JEL: C55, E32, O11, O13

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AGRICULTURAL BUSINESS IN INDEPENDENT UKRAINE: THIRTY-YEAR DYNAMICS OF THE REORGANIZATION PROCESS

Purpose. *The purpose of the article is to identify stages in development and to analyze the content of transformation processes in Ukrainian agriculture for the period of 1991–2022 years.*

Methodology / approach. *This research uses content analysis of legislative field to present basis for organization of agriculture business activity for the 30-years of restoration of Ukraine independence. Official statistical data are studied to reveal repercussion in productivity as an effect of Laws, Acts and Agreements implementation. Methods of regression and correlation analysis are used to unveil peculiarities in agriculture tendency. Hodrick-Prescott method is applied to extract structural components, exclude random impacts on economical processes and to find out significant changes or turnings in the sector development. Quantitative analysis results were obtained by the GNU Octave software tool.*

Results. *Legislative evolution has influenced on the way of agriculture business organization and branch productivity. Analysis revealed two stages in its development. The first one (1991–1999) is the period of business transformation with changes of ownership forms on the land. This period is notable by its descending dynamics. Transformation has required to build relationships in business environment after collapse of Soviet Union, to supply with material and technical resources, to support its activity with financial funds. The essence of the first stage is in findings of an effective form of farming management. The second stage is the exit from the lowest point at which agrarian business was in 1999 and the gradual growth of its activity and profitability. This is the period of strengthening of relationships in the business environment, development of crop and livestock production, implementing of new technologies of land cultivation, plant, and animal care. It is the period of economic recovery on the base of private land ownership, motivation of producers' activity, agreements on free trade and cooperation with the EU and other countries. Simultaneously, it is the years of overcoming of such shocking consequences as economic collapse of the end of 1990s, the instability of foreign currency and the banking crisis of 2008–2009, the beginning of the hybrid occupation of Ukraine by Russia in 2014, the rapid fluctuation of the value of its own currency in 2014–2015 because of war. The alteration of the principles of currency exchange rate formation with the transition from a fixed value to that is formed under the influence of market conditions was a mean to overcome this instability. Russia's full-scale armed aggression against Ukraine since 2022 caused the latest devastating events in the economy.*

Originality / scientific novelty. *The novelty of the obtained research results is in presentation, argumentation, and interpretation of productivity waves in agriculture development for the 30-years of Ukraine independency with the use of extract method of structural components and correlation analysis of smoothed data sets. The continuity of legislative stages of agriculture reorganization was built to reveal ground for agriculture growth and to understand factors of branch sustainability. It is the first time when research shows how to detect latent changes in the development in the context of legislative changes, external threats, and internal peculiarities of branch.*

Practical value / implications. *Results of analysis can be implemented in the historical*

reconstruction of causes and consequences of falls and rises in the Ukrainian economy for the period of 1991–2022. Used smoothing method is suggested to be applied in econometric research when the dynamics of indicators behavior cannot be approximated with certain function unmistakably because of ambiguous form of data scattering or its latent character.

Key words: *transformation processes, dynamics, stages in agriculture business activity, correlation, impact factors, productivity.*

Introduction and review of literature. Specific of agriculture economy growth of any country depends on many factors. Some of them are such significant that change direction of branch development. Among them are not only climate changes that cause drought, flooding, deforestation, or other nature consequences. Internal and external economic conjuncture and political decision can both promote growth in the economy and lead to its decline. The power and endurance of economic system are based on government strategy of development and support for own members, on existing conditions and given opportunity to do business, on proactiveness and motivation of producers. Some impacts can provoke as quantitative changes of some indicators as qualitative transformations in system structure. The question of how factor dominance can be measured is always actual, because in majority situations researchers study consequences or results of influence and cannot precisely predict the volume of losses or some benefits in the future. What the aspects and methods are investigated by scientists to find out leverages to manage processes in agriculture that improve or destroy it development?

Ability of economic system to resist against negative factors is the base of its stable growth. With this reasonable point of view N. Vasylieva emphasizes on that fact that sustainable development of agriculture, especially in Ukraine, depends on crop production as the most influential part of branch economy [1]. Scientist analyzes the role of Ukraine agriculture on international markets of food provision and presents results of investigation of disproportion between the sizes of agricultural lands and productivity of their using. Among applied statistical methods are ranking of areas accordingly to their exploitation, reconstruction of Lorenz curves, comparison of Ukraine productivity with productivity of other producers of cereals and oilseeds.

Group of researchers [2] analyzed changes in profitability of crops and tendencies in plant productivity in regions of Ukraine, compared livestock productivity in households, private farms, and agricultural enterprises. Economists assumed that type of owning in farming impacts on profitability of economies. The same outcome was obtained by other explorers [3] who conclude on existence of correlation between land ownership and branch development. Each country has own peculiarities in economics because of climate, geolocation, historical traditions, preferences in growth, types of owning and other features. This side was studied by investigators [4–6], who reconstructed and described econometric models of trends for European and post-Soviet countries.

The continuation of the importance of relations between countries for their mutual development considering their features is observed in the article of other researchers [7]. The investigation deserves attention because of presented multidimensional trade

model is built with aim to find out how and what the factors impact agricultural trade effectiveness. As a result of their investigation, it is concluded that production-limitations policies and tariffs are obstacles for two-sided trade, but domestic institutional support programs and land endowments promote trade intensification between market-participants. Therefore, successful trading as a part of economic activity helps to enhance macroeconomic output. We agree with this important evidence but understanding that trade is a way to sell goods that can be produced in appropriate conditions we made decision to study such conditions for Ukraine agriculture during the 30-years period of independence.

J. Hutchins, Y. Gong, & X. Du [8] paid more attention to the financial component of business. They studied 60 farms in Wisconsin and assumed that investments in animal breeding and genetics influence on the productivity of agriculture. Researchers applied Cobb-Douglas production function studying changes of such indicators as capital, labor, feed, and size of herd and the quality of milk as output. In Ukraine agriculture, as we would present it below, the size of herd is not decisive because of tendency to livestock shortening and total specific of national agriculture. Therefore, it should be accounted other indicators of agriculture branch.

S. Lehenchuk et al. studied 527 agricultural companies in Slovak and confirmed that financial infusions form the economy efficiency [9]. According to build by them multidimensional models, financial determinants are influenced by factors that related to assets, debt period, capital, and other characteristics of economic health of companies. They reconstructed development of Slovak companies for the period of 5 years scilicet from 2015 to 2019 years and have paid attention more to the financial side of its economies. In our investigation we took the 30-years period of Ukraine independence because of changed realities and conditions for farming. We would like to study its influence later because financial support is significant factor in transformation of branch. It can be seen in mentioned below documents that Ukraine government laid the law foundation to fund agriculture with aim to ensure its growth.

A. Khanal & O. Omobitan [10] proceed from the fact that the investments and start-up capital play substantial role in farther farming activity. As it is pointed, agriculture output depends on biological cycle that demands longer period and expenditures to grow harvest than it is spent by industry to produce and sale production. Successful farmers are basis for rural prosperity. Different types of farmers have different financial opportunities and difficulties, and it is important to support them using appropriate factors, sources, and stimulation to enhance their productivity. Researchers applied probit regression modelling to determine the most influencing limitations for financial support of farmers.

V. Hoang & V. Nguyen [11] assumed that such factors as cooperative membership, quality certification, sale preferences, farming difficulties, technology, supporting program, oversupply, market information flow, association membership, and experience of contract farming failure can cause the transformation in agriculture thanks to rise of farming contract participation. In own research they used probit model to extract the most determinative indicators. Their investigation is valued due to build

model and presented point of view that multiple factors impact some result in agriculture. But there was studied the only one part of system and it is hardly that it can help to describe tendency of development in whole agricultural branch or influence of contracts quantity on effectiveness of economy.

B. Kemmerling et al. [12] unlike others raised another problem. They reasonably noted that such political factor as war can destroy not only economy, but it leads to the food insecurity as in separate country that suffered from the war as in world in total. It is concerning that war is used as a tool of food control. Researchers emphasized, hunger as a consequence of military invasion is applied to manage people by deprivation of food, normal conditions for living, human rights and self-respect. This investigation and its conclusions are relevant for us in aspect of events in Ukraine and agriculture producing in time of war since 2014. It is worth to understand reaction of national economy on hardened circumstances.

Peculiarities of lands structure, humidity, temperature, climate changes make amendments in any econometric model of agriculture development. As some of scientists [13] insist, the climate changes determine the level of food security. They proved that the most powerful negative factors force farmers to transform their strategy of cultivation of crops and keep livestock due to increasing vulnerability of households. According to I. O. Fasanya & T. F. Odudu [14], J. von Braun & S. L. Hendriks [15] the next important aspect of impact on the country development is uncontrolled food prices oscillations. Other part of researchers analyzed data sets of European countries to study leverages for climate control with aim to build model of stable agriculture [16]. Among offered ways are proposed regulation in utility of such resources as water, soil, biodiversity, energy, environment, economic and social integration.

Other scientists noted [17–19] that type and quality of land, natural resources play crucial role in efficiency of agriculture development. Economists [20] used nonlinear methods in analysis allowed them to conclude that food security is depended on balance of supply and demand of goods, purchasing power of population, lack of investments in innovative development, appropriate pricing policy. They paid attention to the factors that are negatively or positively form level of food security.

To resume, it was noted several mainstreams in observed investigations of factors influenced agriculture development. The first part of them emphasizes on the necessity of international trading for successful development. The second group insists on financial support of business. The thirds say about personal characteristics of employees for efficient farming. The representatives of the fourth part discuss more global problems, such as agriculture economy destroy, food insecurity and deprivation of elementary conditions for living as brutal aim and consequence of war. The fifths insist on climate peculiarities impact on prices, supply and demand of agriculture products that lead to decrease or rise of income of the branch. As it is presented by explorers, countries overcome internal and external obstacles, try to eliminate or at last reduce effect of crushing factors, find ways to enhance and strengthen own economics, support agriculture and industry business. In any case they must do that within the law field of their own country and following the international laws. Rarely some of

researchers touch up the legislative basis for decisions in the agriculture branch and professional farming activity. Evidentially, that all investigators formulated positive and negative reasons of growth or decline of the economy from different sides because of complexity of agriculture as system. Nonetheless, it was not said about crucial changes which were provoked by described impacts and was not mentioned the necessity to verify or clean used for analysis data in order to highlight main directions of system behavior.

We try to contribute own vision in way research of agriculture of long-term evolution under conditions and factors that took place in Ukraine during 1991–2022. This exploration fills some gaps in the economic history of independent Ukraine and presents the main tendencies in agriculture development that were reconstructed with econometric modelling on the base of structural components that were extracted from data sets with Hodrick-Prescott method.

