and arrangements with regard to sugar beet's selling price. According to the 2020 projection model, the price of beets will be increasing, annual pace will not be high, it is assessed that it may vary around 1.8%. Taking account of annual increases in yields of roots (by 2.0 to 2.3%) in 2020 we may expect revenues from cultivation of sugar beets higher by 31.1% (at annual pace of changes of 3.7-4.2%). Anticipated in one year increase in total costs is determined at 3.6-4.2%, in consequences they may exceed the level of 2013 by 30.4%. Dynamics of growth in the value of production and costs indicates the improvement in economic results of sugar beets cultivation. It is envisaged that the ratio of profitability will increase by 0.8 p.p., and income from activity without subsidies obtained from 1 ha will be higher than in 2013 by 32.8%.

Effects expected for the year 2020 resulting from dozen-year trend may show, however, deviations in connection with variability in the yielding years of the analyzed agricultural products, as well as price variability. Taking into account the percentage size of deviations of income from activity without subsidies (*in plus* or *in minus*) due to variability of yields, the sequence of the analyzed products is the following:

- 1) winter rapeseed +/-45.5% – in the research sample corresponds to change in yield by 3.5 dt,
- 2) winter rye +/-33.0% – change in yield by 2.8 dt,
- 3) spring barley +/-27.7% – change in yield by 3.7 dt,
- 4) sugar beets +/-25.4% – change in yield by 53.6 dt,
- 5) winter wheat +/-20.8% – change in yield by 3.7 dt.

On the other hand, owing to selling price variability, income from activity without subsidies may assume deviations (*in plus* or *in minus*) that would order products as follows:

- 1) winter rye +/-100.5% – in the research sample price change by 17.02 PLN/dt,
- 2) winter rapeseed +/-75.8% – price change by 45.45 PLN/dt,
- 3) winter wheat +/-66.8% – price change by 18.46 PLN/dt,
- 4) spring barley +/-63.1% – price change by 15.96 PLN/dt,
- 5) sugar beets +/-26.7% – price change by 1.28 PLN/dt.

The research has shown that rye and rapeseed are characterized by the greatest sensitivity to fluctuations in yield and price. It means that in favourable production and price conditions we may expect significantly higher income, but, at the same time, their cultivation is burdened with big risk. This fact is proved by income deviations arising from variability observed in the last 19 years but also from unit changes in yield and price.

Change in yield of rye by 1 dt caused the greatest – as compared to other crops – change in income without subsidies (+/-11.7%). A similar situation happened also in the case of price of grain, the force of impact of its changes on income fluctuations (+/-5.9%) was the highest.

Winter rapeseed, as compared to cereals, was characterized by larger percentage deviations of income from activity without subsidies, owing to yield fluctuations. This fact is proved by changes in income losses resulting from unit deviations (+/-13.0%), but also from variability in the years (+/-45.5%).

To sum up, it should be stated that fluctuations in selling prices of products arising from variability in the years have a definitely stronger impact on level of income than yield fluctuations. In the case of rye, an extremely strong decrease caused unprofitability of its cultivation. Taking additionally into account a small level of income, this explains small interest of farmers in its cultivation. The calculations indicate that the income situation in the case of other products, even despite extremely large falls in the selling price (resulting from variability), will remain favourable.

The presented results show the scope of change in the level of income from production in the agricultural products analyzed in 2020. They indicate, at the same time, high risk of interpretation of the projection results in literal manner, i.e. treating numeric data as certain. It is not a relevant approach because reality in agriculture is such that changes in yields, prices of products or prices of means of production cannot be foreseen with 100% accuracy, both in the mid- and long run. Research shows that even their unit changes have substantial impact on income. The projection of results for the year 2020 and its options are intended to demonstrate the change of direction and to indicate possible hazards and benefits under given production activity.

Other issues taken in paper cover research on the cyclical character of economic phenomena. The results show that the economy may be characterized by simultaneous occurrence of many cycles of different period. It causes overlapping of different types of cycles and their mutual interactions. The most popular example are identified in the research and time series cyclical fluctuations and overlapping them seasonal fluctuations. The research results indicate that prices of the analyzed agricultural products in Poland in the years 2001-2014 were characterized also by great variability, which is not without effect on quality of made forecasts.

Buying-in prices of analyzed raw materials are characterized by cyclical fluctuations. Their presence is the effect of both macroeconomic factors and effect of the presence of the so-called commodity cycles on different markets. An additional element creating cyclical fluctuations were sudden fluctuations in production triggered by weather factors causing deviations from the state of market balance and its slow recovery.

As indicated by the results of analyses, amplitudes of changes in cyclical fluctuations reach more than 68 p.p. around the development trend. It means that the most important element which should be taken into account by the prognostic method is the ability to predict turning points of cyclical fluctuations and pace of their changes.

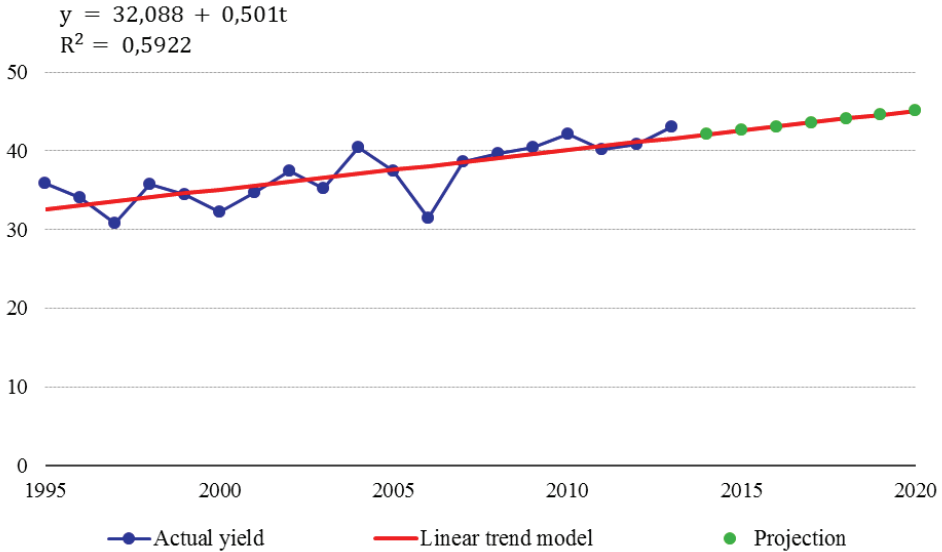
With regard to market predictability, its ratio may be MCD (period of cyclical dominance). In most of the analyzed time series of real prices of agricultural products the value of MCD, informing about permanent nature of changes, was 3-4 months. This measure shows thereby the duration of period for which we should wait so that observed on the curve of empirical values change in prices could be with all confidence considered as a new direction of changes. The longer the period defined by MCD, the greater the probability of error consisting in failure to predict direction of trends in the forecasted variables. It means that confidence as to the direction of long-term changes is obtained after more than three or five months. Therefore, even significant growth in prices for two, three months does not determine changes in the long-term trend. The higher the value of MCD, the greater the risk of inapt forecasts.

One-directional changes in trend and cycle in the course of prices do not exceed one year in any of the analyzed variables. It means that in the case forecasting prices, the risk of error when building forecasts grows significantly along with exceeded one-year forecast horizon.

