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Economic-mathematical modeling of optimal level costs in the greenhouse vegetables in Uzbekistan

Modelo económico-matemático de los costos de nivel óptimo en hortalizas de invernadero en Uzbekistán

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Contents

ABSTRACT:
This article proposes a model for agricultural production optimization, which will allow enterprises to increase their production profitability, built on a number of restrictions. This research is based on the actual data for 2013-2017 on the dynamics of average consumer prices for greenhouse vegetable products in the Republic of Uzbekistan. An econometric pricing model has been constructed, taking into account the seasonality factor and its applicability is shown for forecasting the price of vegetable products for subsequent periods.
Keywords: greenhouse vegetable crops, pricing, seasonal indices, additive model

RESUMEN:
Este artículo propone un modelo para la optimización de la producción agrícola, que permitirá a las empresas aumentar su rentabilidad de producción, basada en una serie de restricciones. Esta investigación se basa en los datos reales de 2013-2017 sobre la dinámica de los precios promedio al consumidor de productos de hortalizas de invernadero en la República de Uzbekistán. Se ha construido un modelo de precios econométricos, teniendo en cuenta el factor de estacionalidad y su aplicabilidad se muestra para pronosticar el precio de los productos vegetales para períodos subsiguientes.
Palabras clave: cultivos hortícolas de invernadero, precios, índices estacionales, modelo aditivo

1. Introduction

According to the Ministry of Agriculture of the Republic of Uzbekistan, more than 17 million tons of horticulture crops are currently produced in the country annually; this makes about 300 kg of vegetables, 76 kg of fruits and berries, 44 kg of grapes and 52 kg of melons and gourds per capita. This is about three times higher than the optimal consumption norms generally accepted in the world (The Permanent Mission of the Republic of Uzbekistan to the United Nations, 2016).

Over the past 25 years, the production of fruit and vegetables has quadrupled, including 9 times in grapes, 8 times in vegetables, 5 times in fruits, 8% in melons and 7 times in beans. Over 350 kinds of agricultural products are produced within the territory of the Republic, of which over 180 names of fresh and processed fruit and vegetable products are exported to foreign markets.

Since the first days of Independence a deeply thought-out agricultural development strategy aimed at ensuring the country's food security has been consistently implemented in the Republic of Uzbekistan.

This approach to the production of fruits and vegetables as an important part of the entire system of life support of the population, maintaining its health, and creating employment conditions has become one of the main vectors of the economic and social policy of our state.

Thus, one of the first measures that radically changed the approach to achieving food independence in Uzbekistan was an unprecedented decision adopted in 1989 to allocate more than 400 thousand hectares of irrigated land for household plots.

Agriculture plays an important role in Uzbekistan’s economy, providing 19.2 % of GDP, 15% of export revenues, and about 44% of employment. The country’s horticulture sub-sector is an especially important source of all-season employment in rural areas and provides a significant number of jobs for women. Moreover, horticultural crops generate significantly higher revenues for farmers than wheat and cotton. Fruit and vegetable production accounts for as much as 50% of the value of crop output and over 35% of agriculture export value (World Bank, 2018).

Further steps to implement market and institutional reforms in the agrarian sector included a change in the structure of sown areas, a reduction of cotton crops by almost twice in favor of grain crops. As a result, Uzbekistan, which previously had imported more than 80% of its need for grain, gained grain independence. Every year the country produces more than 7 million tons of these crops.

Other important areas of government policy in the field of agriculture include:

- the elimination of state and collective agricultural enterprises and creation of farms that ensure the labor productivity growth on the basis of modern agricultural technologies;

- the agricultural sector diversification, the development of potato, viticulture, beekeeping, poultry and fish farming;

- the expansion of the system of preferential crediting for agricultural production;

- the creation of an effective maintenance system for farms and dekhkan farms, as well as the supply of the necessary material and technical resources (fuel and lubricants, chemical fertilizers, biological and chemical plant protection products, seeds) for their needs;

- the formation of a logistics system for storage, transportation and industrial processing of agricultural products.

Much attention is paid to the development of farming. Today, there are 67.804 farms in the country. The legislative framework has been created and improved.

Pursuant to the norms of the Law "On Farmer Enterprise" and the provisions of the Presidential Resolution No. PP-4478 (2010), farms as the main producer of agricultural products are transformed to provide the further development of the agrarian and other industries and to improve the level and quality of life of the population. The President of Uzbekistan has signed a decree featuring measures to facilitate the creation of greenhouse complexes (PP-4020, 2018).

For a short period of our independent development in Uzbekistan, cardinal reforms were carried out, which made it possible to almost completely diversify agriculture and provide our population with basic food crops, and organize large-scale export of them.