The purpose of the article is to identify the stages and find out the content of the processes of transformation of Ukrainian agricultural business for the latest 30-years since the restoration of Ukraine independence. In other words, the main task is to reveal qualitative changes in agriculture development for the period of 1991–2022 years in spite of that the period includes consequences of such significant destructive impacts, as collapsed Soviet Union economics of 1990s, World financial crisis of 2008–2009, hybrid war that was started by Russia against Ukraine in 2014 and as a continuation of that aggression the undisguised brutal armed invasion by Russia in 2022.

The official statistical data and sources are used to study national legal base for transformation and support of the branch, to analyze waves of productivity and effectiveness of the agricultural business. Hodrick-Prescott method was used to clean some data sets and clarify portrays of indicators behaviors that have amorphous form in correlation and dynamics. Extracted structural components helped to get additional proofs of two main directions are existing in the development of the explored period. Calculations and modelling have been made in GNU Octave.

Practical use of methods of correlation and regression helps to build picture of influence of some factors on output indicator. It is typically supposed that the same approach can be successfully applied to long time series. We accept this assertion but assume that long-term data sets should be pre-processed by special methods that promote to make analysis more precise and reveal some latent changes in development of complex economical systems like agriculture.

Results and discussion. Agriculture in independent Ukraine is the most significant part of the economy. It has more then 30-years history of development, points of slumps and rises, struggle for own survival and ability to output and sell own production even in the war conditions.

According to investigations of National Research Center “Institute of Agrarian Economy”, Ukraine in 2021-year had leading positions in some areas of international product supply. Our country headed ranks in export of wheat grain, corn, barley, rapeseed, fresh peas. Moreover, it took the first place in the export of sunflower oil [21]. Unfortunately, since the start of full-scale armed of Russia the development of

Ukraine agriculture has faced with such problems as contamination of its lands with explosive objects, impossibility to grow agricultural crops on lands due to active hostilities, blockade of its seaports, attacks on its energy facilities and other consequences of military invasion. Mentioned causes make growing and export of Ukrainian agriculture production difficult. In such conditions, Ukraine tries to be more flexible in its decisions to succeed the economy branch. It changes directions of supplies, finds alternative ways of export, overcomes various limitations and obstacles in development. Thus, despite the war, Ukraine remained a reliable international partner been exporting grain crops in 2022 as an active participant of the "Grain Corridor" guaranteed by the United Nations and Turkey.

By the estimates of different researchers, the square of lands, that have degraded since 24th February of 2022, raised up to 13 % and it equals to 0.2 mln ha approximately. It means that part of territory of 10 administrative regions were polluted by explosive objects. By the words of Food and Agriculture Organization of the United Nations, due to aggression against Ukraine "the overall damages in the agriculture sector accounted for approximately USD 834 mln, accounting for damage of approximately USD 185 per rural household" [22, p. 10].

Simultaneously, as it is claimed by Ministry of Agrarian Policy and Food of Ukraine, according to data of State Customs Service during the 2022/2023 marketing year (July–June) Ukraine exported 23.963 mln tons of cereals and legumes including grain of wheat (8.712 mln tons), barley (1.663 mln tons) and corn (13.502 mln tons that even more than in 2021/2022 marketing year when volume of this product was exported on the level of 11.871 mln tons) [23]. Taking into consideration that 23.963 mln tons of cereals and legumes is less by 29 % than in 2021/2022 marketing year (33.701 mln tons), it shows ability of Ukraine to do agricultural business in difficult conditions. What stimulates and supports the agriculture in Ukraine? It seems that in conditions of destructive factors impact the branch would be collapsed, but the analysis gives proofs of its growth.

In this article we reveal some changes in agriculture development for the period of 1991–2022 studying legal documents and official statistical data, keeping in mind crucial events in the history of our country that influence on agriculture growth and falls. This period includes years of a transition from the state and collective farm-cooperative form of ownership land to private ones. That meant an alteration of managerial responsibility from the total control over the output processes by the state structures to the personal decision-making by producers. The state formed for farmers tools of their economic motivation to do business activity. It is worth to mention, that in addition to the transformation of agriculture Ukraine faced external threats. Among them are known the world financial crisis of 2008–2009, creeping occupation of Crimea of 2014, war actions in the east region, and brutal invasion of 2022 year. To balance economy government provides policy of decentralization and self-managing. The essence of this social reform is to strengthen independence, appropriateness, and responsibility for decisions in the agrarian sector of the regional economics. After all, the possibility of communities to dispose the part of their income was supposed to

stimulate more responsibility in management with the motivation of obtaining more replenishment to community budgets.

Visualizing statistics of Ukraine agriculture development on the diagram helps to see two main directions (underlined by straight green arrows in Figure 1) in the tendency of value added by agriculture, forestry, and fishing. The first is the slump of productivity from 19066 mln USD in 1991 year to 3750 mln USD in 1999. This downfall was related as to economic crises in Ukraine after collapse of Soviet Union, as to reorientation of the agricultural sector from archaic centralized control and collective way of farming to creation of conditions for farmers initiatives with special financial and technic support for them, land and material funding for farming, transition on a private form of ownership of land. Mentioned changes were provided by Laws of Ukraine. We should find it out them to understand which steps were passed by Government to revive agriculture and farming to obtain successful results of their development.

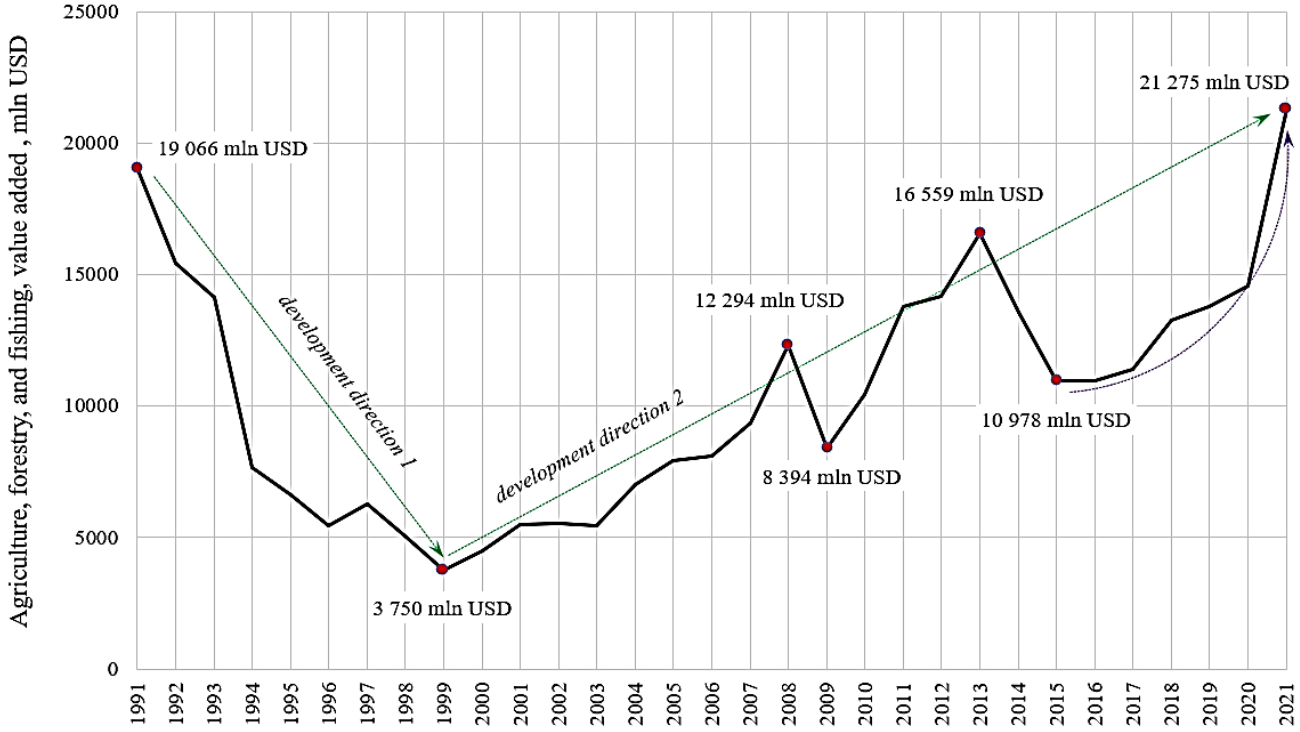


Figure 1. Agriculture, forestry, and fishing, value added (current mln USD) in Ukraine: two directions of development, 1991–2021

Source: built by the authors based on data [27].

The legal base for transformation was laid with the Law on Peasant (Farm) Economy in 1991 [24]. It is worth to notice that term "peasant economy" was used in the title of the Law. For the second and last time the same title was applied in the Law on Personal Peasant Farming (2003). It was a tribute to the Soviet tradition of calling agriculture economies as peasant farms. The Law (1991) includes the formulated concept of the farming, and its distinguishing features from state, collective, lease and other enterprises and organizations. The document describes production and economic relations with other forms of ownership, stipulates rights and responsibility of farmers,

outlines the procedure for providing lands for use and sizes of granted lands, approves property and labor relations.

The next important paper is Decree on Privatization of Land Pieces (Decree of the Cabinet of Ministers of Ukraine was approved in 1993 and amended in 2002 and 2006). It presents conditions for transferring land fields into private ownership [25]. The next pace was made in 1998 year by the Decree of President of Ukraine "On Support of Agricultural Producers" [26]. According to this document agricultural producers were liberated from value added tax paying during the period of 1999–2004. It helped to involve those finances for the purchases of material and technical resources for production purpose. That were the first steps of the transformation agriculture from command to democratic system and this stage took almost 9 years to get subsequent successful results due to reforming of the branch.

The second direction (right green arrow in Figure 1) is the growth that happened thanks to previous steps and because of further approved regulations. The Law (2001) on Stimulating the Development of Agriculture for the period of 2001–2004 [28] claimed agriculture as a priority branch for reformation. This document pronounces special principles for free price-forming with antimonopoly control over the prices of agricultural products, material, and technical resources (services) consumed by agriculture. Besides that, it was the first precedent when prices for goods, works and services were declared as formed according to market supply and demand. The role of government was in price monitoring, but not in price forming in authority way. It was significant decision in transformation of agriculture and its adaptation to market conditions. With this document the system of taxation and custom pay was simplified. Particularly, the value added tax was directed on purchases of agriculture means of production, but producers were obliged to pay fixed tax. Moreover, this Law canceled import custom on agriculture technical means and components that were not produced in Ukraine. Government insisted to assign for agriculture development not less than 5 % of budget expenditures annually during the period of 2001–2004. Additionally, one of the document articles outlined crop insurance conditions for economies.