GRAPHIC

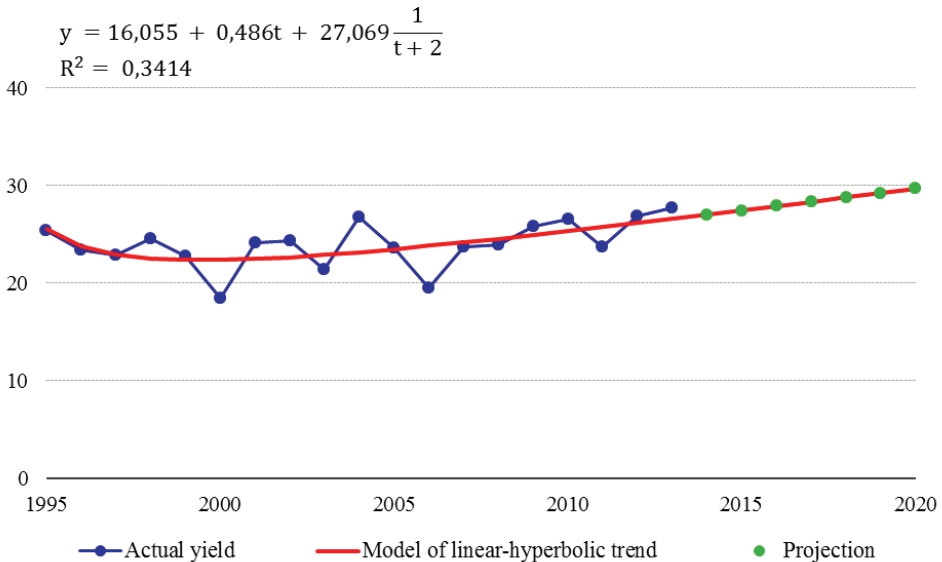
ANNEX

Chart 1. Yield of winter wheat in individual farms (dt) and selected development trend model



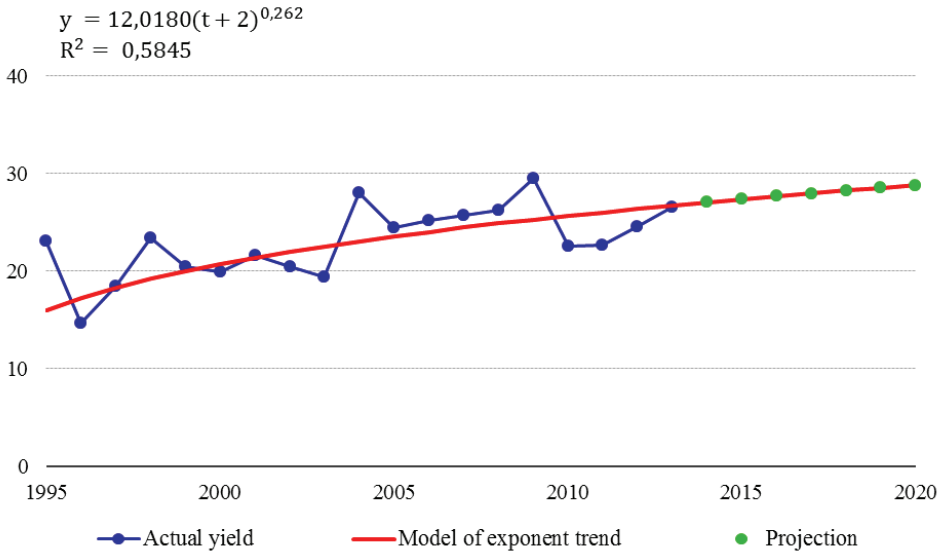
Source: calculations of the author on the basis of data from the Central Statistical Office (GUS).

Chart 2. Yield of rye in individual farms (dt) and selected development trend model



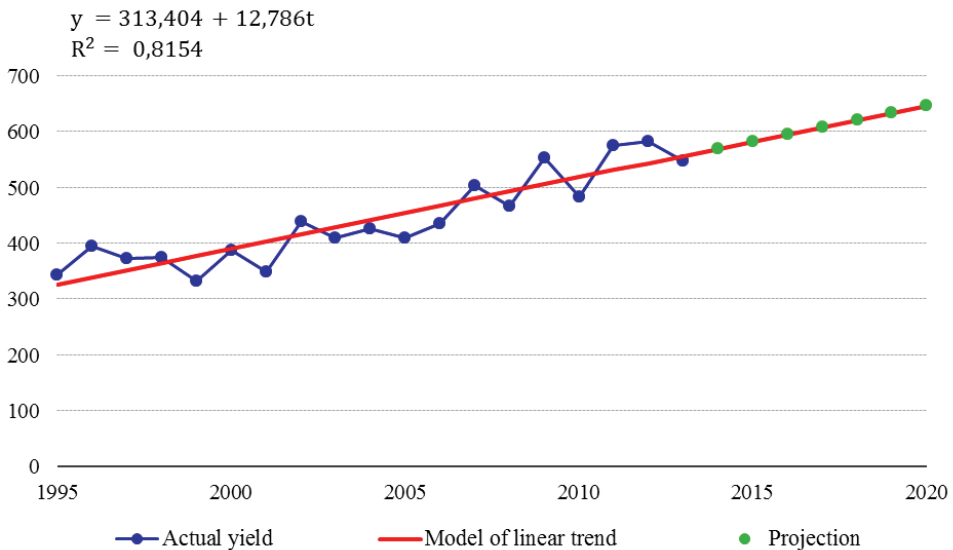
Source: calculations of the author on the basis of data from the Central Statistical Office (GUS).

Chart 3. Yield of winter rapeseed in individual farms (dt) and selected development trend model



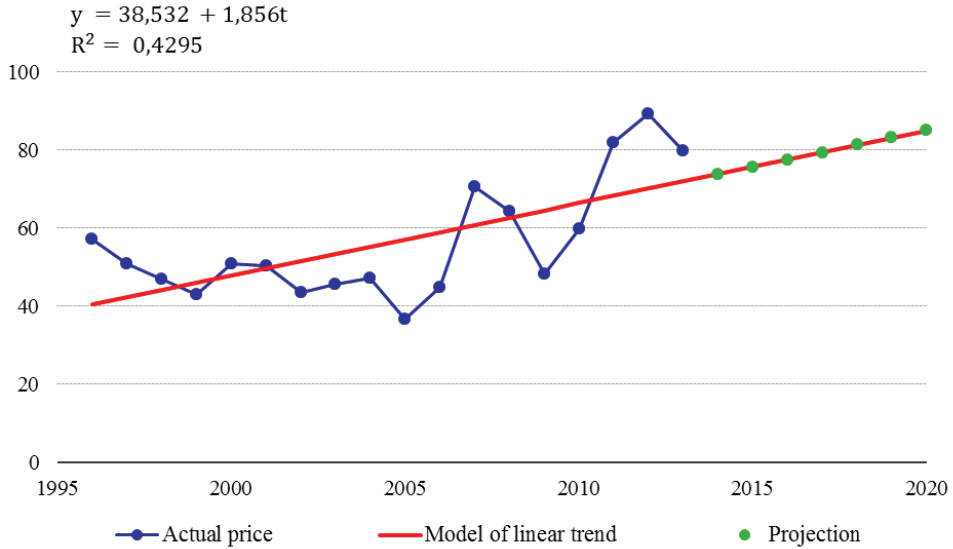
Source: calculations of the author on the basis of data from the Central Statistical Office (GUS).