Since 1997, the agriculture of our country has been demonstrating a steady positive growth rate of 6-7% per year. From 1991 to the present, the volume of agricultural products has doubled as a whole. This made it possible to increase per capita consumption of meat by 1.3

times, that of milk and dairy products by 1.6 times, potatoes by 7 times, vegetables - more than twice, fruit - almost by 4 times.

Owing to the systematic measures taken, the export potential of the industry is steadily increasing. In recent years, Uzbekistan has become a major exporter of high-quality and competitive fruit and vegetable products. To ensure it throughout the year, much attention is paid to the issues of processing and storage. Over the past 10 years, the volume of processing of fruits, vegetables and grapes increased by 3.5 times, including increase in production of canned fruits and vegetables by 2.5 times, that of dried fruit by 4 times and natural juices by 7 times. The share of processing exceeds 16% of the total production of fruits, vegetables and grapes. Currently, more than 180 types of fresh and processed fruits and vegetables are exported. In the export structure, its share reaches 73%.

In 2017 the geography of horticulture and viticulture exports was expanded by 17 new countries. In general, Uzbek exporters delivered fruits and vegetables to the markets of 57 countries of the world. Canned capers were first brought to Spain and Italy, walnuts to Lebanon, dried grapes to Vietnam, dried vegetables to Belgium, fresh grapes and melons to Switzerland, and dried apricots to Holland (UzDaily.com, 2018). In 2018 Uzbekistan increased horticulture exports in real terms to 1.23 million tons or by 36.1 %, and in monetary terms to USD 874.5 million or by 37.5%.

To increase the production and competitiveness of greenhouse vegetable crops within the framework of the State Program for 2018-2020, a partial (up to 20%) cost recovery for energy resources is envisaged, which will ensure an increase in the greenhouse profitability.

1.1. Literature review

Theoretical and practical aspects of greenhouse farming development, issues of specialization and concentration of production, cost management and the formation of the organizational and economic mechanism for vegetable and water enterprises were studied by agricultural economists. For instance, Zuev & Abdullaev (2002) devoted their publication to vegetable growing in protected soil. Regional allocation of green houses and their advantages in Uzbekistan are their main contribution emphasizing the importance of the work. Chazova (2009) focused on the aspect of forecasting consumer demand for vegetable products of closed ground. The author’s findings are essential in the area of mathematical modeling of greenhouse vegetable crops and demand for it in the market. Medvedeva (2015) approached the forecasting of cycles and crises in overall agricultural products. However, the author produced a generalized forecasting model for agricultural products. Umarov (2017) highlighted the issues of innovative irrigation in green houses located in Tashkent Region of Uzbekistan Therefore a need for a particular approach for greenhouse farming is observed through the literature review.

Significant contributions to the area of sustainable development of public production were made by such scientists as A.S. Ermakov, and D.S. Ermakov (2012), O.L. Kuznetsov and B.E. Bolshakov (2001), M.A. Kuvshinov (2011), L.P. Silaeva (2015), A.D. Ursul (2005), G.R. Yarullina (2011). Their findings were used in this research as a basis for mathematical calculations.

Some publications are devoted to scientific research of theoretical and methodological aspects of the problem of sustainable development of agriculture and the greenhouse farming market (Altukhov, 2016; Antsiferova, 2011; Botkin et al., 2016; Buzdalov, 2017; Kundius and Kharchenko, 2017; Minakov, 2015; Pustuev, 2016; Rubaeva and Prokhorova, 2015; Shaymardanova, 2010).

Methodological framework for the research of management and marketing, competitive market structure, industry and enterprise was built on the basis of studying the following works (Grishin et al., 2015; Gogolev, 2006; Nabokov and Nekrasov, 2017; Osipov and Ovchinnikova, 2005; Svetlakov and Zekin, 2017; Fatkhutdinov, 2002; Sharapova, 2016; Porter, 2006; Ostrom, 1998, Drucker, 2004; Kirtsner, 2001; Kotler, 1994; and others).

Various aspects of the organizational and economic mechanism for the sustainable development of the greenhouse vegetable market require further research, especially with

regard to the mechanisms for increasing the sustainable development of greenhouse enterprises in Uzbekistan.

The purpose of the study is to substantiate the theoretical and methodological provisions and develop practical recommendations for improving the organizational and economic mechanism for the development of greenhouse organizations.

2. Methodology

Currently, there are no universally recognized methods that allow predicting the production development in organizations with satisfactory reliability. It should also be noted that strengthening the economic freedom of participants in the reproduction process at the regional level causes a probabilistic image of the economic processes taking place in different sectors and forces to apply the scenario approach and multivariate alternative ways of finding solutions. To solve this problem, it is proposed to use methods of economic-mathematical modeling and multidimensional statistical analysis. Changes occurring in the modern economy lead to the compilation of new and improved systems of economic and mathematical modeling, enabling to analyze the dynamics of the regional organization development and take advantage of large amounts of actual information.