The Law on Grain and the Grain Market in Ukraine [29] was approved in 2002 and annually is updated by Verkhovna Rada. It focusses on the grain market as the main sector of economy. Hence, the legal document is aimed at the creation of appropriate conditions for it with ensure the internal needs of the state in food, seed, and fodder grain, increasing its export potential. The principal idea of this Law is to provide food security for country. This document founded the necessity of forming comfort conditions for grain market and its export, state control of agriculture production quality and check of its conformity with the norms, regulation of prices, internal and external markets monitoring. Government offers financial support for seed producers, research institutions and testing stations. Simultaneously, state storages are obliged to declare volumes of grain monthly and keep safe the grain in relevant conditions. The next significant decision according to this Law is creation of Guarantee Fund, which the main task is to minimize risks for grain market subjects.

The Law (2003) on Farming Economy [30] details rules for creating a farm,

formulates who can be a participant or head of farm enterprises. It describes elements of the state support for farmers. Moreover, it specifies the procedure for ownership, usage, and disposal of farm property, indicates conditions for farming and other facilities. The next Law on Personal Peasant Farming [31] was accepted in 2003 year and been amended in 2005, 2008, 2015 and 2020 years. As mentioned above Law on Peasant (Farm) Economy (1991), this document defines main principles. It formulates sense of personal farming with rights of lands ownership or leasing to use for agriculture or farmer production, rights and obligations for members, conditions of state support. The government offers support in obtaining loans for farm buildings and other structures, in the agricultural equipment purchasing, in the lands granting, in providing with engineering, technical, veterinary, and agronomic services. It backs services for the provision of varietal seeds, planting material, promotes breeding of livestock and poultry.

The next document is the Law on State Support of Agriculture of Ukraine [32]. It was passed in 2004 year. It contains all annual amendments. This Law defines the basic points of state policy in the budgetary, credit, price, and other spheres of state administration in stimulation of the development of agriculture production and market. The main aim of regulation is to ensure food security for population. According to this Law term "food security" means complete defense of vital human interests in economical access to food to support and provide humans activity that must be guaranteed by state. Informational and financial backing is declared as accessible for agriculture producers. Information assistance becomes possible for them after authorization in the State Agrarian Register. Financial support is expressed in mechanisms of cheaper loans and compensation of leasing payments. Besides, it was claimed about state subsidy for some kinds of crop and animal husbandry.

In 2012 Verkhovna Rada of Ukraine approved the Law on the State Land Cadaster [33], as a unified geo-information data system about lands located within the Ukrainian borders. This paper presents purposes and restrictions on their use, information on quantitative and qualitative characteristics of lands, their assessment, possession and distribution between owners and users.

In September of 2015 the Cabinet of Ministers of Ukraine ratified the Concept of Development of Rural Areas [34]. As it is explained in the document, transformation actions that were taken to provide prosperity of agriculture revealed insufficient to promote progressive evolution of countryside areas and improvement of living standard of rural population. According to Law, accessibility to social services and state support plus economic motivation of farmers should become the driving force of rural development. To solve problems of agriculture economy in December of 2015 Ukrainian Government accepted the Concept of the State Target Program for the Development of the Agrarian Sector for the period until 2022 [35], as a continuation of the development strategy. Particularly, government accentuated on such problems as degradation of lands, high level of their cultivation, excessive consumption, dependence of agricultural production on imported fuel and energy resources, poor supply with agricultural equipment. It is admitted the loss of fixed assets of enterprises

including the fishing fleet due to occupation of Crimea. The Program examined three variants of development. The first one supposed administrative regulation of agrarian market and has many disadvantages for private initiative in farming. The second provided short-term planning of tasks. By the words of document, second plan means the absence of systematicity and consistency of their execution. The most receptive third variant assumed to optimize agricultural infrastructure and increase competitiveness of production. Ukrainian government offered to modify national legislation to the demands of European Union. Mentioned modification touches food safety requirements, support of producers, tax improvement and other methods of problem solving to gain successful results and consequently to be competitive on international markets.

The year of 2017 is noticeable by the approved plan of measures for the implementation of the Concept of the Development of Rural Territories [36]. It declared the urgency to execute the common tasks for life quality raising, protection of natural resources, diversification and growth of the rural economy, improvement of the management system on the rural territory, education, informational and consulting support. Many other Laws and documents were accepted to support as rural sector as agriculture producers. In 2021 government passed the Law on Amendments to Certain Legislative Acts of Ukraine Regarding the Market of Land Holdings and Acquisition of the Right to Use Them Through Electronic Auctions [37]. This paper normalizes the mechanism of buying and selling land as property.

This review of legislative field of agriculture sector activity for the period of 1999–2021 has been reviewed to understand what steps have been taken to reform the agriculture branch by the state. Obviously, some of them were successful or faced certain obstacles. Real statistics give us information about the cumulative results of the implementation of mentioned regulations.

Period of 1999–2021 is interesting by the main tendency of productivity rise (value added gained up finally to 21275 mln USD in 2021) despite the two considerable periods of instability. One of them happened in 2008–2009 year through the well-discussed in scientific literature world financial crisis. The second occurred in 2014 year because of russia aggression. It is worth to add that Association Agreement with the European Union [38; 39] and Agreement on the Free Trade Zone of Ukraine with the EU (effective from 01.09.2017, in fact it was applied from 01.01.2014) [40] became a prerequisite for the economic rise of the agricultural sector in spite of war time.

As it can be examined in the Figure 2, the waves of economy branches productivity have declines in 1999, 2009 and 2015 years. Simultaneously, since 1999 role of services and its contribution in total value added (in comparison with other sectors) has jumped and exceeded the figures of value added of agriculture and industry. That means the fast develop of all types of services including trade, hotel and restaurant business, transport, education, health care, financial, governmental, and personal services. Thus, the contribution by agriculture, forestry and fishing in GDP decreased from 25 % in 1999 to 11 % in 2021 year, but it continues to significantly affect the productivity of the economy.

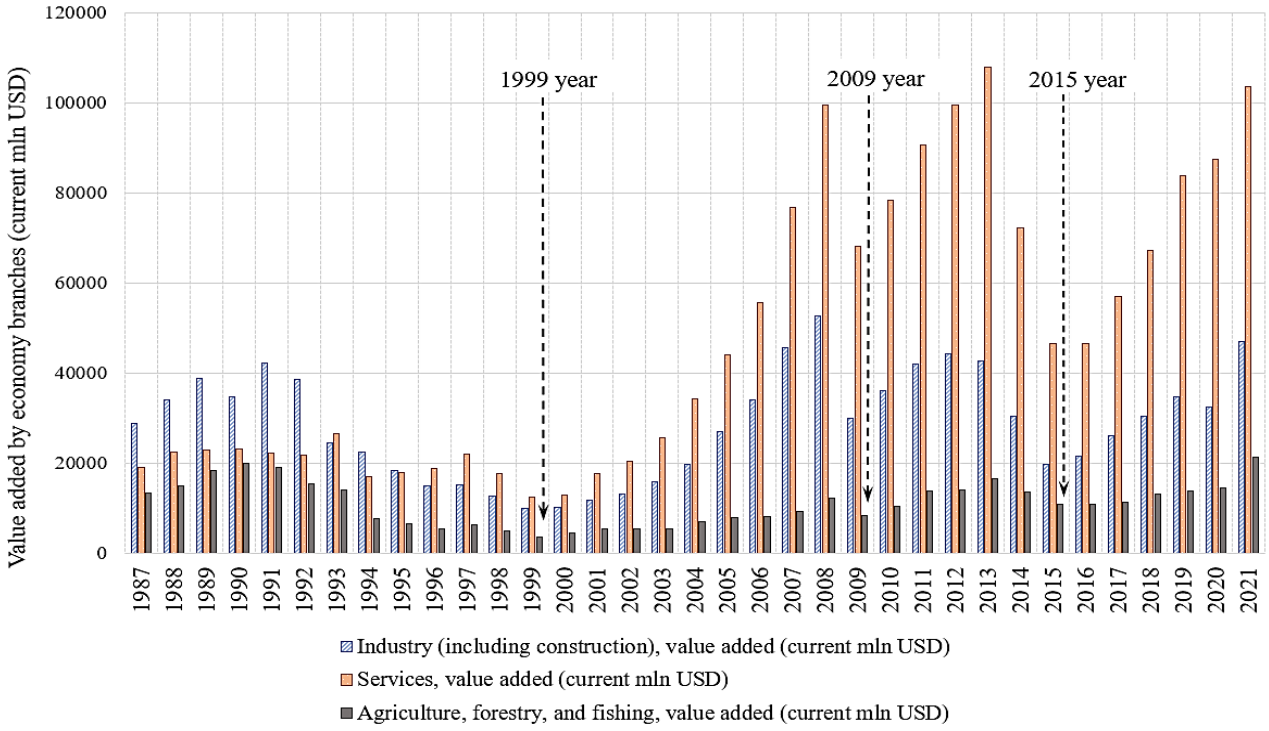


Figure 2. Dynamics of the industry, services and agriculture value added (current mln USD) in Ukraine, 1987–2021

Source: built by the authors based on data [27].

Mentioned impact is expressed in the figures of the next indicators. Fraction of food exports by Ukraine in its merchandise exports gained from the level of 12 % in 1999 year up to 40 % in 2021 (Figure 3).

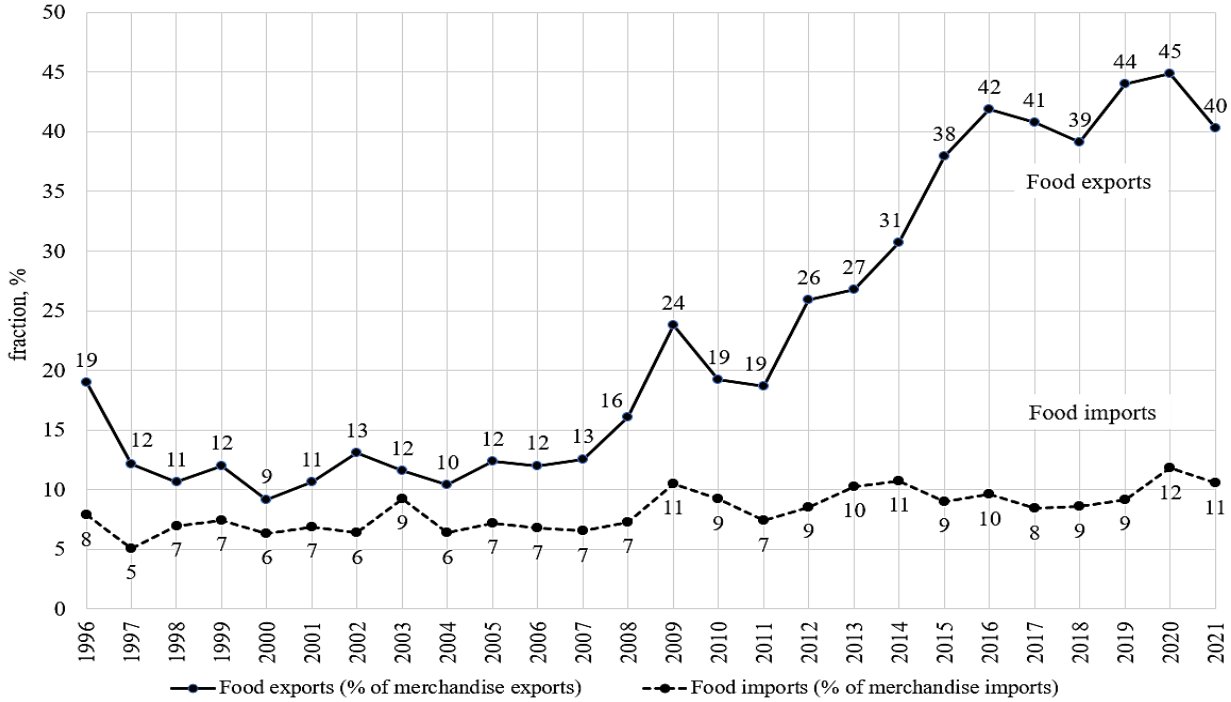


Figure 3. Ukrainian food exports (% of merchandise exports) and food imports (% of merchandise imports), 1996–2021

Source: built by the authors based on data [27].