Chart 4. Yield of sugar beets in individual farms (dt) and selected development trend model



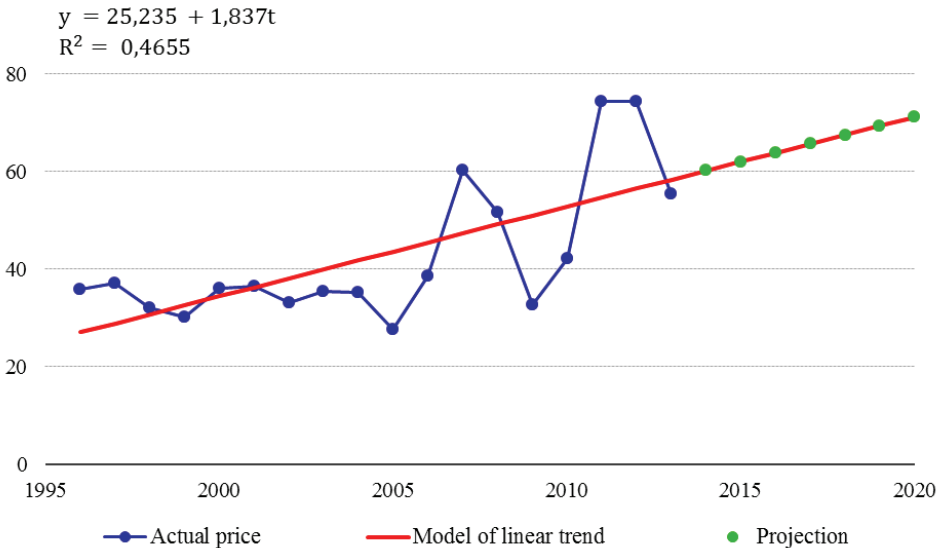
Source: calculations of the author on the basis of data from the Central Statistical Office (GUS).

**Chart 5. Buying-in price of wheat (PLN/dt)
and selected development trend model**



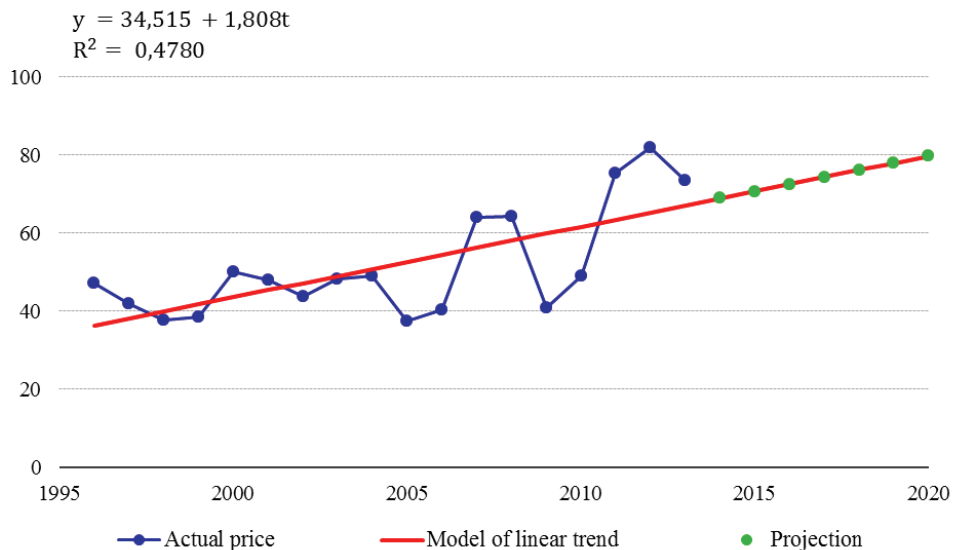
Source: calculations of the author on the basis of data from the Central Statistical Office (GUS).

**Chart 6. Buying-in price of rye (PLN/dt)
and selected development trend model**



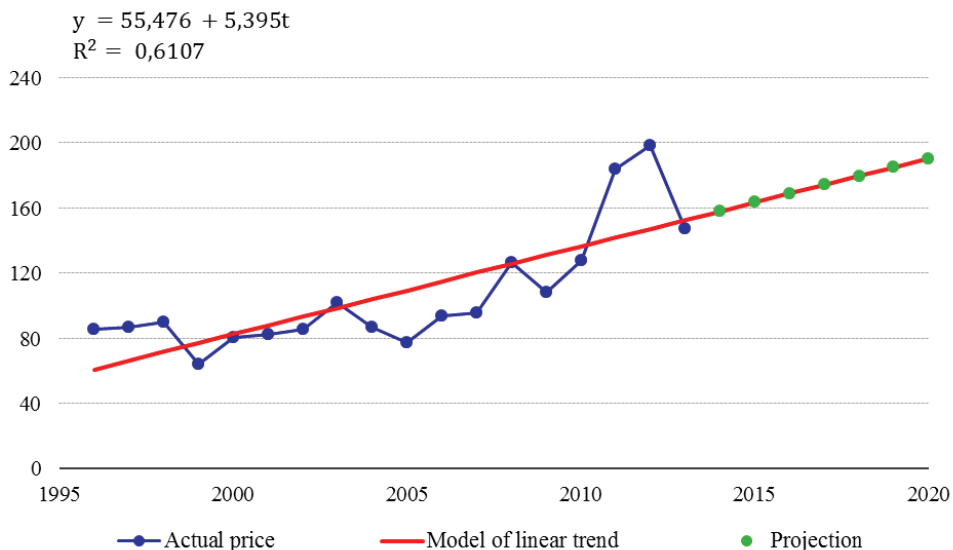
Source: calculations of the author on the basis of data from the Central Statistical Office (GUS).

**Chart 7. Buying-in price of barley (PLN/dt)
and selected development trend model**



Source: calculations of the author on the basis of data from the Central Statistical Office (GUS).

**Chart 8. Buying-in price of rapeseed (PLN/dt)
and selected development trend model**



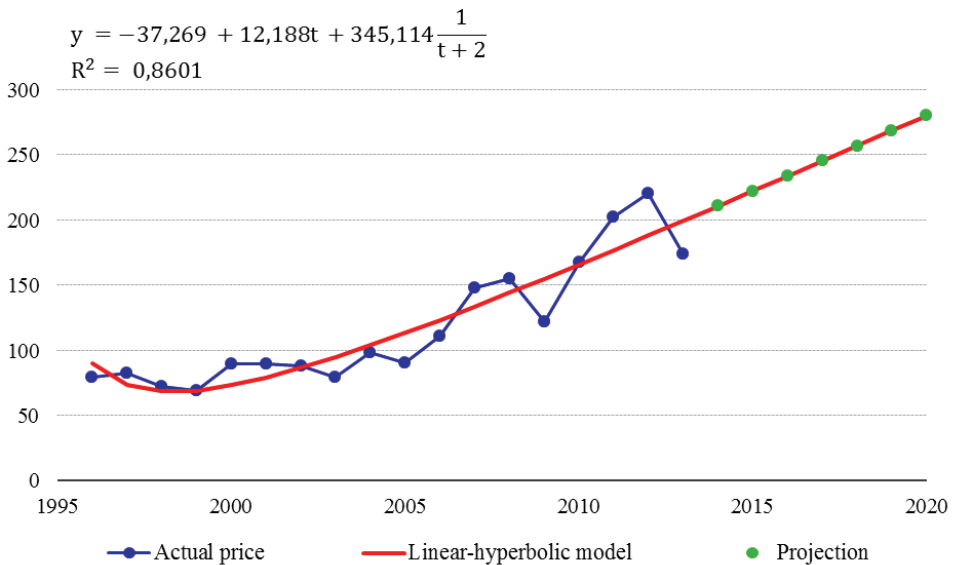
Source: calculations of the author on the basis of data from the Central Statistical Office (GUS).