The methodology of the organizational and economic mechanism for the sustainable development of the greenhouse farming market is based on an integrated and systematic approach. The integrated approach takes into account a combination of market factors that influence the management of sustainable development of the greenhouse farming market. The systemic approach is applied in the study as a general methodological basis. It provides the objective reflection of the systemic properties of the greenhouse farming market players functioning and considers a set of interrelated elements, with regard to the peculiarities of local agriculture, the variability of external and internal factors, the level of state support in order to meet the social needs generated by enterprises in conditions of constant changes in the market environment elements.

The inconstancy of the external environment, the limited resources, the existence of highly profitable and unprofitable production in greenhouse farms located in the same natural and economic conditions does not allow us to determine the single most effective methodological approach.

The general theoretical and methodological basis of the research is formed by the scientific publications on the problems of the development of the agro-industrial complex and agriculture, in particular, the greenhouse vegetable crops market; analysis of intra-industry competition and enterprise competitiveness enhancement in the current economic conditions.

The research employed the methods commonly applied in economic sciences: general scientific (dialectical method, analysis and synthesis, comparisons and analogies, and graphical method); special (systemic, statistical-economic, economic-mathematical, experimental methods, comparative analysis and mathematical modeling).

Information base of the research is made up of official state statistics; normative legal acts of federal and regional levels; statistical data of the Ministry of Agriculture of the Republic of Uzbekistan; reference materials of specialized publications on the topic; data received from the participants in the greenhouse farming market, own research; the Internet data (industry portals, websites of greenhouse crops producers, articles and reviews).

3. Results

Analysts estimate the export potential of Uzbekistan’s agrarian sector making more than USD 5 billion. The Republic is gradually becoming one of the major exporters of high-quality and competitive fruit and vegetable products. But in general, the grain problem has not been solved so far, the country buys more than one million tons of food grain in Kazakhstan alone.

The climate of Uzbekistan favors the development of agriculture. The abundance of solar heat and light, mild short winters, fertile irrigated soils, extensive pastures allow growing

cotton and other valuable heat-loving crops here, obtaining high and stable grain yields, and breeding cattle.

Agriculture of the republic is characterized by high intensity. This allows the most rational and full use of a variety of natural conditions. The structure and nature of agriculture can be divided into three main climatic subzones.

Since 2016, crop yields have been growing at a fairly rapid pace in Uzbekistan. Thus, in 2016 the share of crop production in the structure of gross agricultural output increased to 61.2 % against 50.2 % in 2000. The coefficient of average growth rate of gross agricultural output (in 2006-2017) was 2.4% per year (Zuev anf Abdullaev, 2002). The increase in production was noted both among domestic producers and importers of agricultural products. The national consumers, taking into account the comparative advantages and competitiveness of domestic products aspire to purchase the products of domestic commodity producers.

In accordance with the third priority direction of the Development Strategy of the Republic of Uzbekistan, the country is carrying out cardinal reforms to liberalize foreign exchange regulation, foreign trade regime, customs and tax legislation, which creates the most favorable conditions for the resumption of Uzbekistan’s accession to the World Trade Organization (WTO). Within the framework of elaborating the issues of Uzbekistan’s accession to the WTO and attracting technical assistance, the Ministry of Foreign Trade of the Republic of Uzbekistan with the support of the United Nations Development Program organized a working meeting with the representatives of international organizations such as the Asian Development Bank (ADB), the World Bank, the United States Agency for International Development, the Delegation of the European Union in Uzbekistan, the German Society for International Cooperation (GIZ) and others.

In order to ensure effective systemic work and regular monitoring of the process of Uzbekistan's accession to the WTO, the Cabinet of Ministers approved a "road map", which includes 34 activities aimed at preparing documentation to resume the process of accession and adaptation of national legislation.

Some conditions for the accession of Uzbekistan to the WTO were the reduction of the import customs duties, the restriction of the dominance of a number of industries and agriculture, which may lead to an increase in the competitiveness of foreign goods.

Farmers will account for more than one-third of the short-lived economic growth (Li et al., 2017). In the current situation, the price of domestic agricultural products is one of the key tools for the successful development of domestic agricultural producers and the entire agricultural sector as a whole. The cost-based approach to pricing is the most traditional in terms of the transition period. It focuses pricing mainly on the internal production factors of economic activity development and the predetermined rate of return on products. However, this approach does not take into account the consumer demand for products and the presence of a huge army of producers-competitors, which appeared when Uzbekistan joined the WTO as observer country.