Such export consists of food, live animals, beverages and tobacco, oils (vegetable, seeds, nuts, kernels) and fats (animal). The fact of increasing part of agriculture products export means the raise of productivity of this economy sector and its expansion into foreign markets. As in opposite to it, in import merchandise food took part of no more than 12 % during the period.

According to official statistics of the World Bank [27], exports of goods and services in Ukraine raised more than a third part of gross domestic product (GDP) and in 2021 year it was equal to 41 % even considering its unstable dynamics (Figure 4).

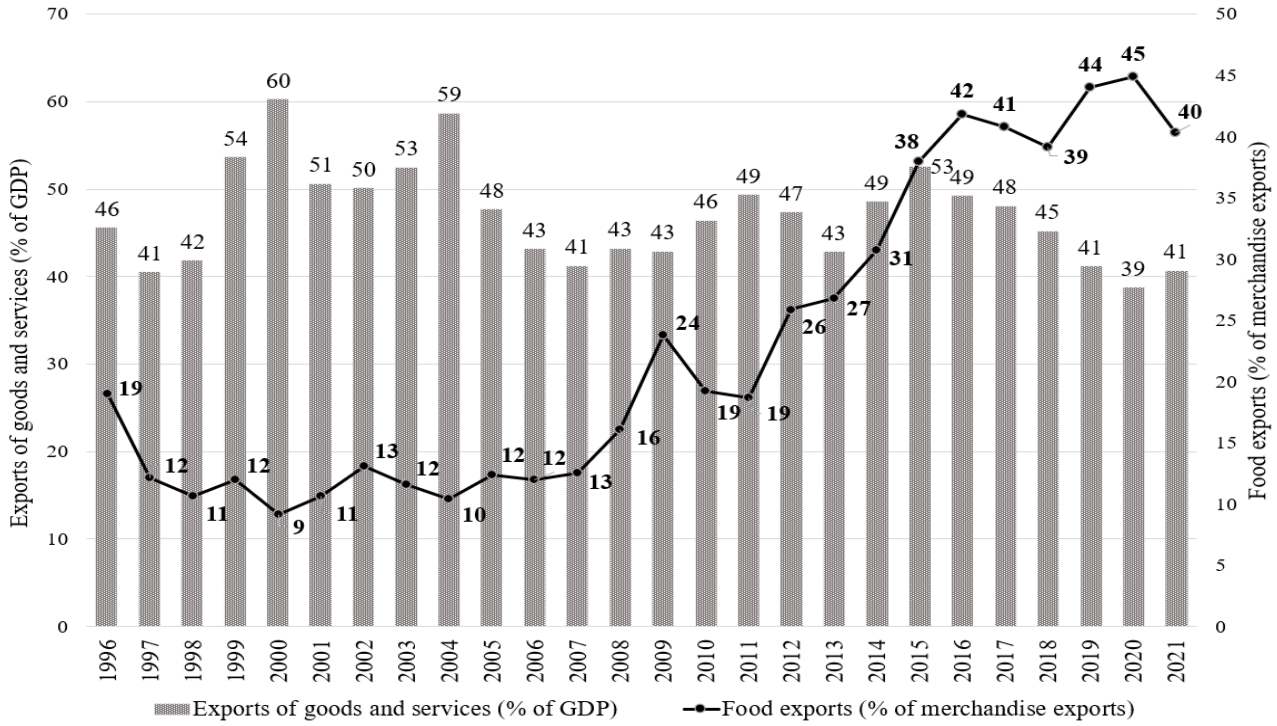


Figure 4. Exports of goods and services (% of GDP) and food exports (% of merchandise exports) from Ukraine, 1996–2021

Source: calculated and built by the authors based on data [27].

Fact of rising productivity of Ukraine agriculture can be proved by the next diagram (Figure 5). The square of agricultural lands under crops, gardens, pastures has shortened since 1991. Sometimes land square had extended but it has never become larger since 1992 (in dark gray narrow marker on the picture). It is worth to note that in dynamics agricultural lands were reduced from 419290 sq km (in 1992) to 414530 sq km (in 1999) and at last to 413110 sq km (in 2020). According to official data [27] the ratio of the value added by agriculture to the square of lands used for farming has positive changes from 9047 USD per sq km in 1999 to 32112 USD per sq km in 2018 (transparent wide marker). Presented enlargement can be explained by the next picture (Figure 6a) with data of crop production index aligned and calculated for the FAO's production indexes in international dollars to the base period of 2014–2016. Since 1999 this indicator has growing trend. Its value raised more than in twice: from 40.74 points in 1999 to 112.82 points in 2021. Such tendency means that crop production has successful support, and it influences on agriculture growth.

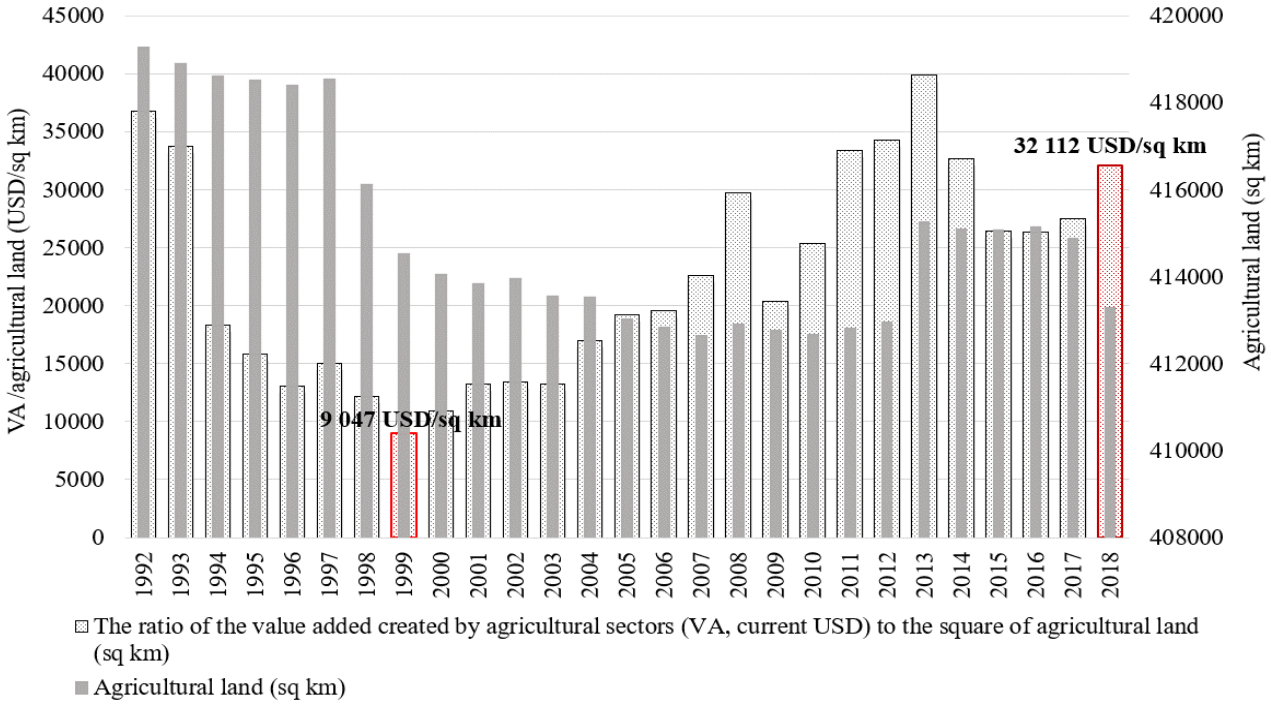
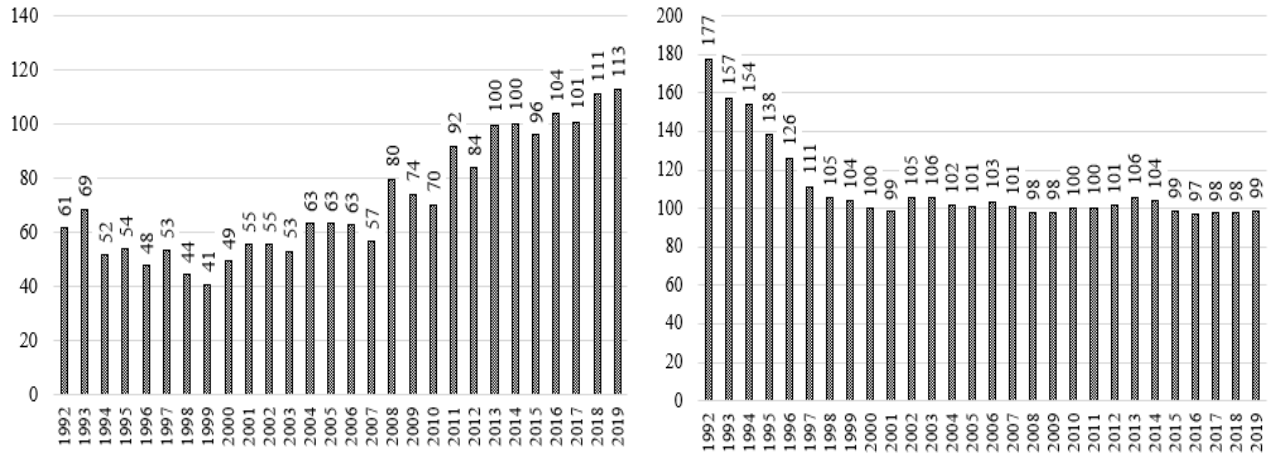


Figure 5. The tendency of the ratio of the value added by agricultural sectors (VA, current USD) to the square of agricultural land (sq km) in Ukraine, 1992–2018

Source: built by the authors based on data [27].