**Chart 9. Buying-in price of sugar beets (PLN/dt)
and selected development trend model**



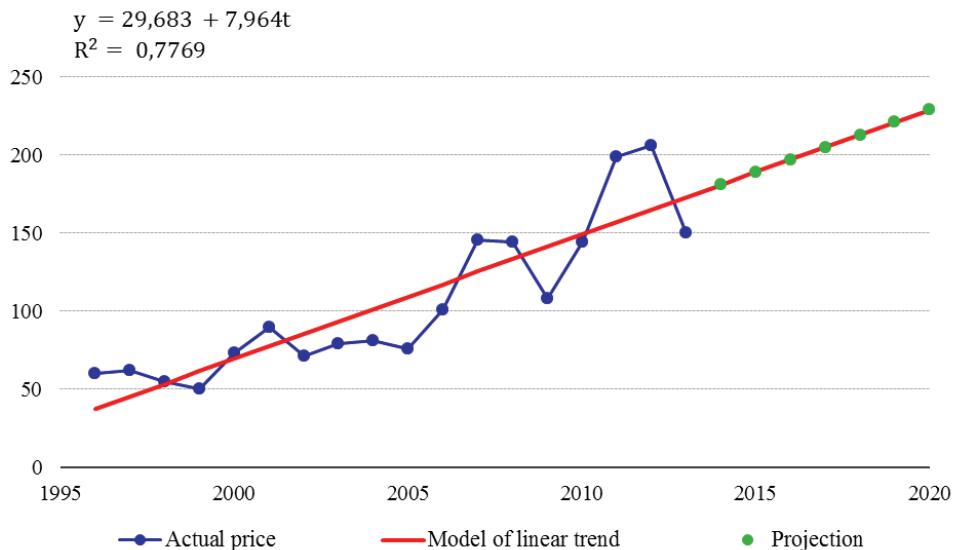
Source: calculations of the author on the basis of data from the Central Statistical Office (GUS).
z – variable has value 1 in 2004 and 2005 and value 0 in other years.

**Chart 10. Price of wheat seed material (PLN/dt)
and selected development trend model**



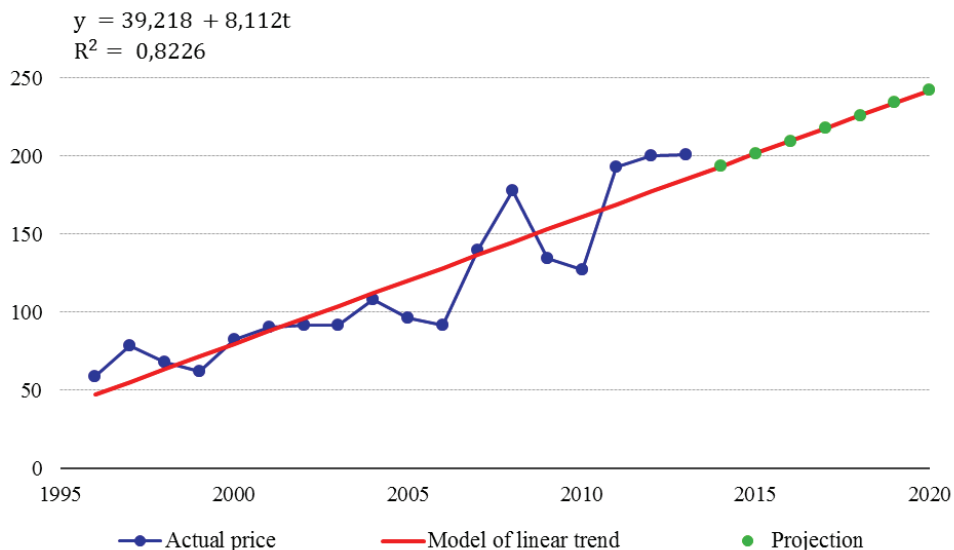
Source: calculations of the author on the basis of data of the Central Statistical Office (GUS).

Chart 11. Price of winter rye seed material (PLN/dt) and selected development trend model



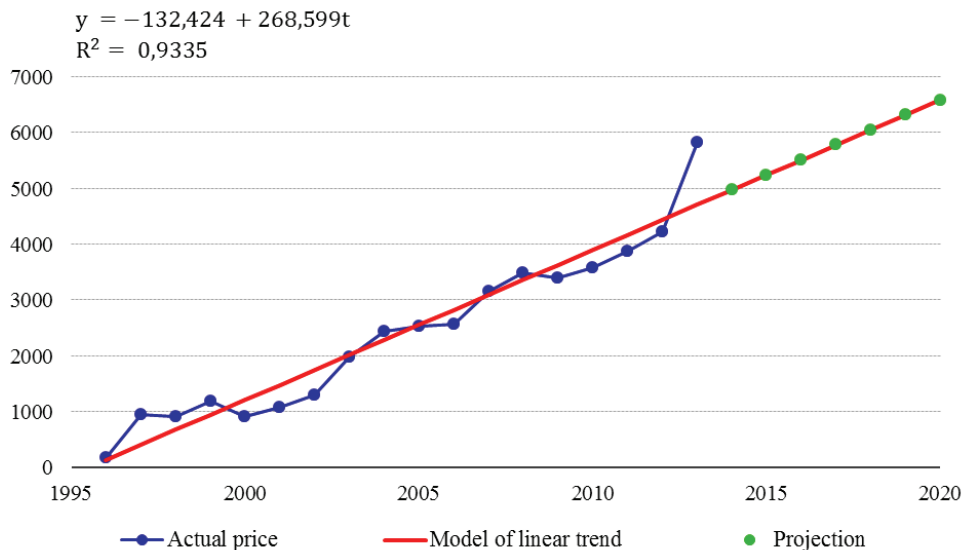
Source: calculations of the author on the basis of data from the Central Statistical Office (GUS).

Chart 12. Price of spring barley seed material (PLN/dt) and selected development trend model



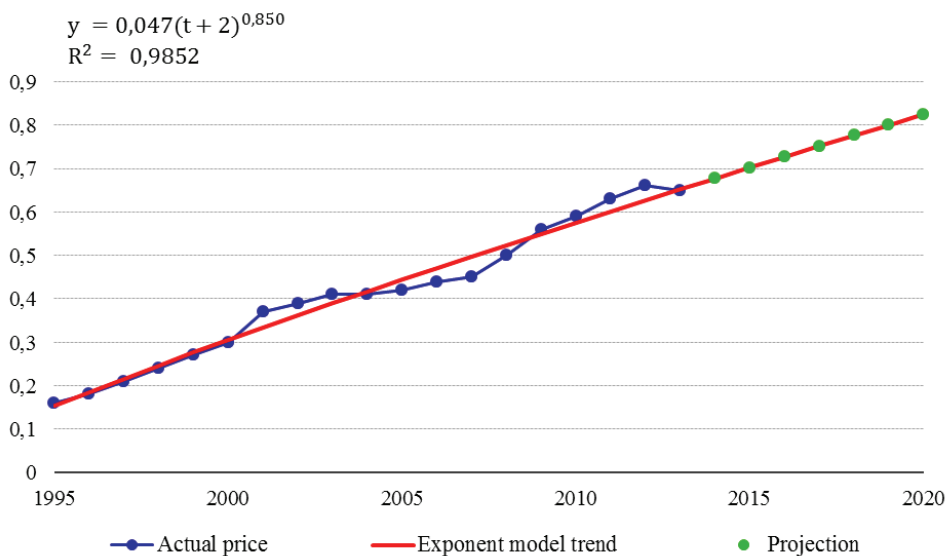
Source: calculations of the author on the basis of data from the Central Statistical Office (GUS).