a) Crop production index

b) Livestock production index

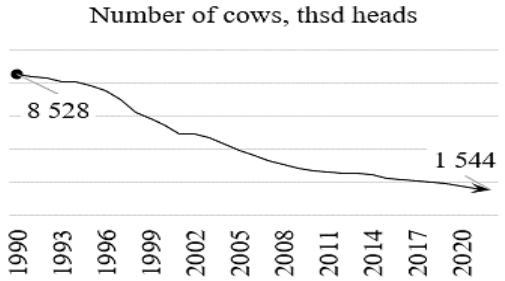
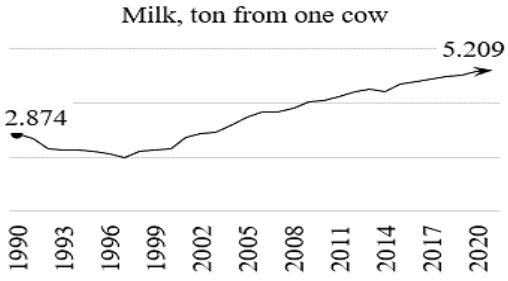
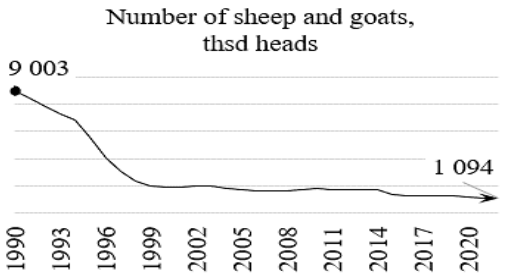
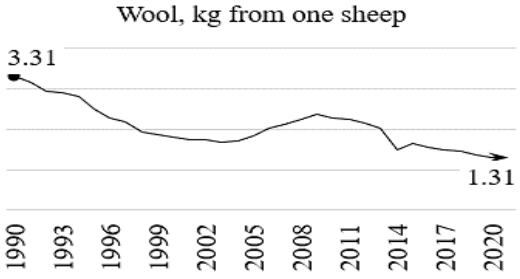
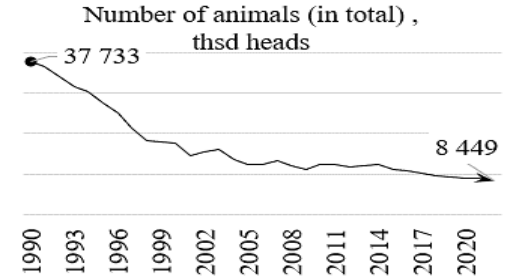
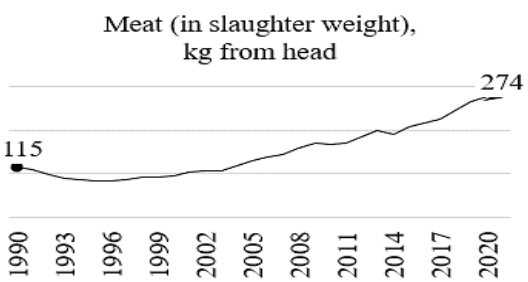
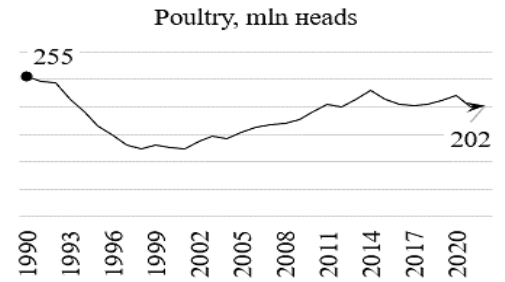
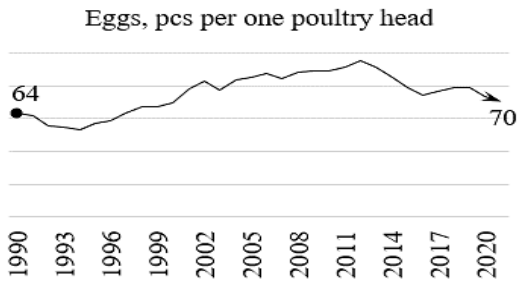
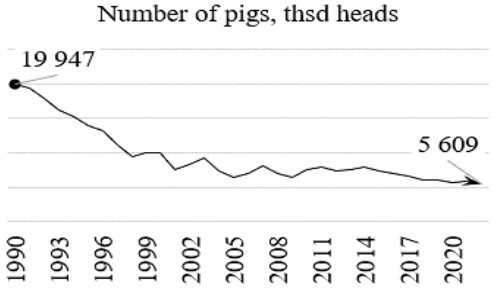
Figure 6. Crop and livestock production index (2014–2016 = 100) in Ukraine, 1992–2019

Source: built by the authors based on data [27].

In contrary to crop the livestock production index has unspecified trend (Figure 6b). It seems that since 1999 this indicator has fluctuated almost around the same value: without any signs of falls or grows. Official data [41] show that number of livestock is different in groups, but the total tendency of the number of cows, pigs, sheep, and goats in farms decreases year by year. It can be illustrated with infographics in the Table 1.

Table 1

Trends of livestock and its productivity in Ukraine, 1990–2021

Trends of number of agricultural animals, at 1st January, thsd heads	Trends of productivity from one head for year
 Shortening in 5.5 times	 Rising in 1.8 times
 Shortening in 8.2 times	 Decreasing in 2.5 times
 Shortening in 4.5 times	 Rising in 2.4 times
 Changing dynamics	 Changing dynamics
 Shortening in 3.6 times	

Decreasing quantity of animals does not mean that productivity of livestock in agriculture slumped too. It changed its level depending on the category. Analysis of productivity per head and correlation of indicators gives interesting picture. As it can be seen, production of meat and milk grows in 1.8 and 2.4 times accordingly. Positive changes in that production can be explained by the effectiveness of farming methods and tools have applied in this sphere Trend of wool production is unstable and in total it has decline in volume (in 2.5 times) with simultaneous shortening of number of sheep and goats. Likely, production of this sector is less in demand in Ukraine.

So, crop production has the most expressive dynamics. Moreover, it is the most influencing branch in agriculture. The simplest way to check this assertion is to analyze correlation of crop production index and agriculture sector value added. The model of line regression is obtained with high determination coefficient (Figure 7). Applied Fisher criteria confirmed the adequacy of equation. But it cannot be seen any down before 1999 year or positive changes after 1999 that were noticed in diagrams above. Where are the changes after the approval of private land ownership and adoption of legislation to support agricultural producers? What is happened with picture? Remembering dynamical character of such correlated data series it is worth to research this tendency more attentively.

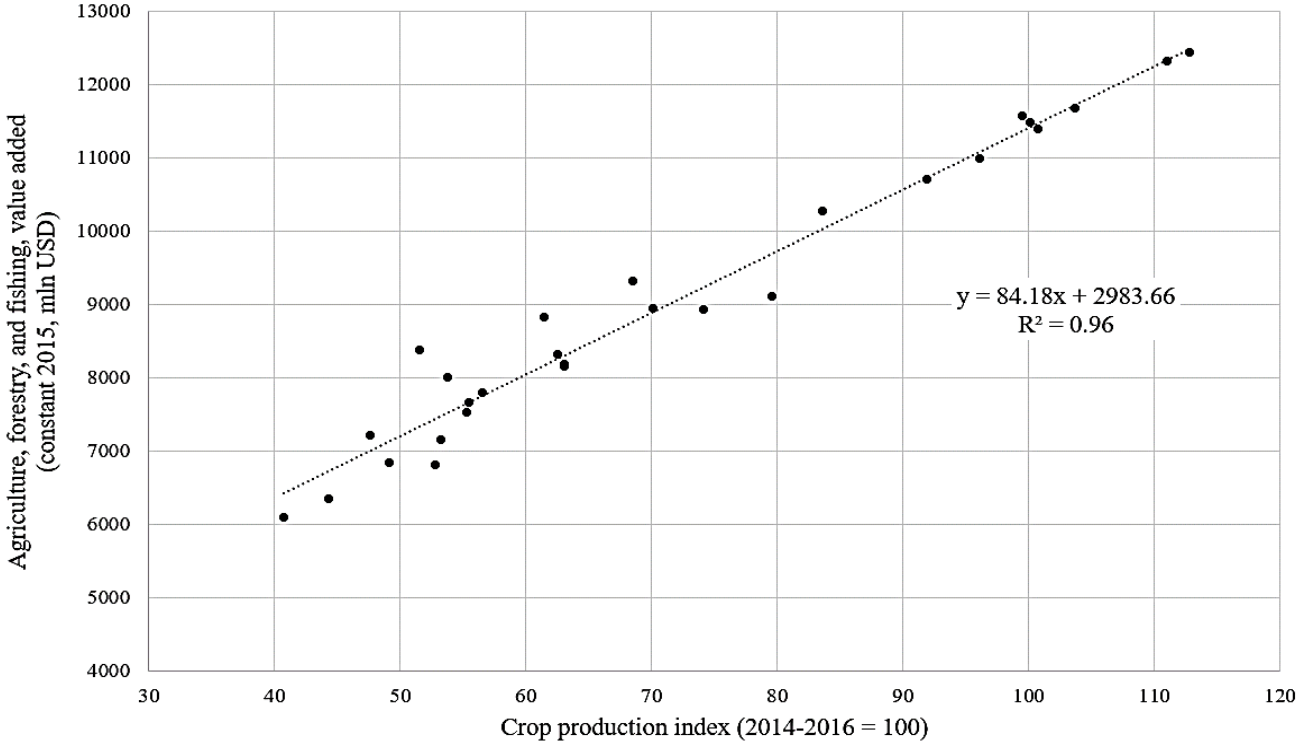


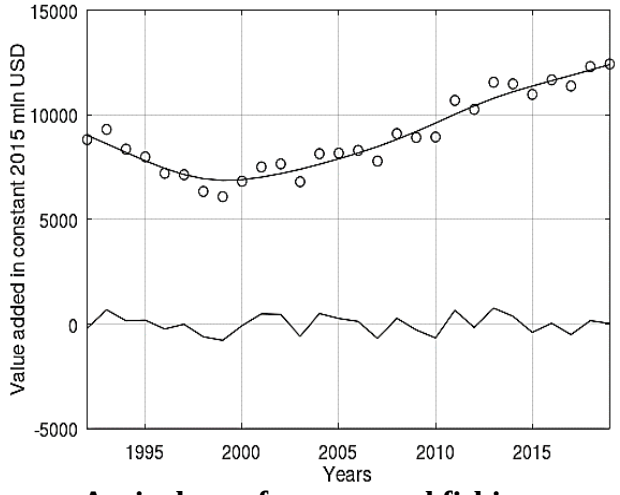
Figure 7. Correlation of unsmoothed data sets of agriculture, forestry, and fishing value added (constant 2015, mln USD) and crop production index (2014–2016 = 100) in Ukraine, 1992–2019

Source: calculated and built by the authors based on data [27].