Chart 13. Price of winter rapeseed seed material (PLN/dt) and selected development trend model



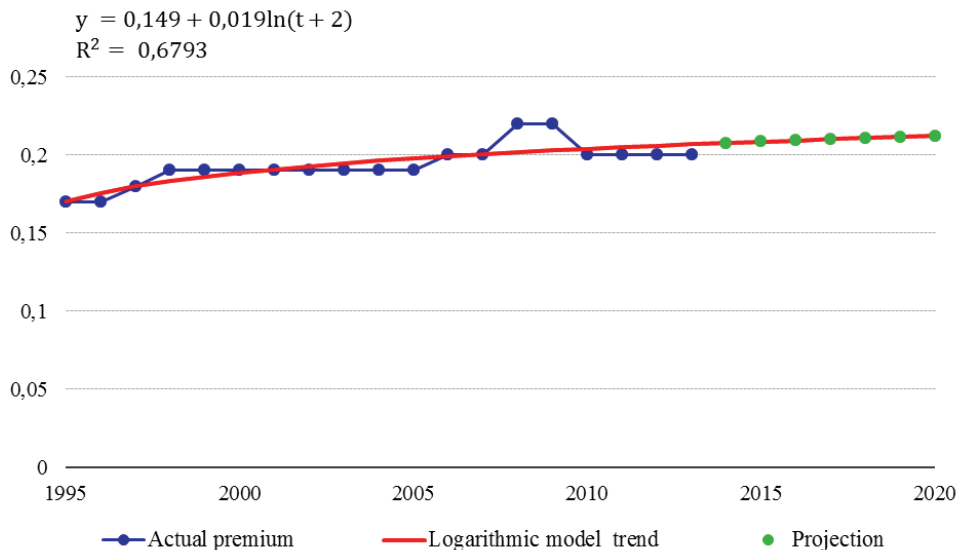
Source: calculations of the author on the basis of data from the Central Statistical Office (GUS).

Chart 14. Price of electric energy (PLN/kWh) and selected development trend model



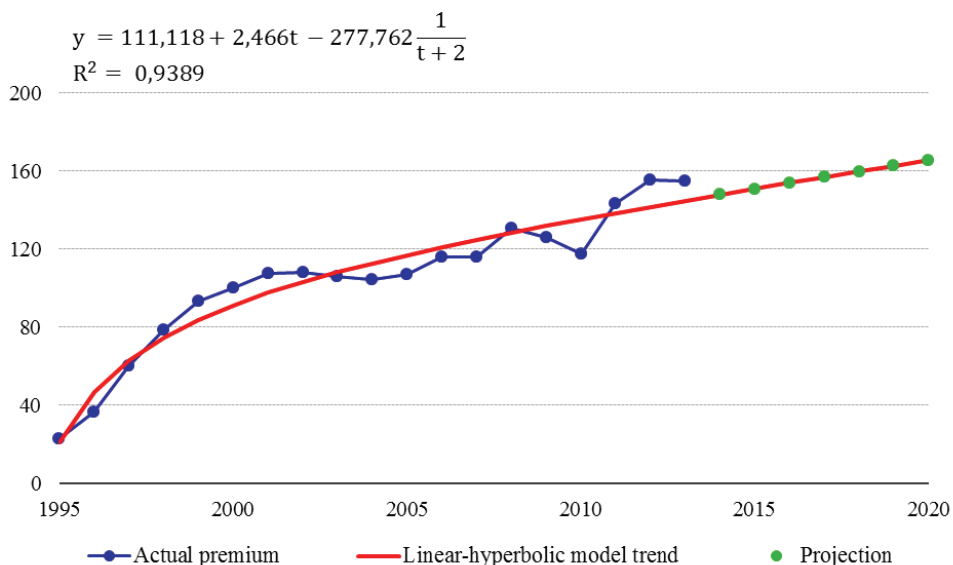
Source: calculations of the author on the basis of data from the Central Statistical Office (GUS).

Chart 15. Annual premium from PLN 100 per insurance of building connected with a farm (PLN) and selected development trend model



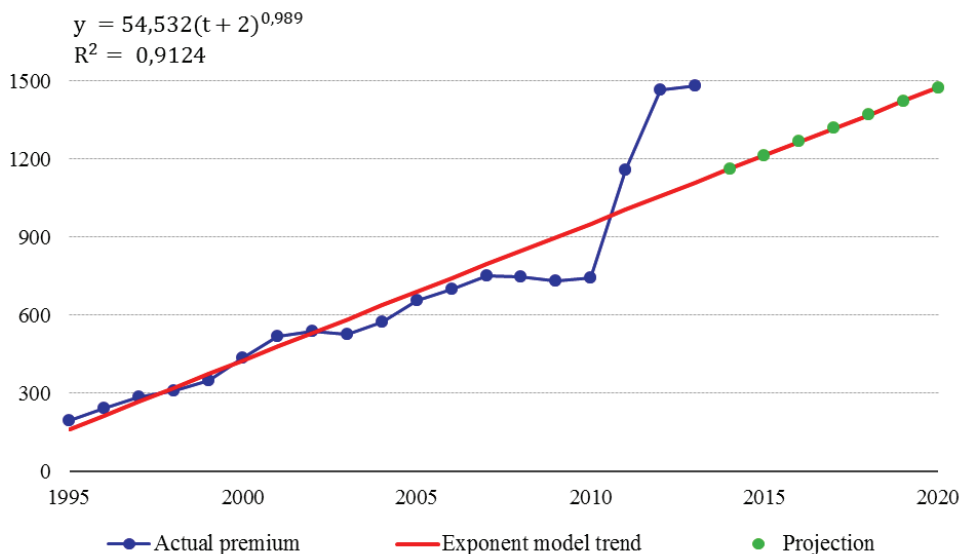
Source: calculations of the author on the basis of data from the Central Statistical Office (GUS).

Chart 16. Annual premium for civil liability insurance of tractor (PLN) and selected development trend model



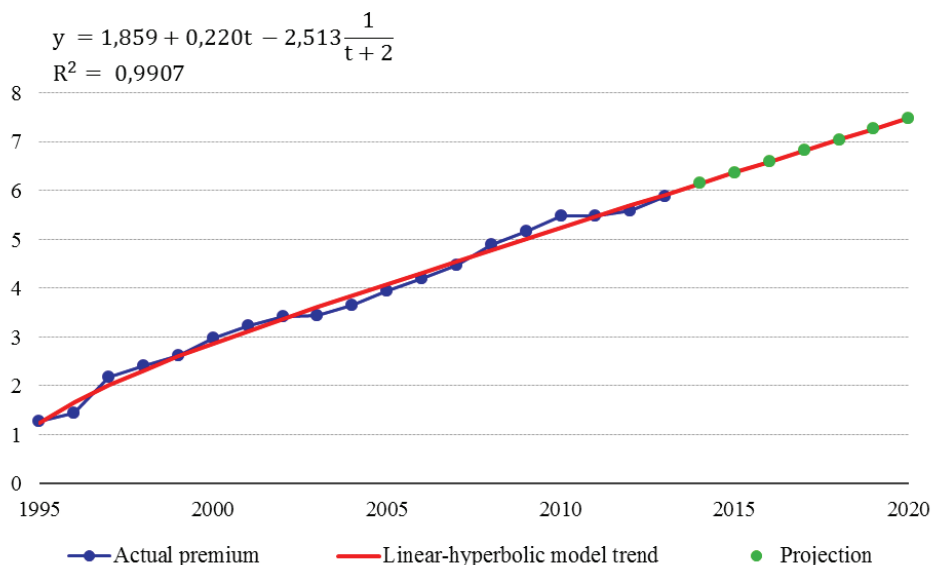
Source: calculations of the author on the basis of data from the Central Statistical Office (GUS).

Chart 17. Annual premium for voluntary comprehensive and collision insurance of the tractor (PLN) and selected development trend model



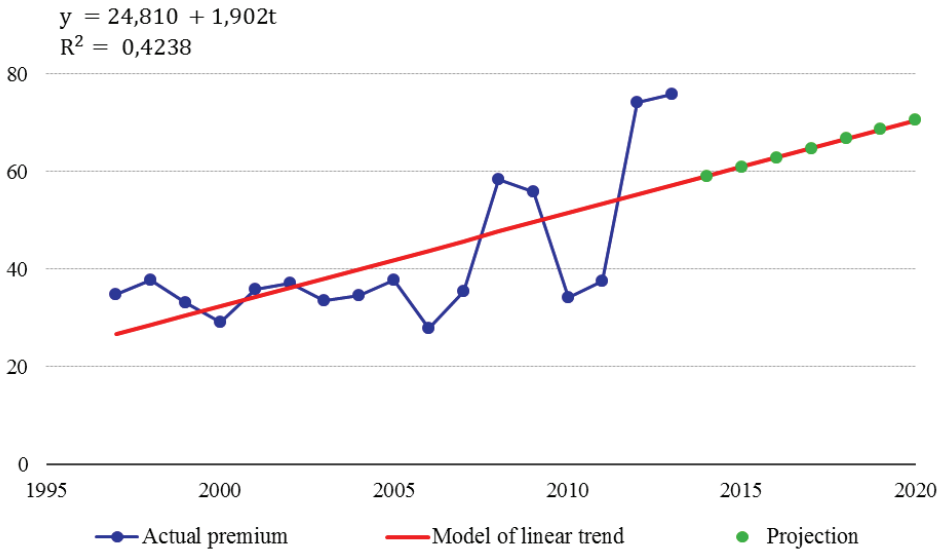
Source: calculations of the author on the basis of data from the Central Statistical Office (GUS).

Chart 18. Annual premium for civil liability insurance of farmers, per 1 ha of area of farm (PLN) and selected development trend model



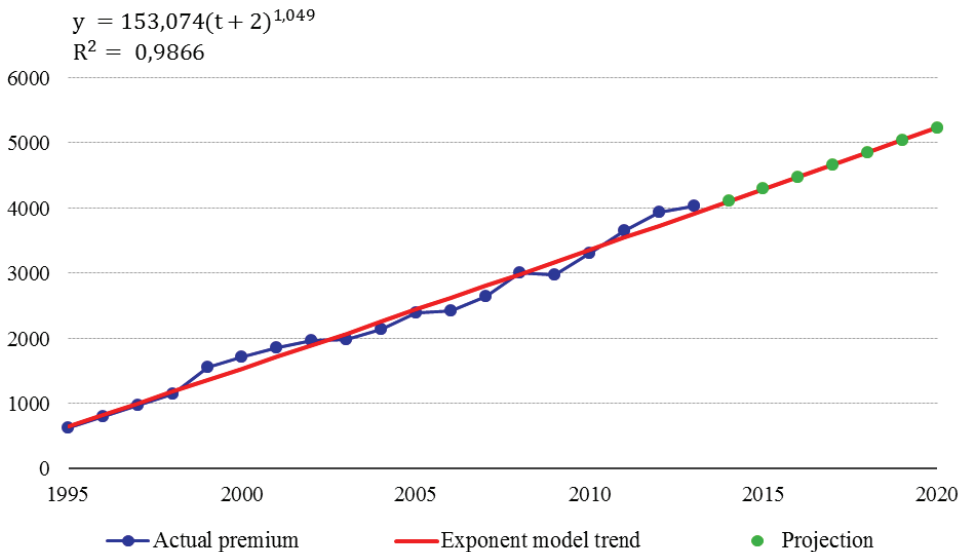
Source: calculations of the author on the basis of data from the Central Statistical Office (GUS).

**Chart 19. Agricultural tax rate (PLN/ha)
and selected development trend model**



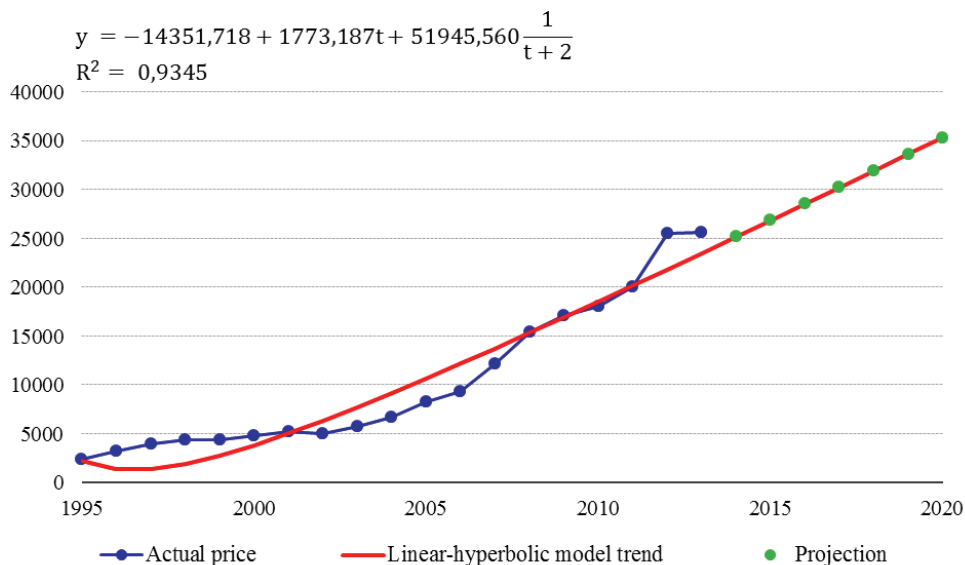
Source: calculations of the author on the basis of data from the Central Statistical Office (GUS).

**Chart 20. Average gross monthly remuneration in agriculture, hunting
and forestry (PLN) and selected development trend model**



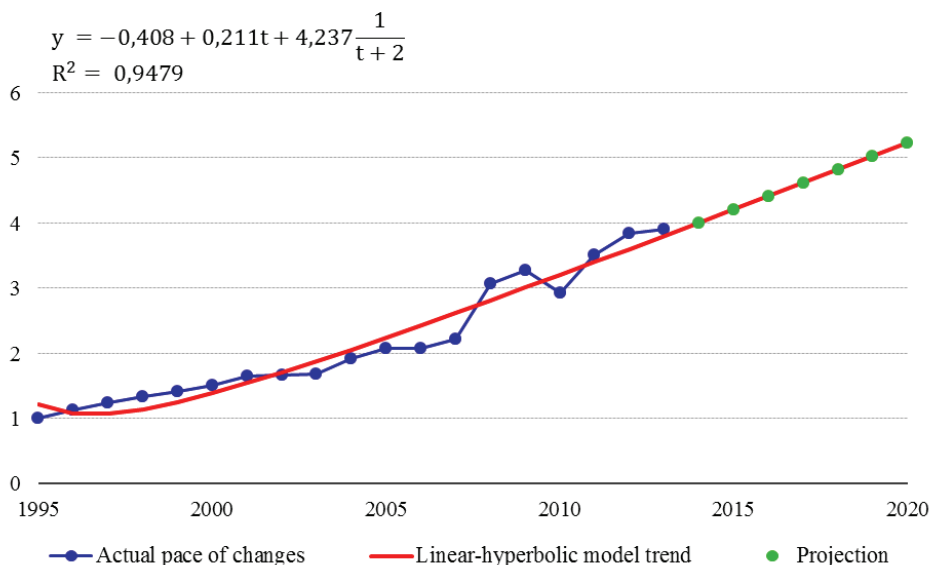
Source: calculations of the author on the basis of data from the Central Statistical Office (GUS).