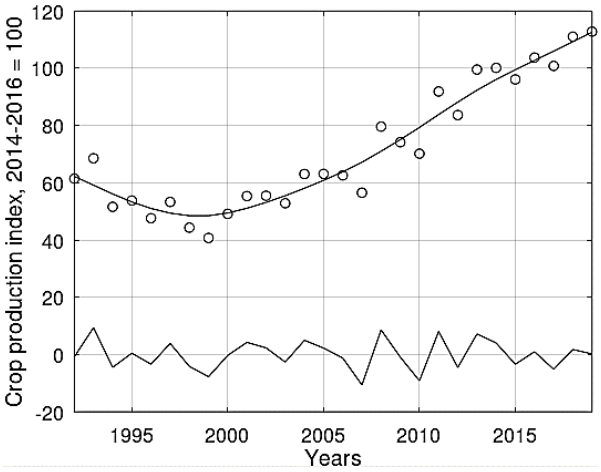
The article [42] described Hodrick-Prescott method applied to clean data from stochastic influences. Obtained components determined tendencies in indicators behavior. As it was displayed by authors, any economical process of a long-term period

can be presented with portrays that are different in raw and smoothed state. Smoothed data series can give information about main direction of development. Tendencies build on empirical data are characterized by a scattering of points that can be approximated by a theoretical model but such theoretical model not on any occasion can describe the moment of crucial changes or show significant deviation of values. It looks like relationship between indicators is disfigured by oscillation of their values from their basic dynamics. Relevant smoothing unveils unexpected results in analysis.

Constructed portrays of dependence of agriculture value added on crop production index confirm mentioned existence of distinguishes. Scatterplot of raw data (Figure 7) traditionally presents regression line that passes through a cloud of points and demonstrates the elongation of this cloud from the lower left corner to the upper right corner of the coordinate plane. It means that value added grows as crop production index goes up. It seems that it was systematically from year to year. We extracted structural components from both data series (Figure 8) and revealed that this is not entirely true. Dynamics changes own direction under impact of certain factors. We assumed that such turning was provoked by accepted decisions in agriculture development and crop production stimulating.



Agriculture, forestry, and fishing, value added (constant 2015, mln USD)



Crop production index (2014–2016 = 100)

Note. Structural components of indicators are shown with solid smoothed lines.
Real data are in scattered points.
Other oscillations are in broken lines.

Figure 8. Data sets of agriculture, forestry, and fishing, value added (current mln USD) and crop production index (2014–2016=100) in Ukraine, 1992–2019

Source: calculated and built by the authors based on data [27].

It is clearly seen in Figure 9 that dynamics in the branch can be separated on two periods. First of them is the period of downturn in the crop production, a decline in the volume of added value and perhaps elaborating of new solutions to stimulate the development of the national farming. First period lasted up to 1999 year. After reversal the second period started as a turn to a positive dynamic with development of grain sector and progress of agricultural branch. This achievement is a consequence of the evolution of form of business from a collective ownership to a private one, freedom of

entrepreneurial activity in plant growth, animal breeding and trading, enhancement of the technical support for farming, material motivation and the opportunity for farmers to sell products as on domestic as on foreign world markets.

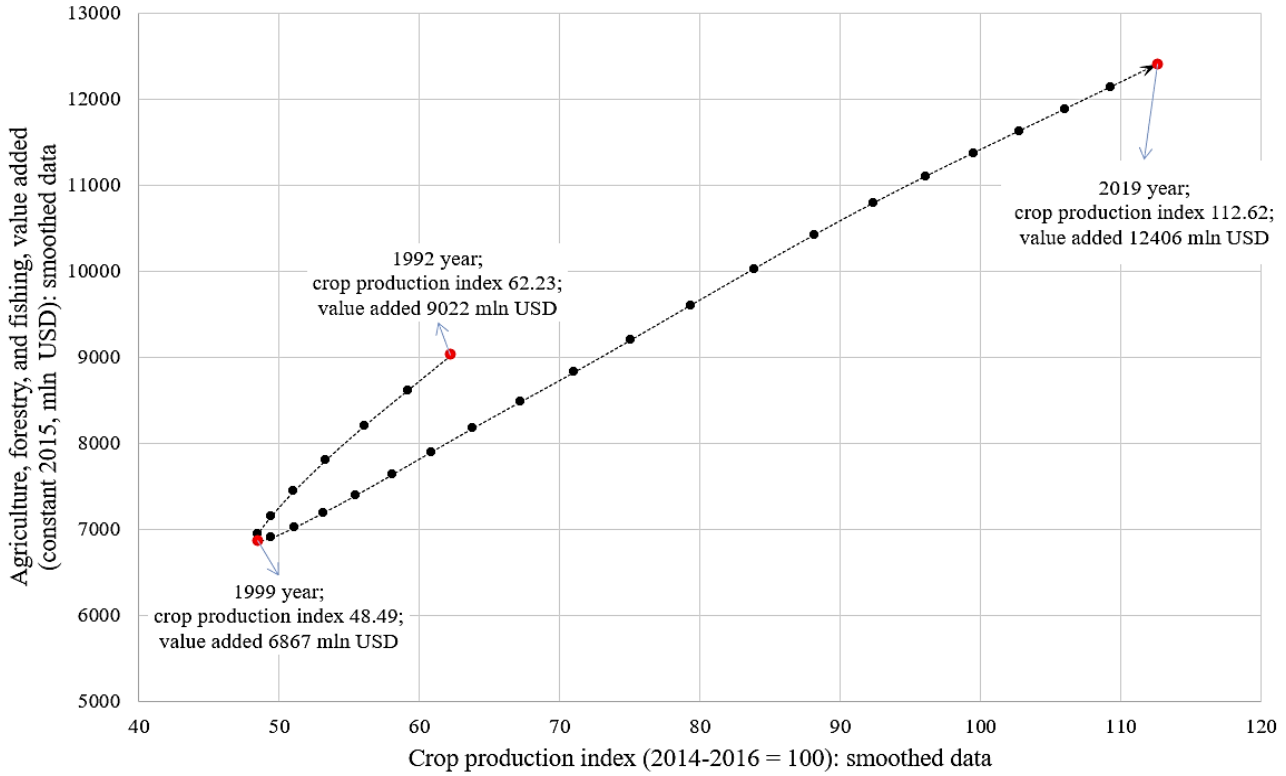


Figure 9. Correlation of smoothed data sets of agriculture, forestry, and fishing, value added (constant 2015, mln USD) and crop production index (2014–2016 = 100) in Ukraine, 1992–2019

Source: calculated and built by the authors based on data [27].

Simultaneously, according to the International Labor Organization estimation since 1999 the partitions of employment in agriculture have declined in twice nearly from 27 % to 12 % of total employment. Investigation of impact of employment share shrinking on the changes of agriculture value added helped us to reconstruct and compare such portrays of behavior. The Figure 10 of raw data series demonstrates a vagueness in trend. It cannot be said for sure with what model of regression the scattering of data points can be approximated. It cannot be found any precise type of model. It is seen cloud of points that spilled on the coordinate plane in some ambiguous order. Calculated coefficients of determination for analyzed models are insignificant to answer the question unmistakably how the productivity of employees' activity impacted on the agriculture development during the studied period. After data cleaning (Figure 11) the obtained structural components helped to highlight some changes.

Noted reversals in the portray of indicators behavior (Figure 12) show that from 1991 to 1999 slight growth in the percentage of farmers in total employment has not affected positively on the volume of branch output. Agriculture lost capacity factually from 19066 mln USD (1991) to 3750 mln USD (1999). But further process in the opposite direction in built graph demonstrates shortening of agriculture employee share and as a reaction is the rising of value added by the branch.

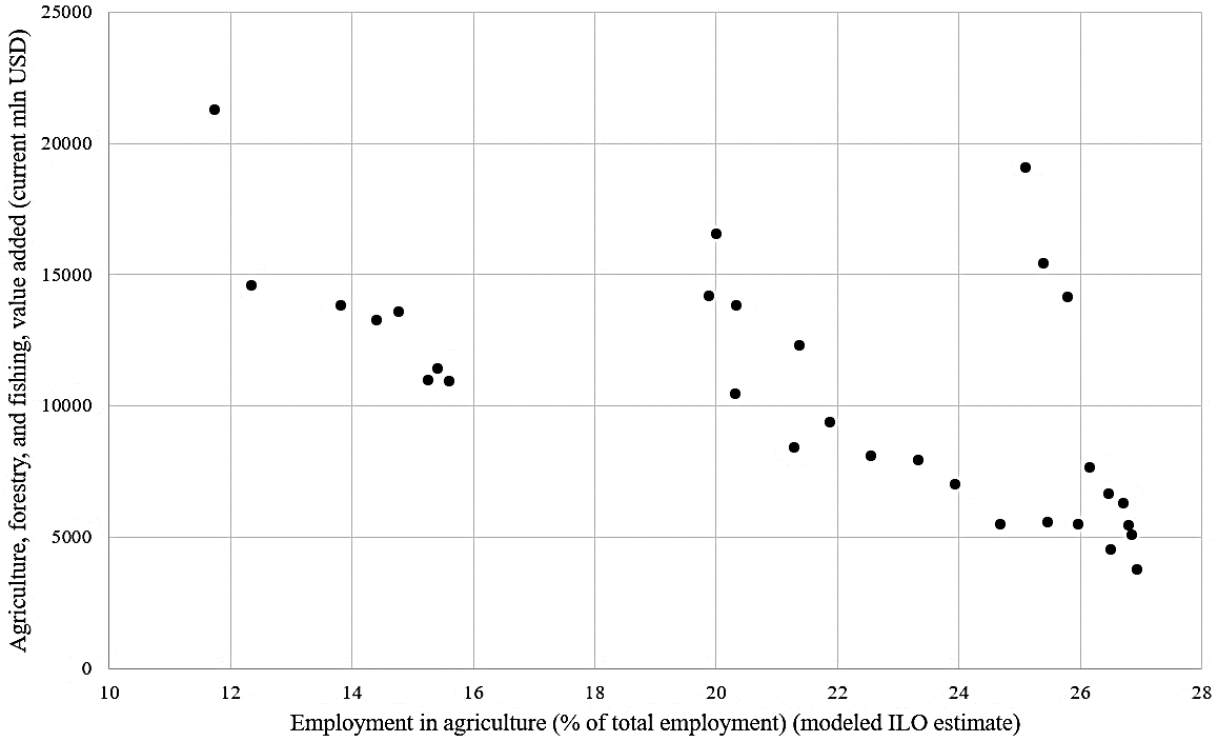
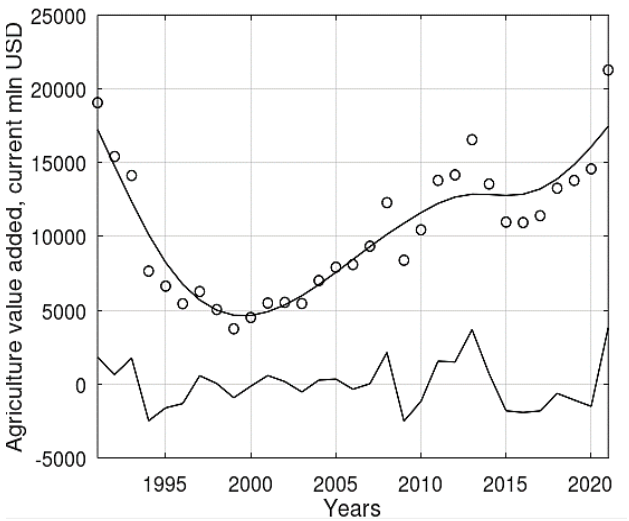
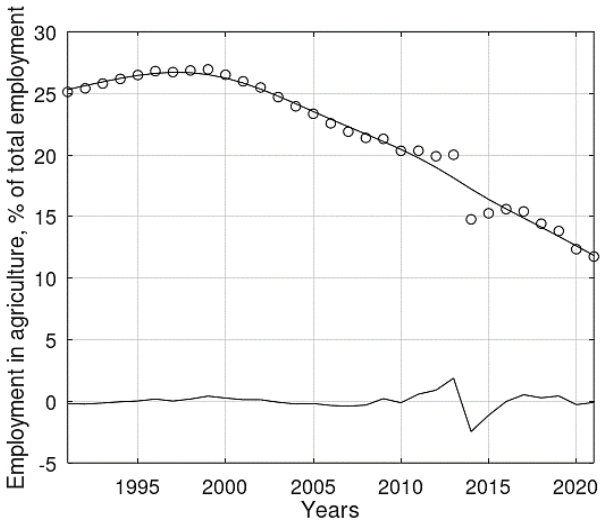