Chart 21. Average price of arable lands (PLN/ha) and selected development trend model



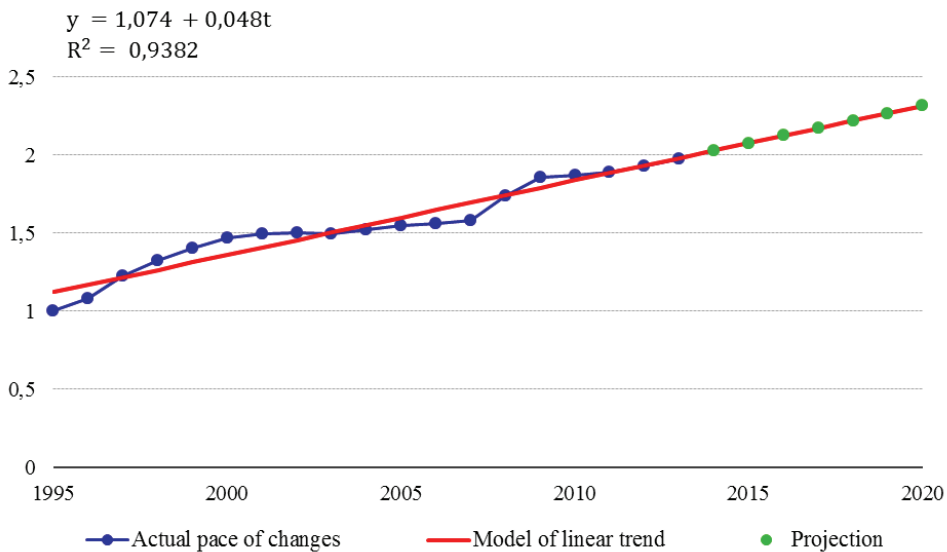
Source: calculations of the author on the basis of data from the Central Statistical Office (GUS).

Chart 22. Pace of changes in prices of mineral and calcium fertilizers (cumulated values, year 1995 = 1) and selected development trend model



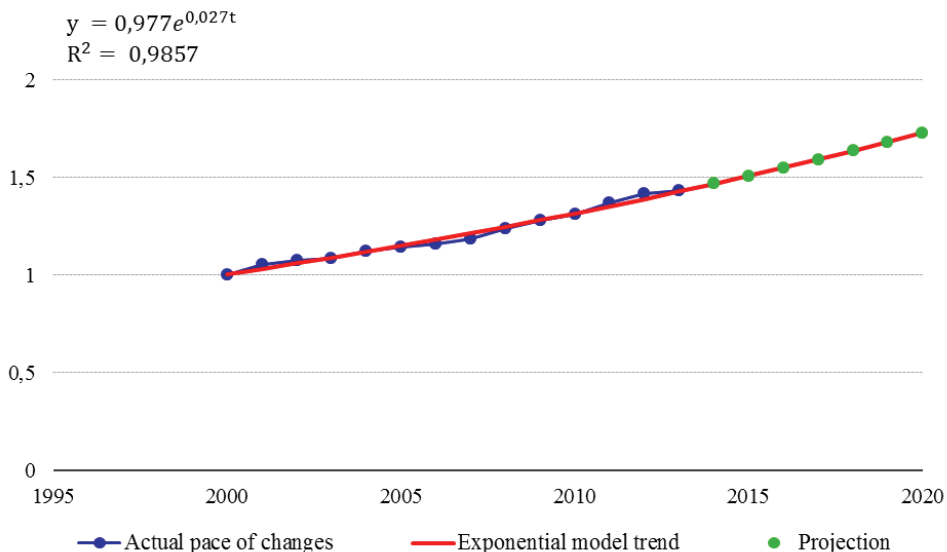
Source: calculations of the author on the basis of data from the Central Statistical Office (GUS).

Chart 23. Pace of changes in of prices of plant pesticides (cumulated values, year 1995 = 1) and selected development trend model



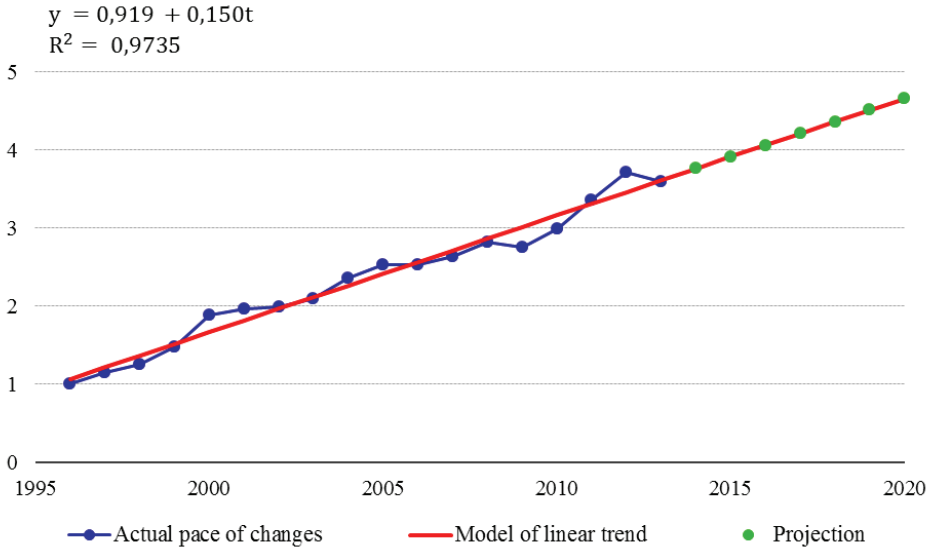
Source: calculations of the author on the basis of data from the Central Statistical Office (GUS).

Chart 24. Pace of changes in prices of consumer goods and services of plants (cumulated values, year 2000 = 1) and selected development trend model



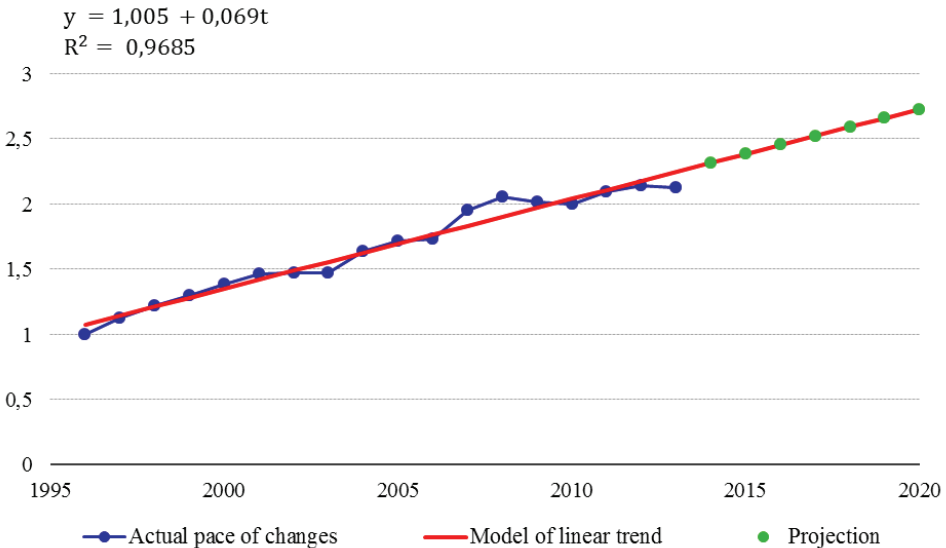
Source: calculations of the author on the basis of data from the Central Statistical Office (GUS).

Chart 25. Pace of changes in prices of fuels, oils and lubricants (cumulated values, year 1996 = 1) and selected development trend model



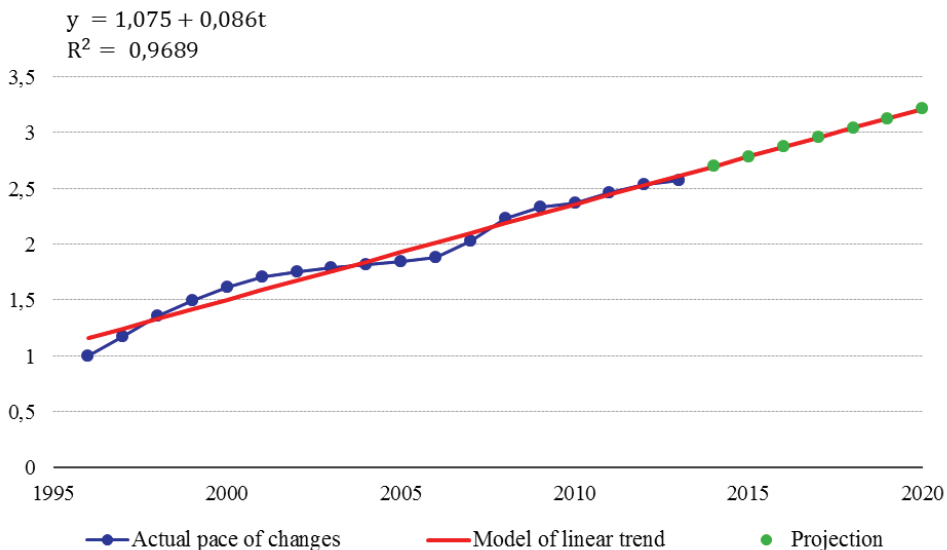
Source: calculations of the author on the basis of data from the Central Statistical Office (GUS).

Chart 26. Pace of changes in prices of building materials (cumulated values, year 1996 = 1) and selected development trend model



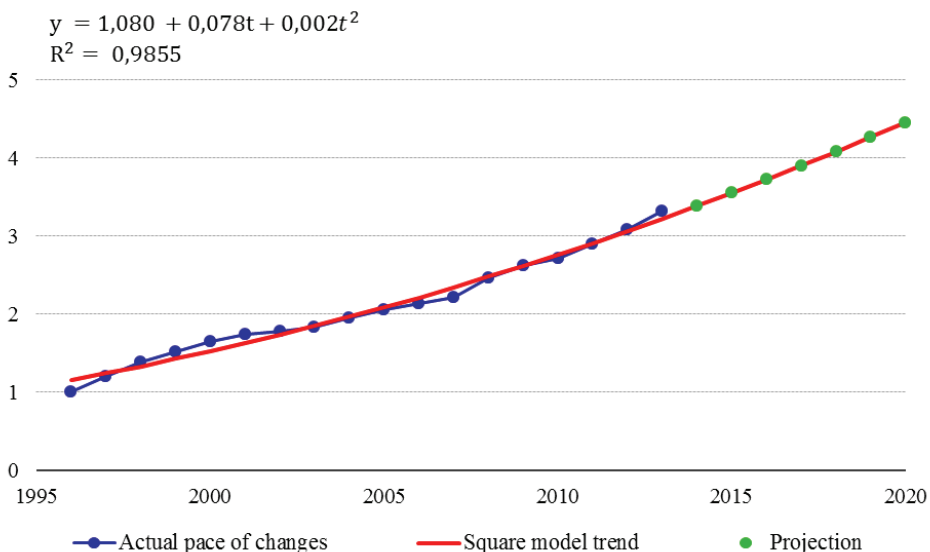
Source: calculations of the author on the basis of data from the Central Statistical Office (GUS).

Chart 27. Pace of changes in prices of repair-construction services (cumulated values, year 1996 = 1) and selected development trend model



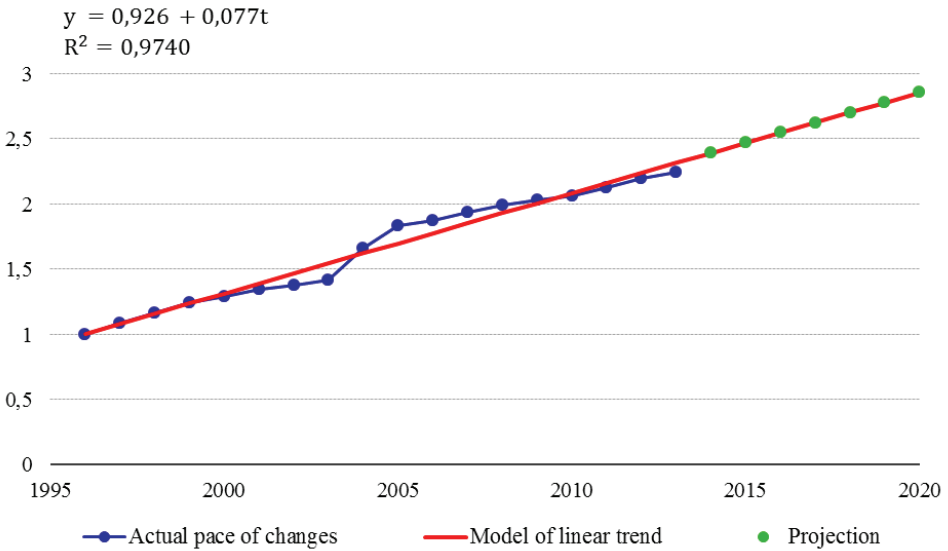
Source: calculations of the author on the basis of data from the Central Statistical Office (GUS).

Chart 28. Pace of changes in prices of agricultural services (cumulated values, year 1996 = 1) and selected development trend model



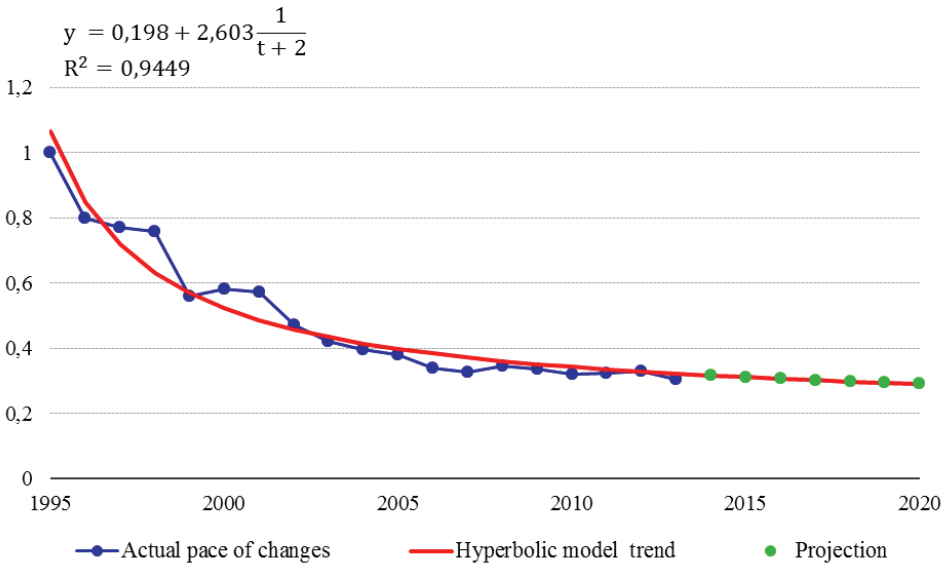
Source: calculations of the author on the basis of data from the Central Statistical Office (GUS).

Chart 29. Pace of changes in prices of agricultural machines and devices (cumulated values, year 1996 = 1) and selected development trend model



Source: calculations of the author on the basis of data from the Central Statistical Office (GUS).

Chart 30. Pace of changes in interest on credits (cumulated values, year 1995 = 1) and selected development trend model



Source: calculations of the author on the basis of data from the Central Statistical Office (GUS).

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