Figure 10. Correlation of unsmoothed data sets of value added created by agricultural sectors (current mln USD) and employment in agriculture (% of total employment) in Ukraine, 1991–2021

Source: calculated and built by the authors based on data [27].



Agriculture, forestry, and fishing, value added (current mln USD)



Employment in agriculture (% of total employment) (modeled ILO estimate)

Note. Structural components of indicators are shown with solid smoothed lines.
Real data are in scattered points.
Other oscillations are in broken lines.

Figure 11. Data sets of agriculture, forestry, and fishing, value added (current mln USD) and employment in agriculture (% of total employment) in Ukraine, 1991–2021

Source: calculated and built by the authors based on data [27].

Even taking into consideration that indicator of value added was measured in current USD (not in national currency that suffered from inflation of 1990s, 2008–2009 year and 2014–2015 year), it raised more than in 5 times from 3750 mln USD in 1999 to 21275 mln USD in 2021 year. It does not mean that the employment rate determined situation in the branch. Rather this fact suggests that the number of employments in agriculture becomes less significant for the branch effectiveness. It is assumed that modern machines, fertilizers, new crop cultivation technologies and animal care products replaced routine work.

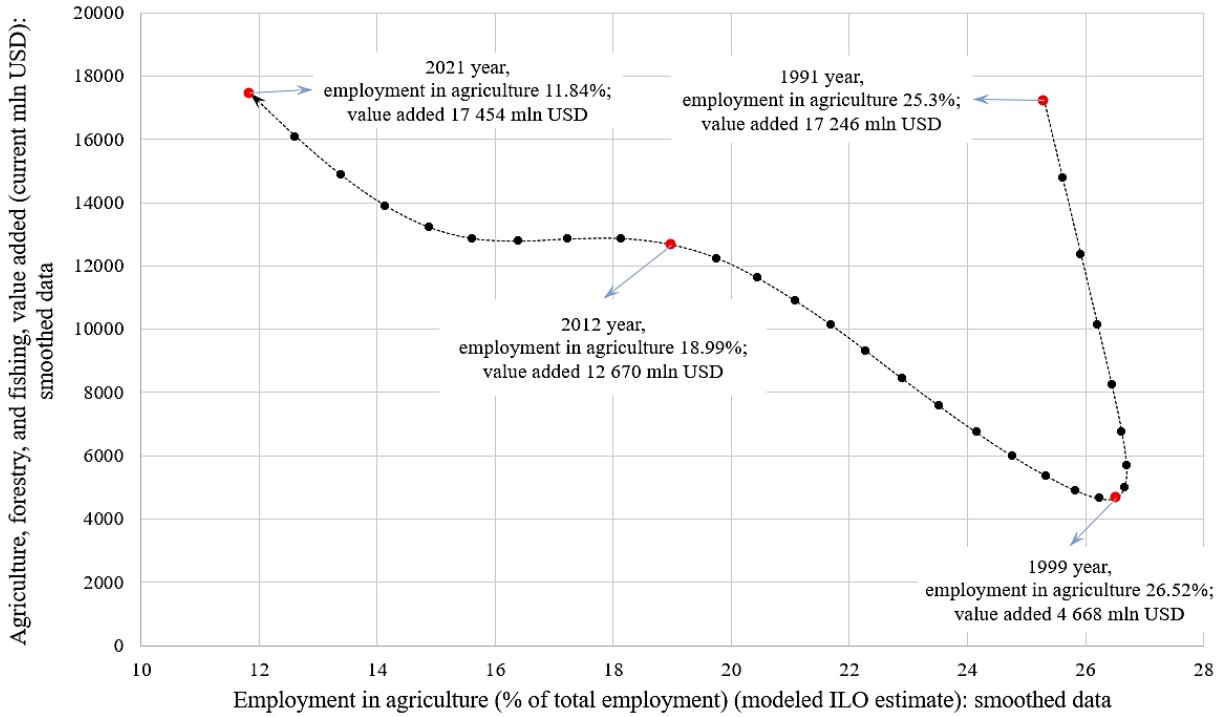


Figure 12. Correlation of smoothed data sets of the value added created by agricultural sectors (current mln USD) and employment in agriculture (% of total employment) in Ukraine, 1991–2021

Source: calculated and built by the authors based on data [27].

Let's look at the portrays of correlated dynamics of cereal yield (kg per hectare) and fertilizers consumption (kg per hectare of arable land) in raw and purified state. They have the same symptoms. Build scatter plot based on uncleaned data is characterized with weird form of points ordering. It seems that dots formed some wave, and it is difficult to determine effect of nutrients appliance on soil quality and thus on harvest of crop (Figure 13). It can be said that with intensive use of fertilizers the cereal yield as increases as declines. It can be supposed an existence of some point (assume even that this is point of saturation with fertilizers) after which land loss own productivity. But how to explain dominant concentration of dots in the left part of diagram before imaginary point of saturation and small amount of them after? Thus, to answer this question and clarify impact of nutrients appliance on cereal yield, structural components were extracted from raw data (Figure 14) and the portrays were rebuilt.

Structural components (Figure 15) in their relationship show two directions in dynamics of plant nutrients appliance and their impact on harvest. For the period of

1992–1999 it cannot be seen in the graph any utility from fertilizers usage. Moreover, the quantity of them shortened from 59.5 to 13.48 kg per ha. Then, after 1999 year it is observed evidential obtain from their contributions in soil that increased the crops harvest. Grain yield magnified in twice from 2252.33 kg per ha (1999 year) to 4757.13 kg per ha (in 2020).

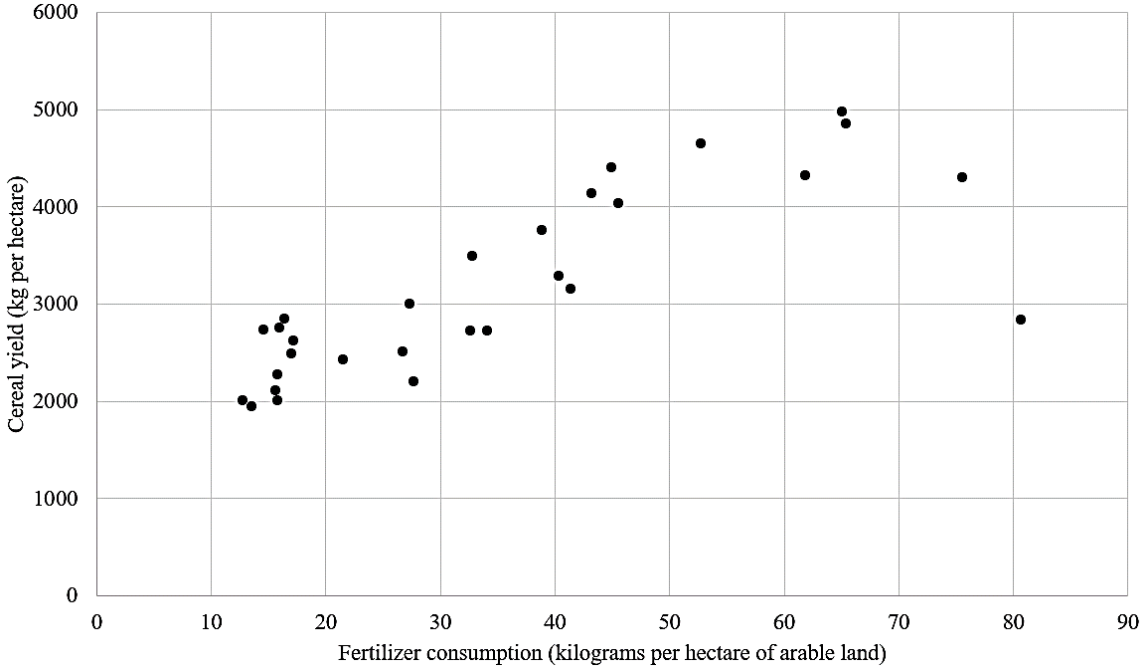
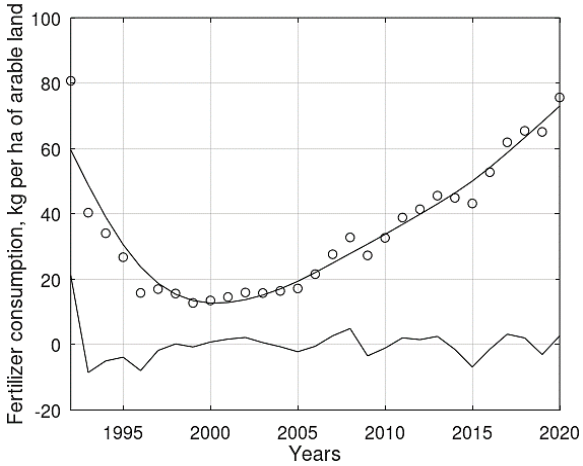
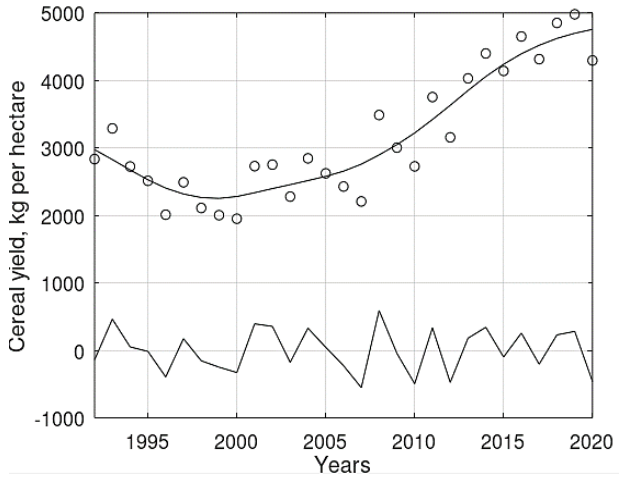


Figure 13. Correlation of unsmoothed data sets of cereal yield (kg per hectare) and Fertilizer consumption (kg per hectare of arable land) in Ukraine, 1992–2020

Source: calculated and built by the authors based on data [27].



Fertilizer consumption (kg per hectare of arable land)



Cereal yield (kg per hectare)

Note. Structural components of indicators are shown with solid smoothed lines.
Real data are in scattered points.
Other oscillations are in broken lines.

Figure 14. Data sets of fertilizer consumption (kg per hectare of arable land) and cereal yield (kg per hectare) in Ukraine, 1992–2020

Source: calculated and built by the authors based on data [27].

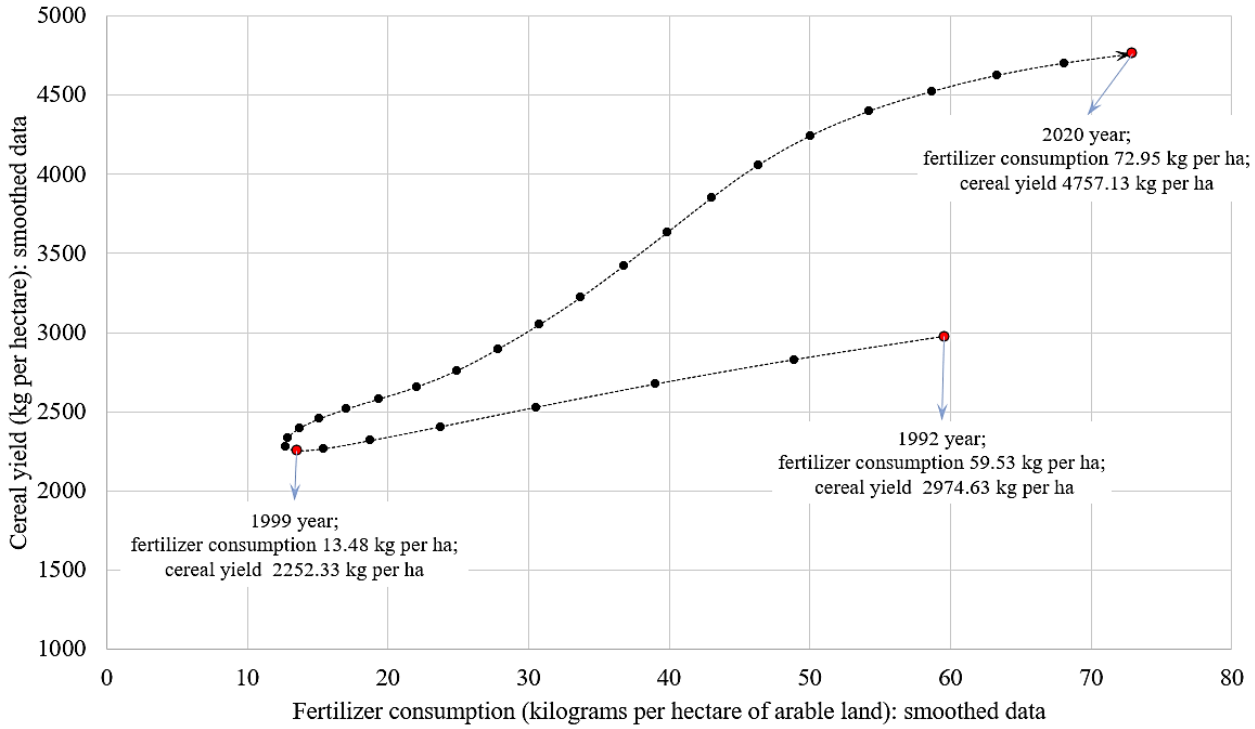


Figure 15. Correlation of smoothed data sets of cereal yield (kg per hectare) and fertilizer consumption (kg per hectare of arable land) in Ukraine, 1992–2020

Source: calculated and built by the authors based on data [27].

As it is noticed, the influence of World financial crisis of 2008–2009 year was not significant for agriculture in some way. We have not observed any crucial downturns in trends because of it. What about impact of 2014–2015 years when the hybrid creeping occupation of the Ukrainian territory was initiated by the Russia that considered as one of the "guarantors" of our country's security? As it can be seen in results of analysis the events of that period shook the economy (Figure 1 and 2), but later it regained its balance. That means that consequences of that events could not destroy agriculture that has strengthened from 1999 year thanks to right regulations of economy stabilization and development. This branch had losses in lands and part of harvest but continued develop own capacity to provide population of own and other countries with food and other resources. The 2022 year has started in Ukraine from undisguised armed invasion of that "guarantor", that is accompanied with the killing of civilians, destroy of buildings and economic structures, destruction of plant and animal husbandry in the occupied territories and areas affected by fire, littering of land with explosive substances, creating conditions that make normal life and functioning of the economy impossible on the occupied territories. This invasion caused problems not only for economy and population but for environment too that are as in the land and water pollution, as in the extermination of rare species of animals and birds.

As it is reported by Food and Agriculture Organization of the United Nation, in Sumska, Dnipropetrovska, Chersonska, Odeska, Chernihivska, Donetska, Kharkivska, Zaporizka, Mykolaivska oblasts farms are suffered from war and farmers "have suspended or reduced agricultural production" because of impossibility to grow crops

and breed animals. The FAO's publication (in December of 2022) evaluated the reduce of production approximately in 38 % and they emphasized that the figure in some areas can be higher [22, p. 6]. The FAO published in the end of 2022 year losses in Ukraine. Production of livestock has decreased by 192.5 mln USD because of number of animals shortening, if not account the decrease of productivity of remaining farms. According to issue results of investigation, reducing in production of crop sector made up by 102.5 mln USD, including loss of 172.8 mln USD on account of reduced yields of crops [22, p. 11]. Besides that, Ukrainian grain trading lost opportunity to get income due to hindering in sale agricultural products abroad by the sea. We cannot say for sure about full impact of war on our economy from 2022 year because of ongoing war and therefore because of absence of precise data about occupied territories and territories affected by shelling.

Agriculture in Ukraine passed through complex transformation and is developing now in adverse conditions. Our country has international support, and it helps to economy to resist external threats. Besides, Ukraine during the years of independence worked out new ways of agrarian business. Farmers have possessed new technologies in crop and livestock production. They have accented on more profitable things: concentrated on growth of crops through the enriching the fields with useful substances; shortened the size of livestock but used the technologies of productivity increase; shortened number of employees in agriculture but have intensified work through the motivation of their activity simultaneously.

Practical importance of obtained results is in disclosure of two trends in 30-years development of Ukraine agrarian sector in the period of 1991–2022. The end of 1990s in country became the breaking point that has demonstrated the effectiveness of reforms in agriculture, gain from ownership transition from state to private form and successful steps to freedom of entrepreneurial activity. Applied methods of structural components extraction conduced to filtering out of insignificant fluctuations in data sets and helped get precise comprehension of agriculture system development. This exploration has not presented effect on the level of separate farms but has clearly displayed achievements in branch system at whole.

Conclusions. This article presents results of analysis of legislative evolution in decisions which were related to the development of agriculture and reveals real state in this sector of economy on the base of official statistical data exploration. Research of long-term period allowed us to establish that after the declaration of independence in Ukraine the 1999 year became the most determinative in alteration of agriculture progress direction. Hence, a thirty-years period of independence in Ukraine agriculture can be divided on two parts that have distinguished features. The first one could be named as a period with rapid descent. Simultaneously, it is the time of reformation of agriculture and launching of farming economy on the base of private ownership, farmers initiatives, material and financial support for crop and livestock. This period demanded some reserves, and such transformation costed the shortening of branch value added almost in 5 times. The second period we would describe as a period of business activity revitalization and intensification. It lasted more long time and had

shocked factors in the development. World financial crisis of 2008–2009 years and external aggression beginning of 2014–2015 years are among them. If financial crisis lightly shook the branch and then it balanced again, the aggression left more deep mark with essential fluctuation of national currency, losses of territories, fertile lands, factories, and other fixed assets. But even after that the economy gradually began to pick up growth and then it gained the level of 21275 mln USD in value added by agriculture, forestry, and fishing. Thus, the main direction of development remained progressive. Results of analysis displayed the productiveness of the agriculture branch. As research presents, the quantity of lands and the number of employments had been replaced with quality of their usage. For instance, at the end of studied period the ratio of the value added to the square of lands are used for agriculture purpose gained to 32112 USD/sq km in comparison with 9047 USD/sq km in 1999 is recognized as breaking year. The employment in agriculture has shortened from 26 % to 12 % for the period of 1999–2021 but at the same time value added by agrarians raised to 17454 mln USD from 4668 mln USD. Reduction of livestock from 1990 to 2021 was combined with rise of some kinds of its production. The number of animals in total in 1990 year equaled to 37 mln heads and in 2021 year it was 8.4 mln heads. Meat in slaughter weight accounted as 115 kg from head in 1990 and 274 kg from head in 2021 year. Considering that at the beginning of studied period the number of cows was 8.5 mln heads and to the end it slumped to 1.5 mln head, volume of milk changed tendency from 2.9 to 5.2 ton from one cow. As a result, Ukraine increased export of agriculture production. Thus, in 1999 the fraction of food in merchandise export was on the level of 12 % but in 2021 it soared to 40 %.

To clarify the behavior of indicators and bring to light veiled directions in development we extracted structural components from data sets applying the Hodrick-Prescott method and modelling relationships between them. Therefore, the assumption about existence of latent changes in agriculture productivity has received additional proofs in presented results of data analysis.

Two main recommendations proceed from results of investigation. First, big data sets or time series should be carefully processed with methods that help to get a clear picture of the development of complex systems. Special technologies are used to clean data without loss. This research is based on Hodrick-Prescott method as the most precise. The second, to reconstruct development of economy it should be used complex vision of internal and external background of changes in economy functioning.

This investigation left opened methodological question for discussion: why some points in data have small deviation from direction and some have big rejections from it. Is it always because of some stochastic component? When can we make decision that the certain point deviated through the accidental impact or because of planned impact on process? Moreover, it would be interesting to forecast future behavior of agriculture economy considering internal and external factors that form main trend in development. Such questions should be answered that is the next task of investigation.

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