In the present research, the dynamics of prices have been studied for greenhouse vegetable products in the Uzbekistan for the last five years from 2015 to 2020. In addition, an attempt is made to forecast the prices of agricultural-economic output for subsequent years (Li et al. 2017; Chazova, 2009). At the initial stage, the dynamics of prices for vegetable crops as a whole will be analyzed. For the sake of clarity, a number of chain price indices are converted to a number of basic indices. Figure 1 shows a numerical series of the moving average of the price, as well as its linear trend.

Over the past five years, the price for greenhouse cucumbers has grown about by 1.5 times, and the income of the population increased by 1.7 times. In accordance with observations in 2006 and the required consumption of vegetable products recommended by the Ministry of Health of Uzbekistan, there is a clear tendency to reduce the share of income of the population spent for the purchase of agricultural products, in particular, greenhouse cucumbers (Figure 2).

Figure 1

Dynamics of prices for greenhouse
cucumbers by the moving average value

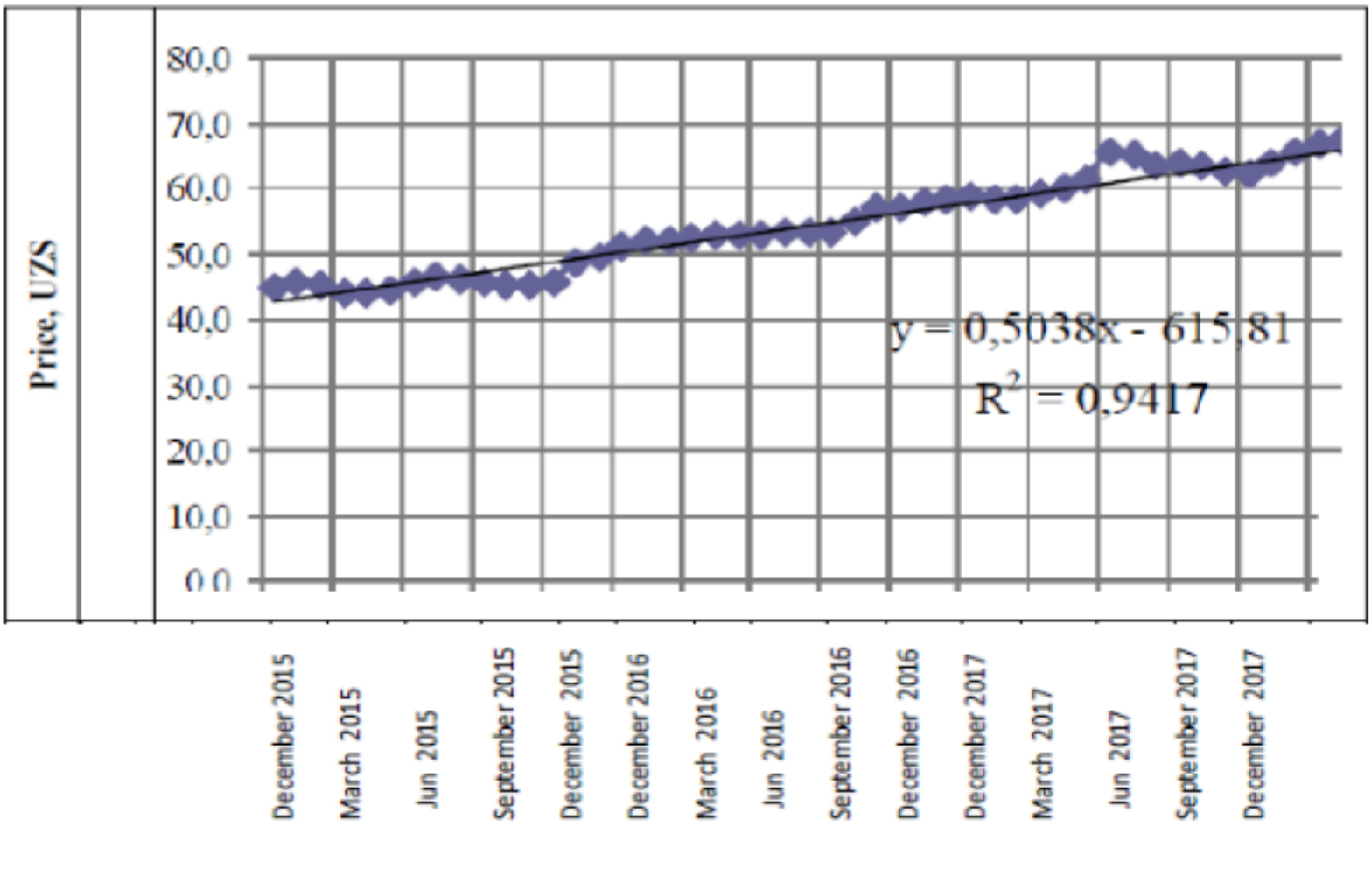
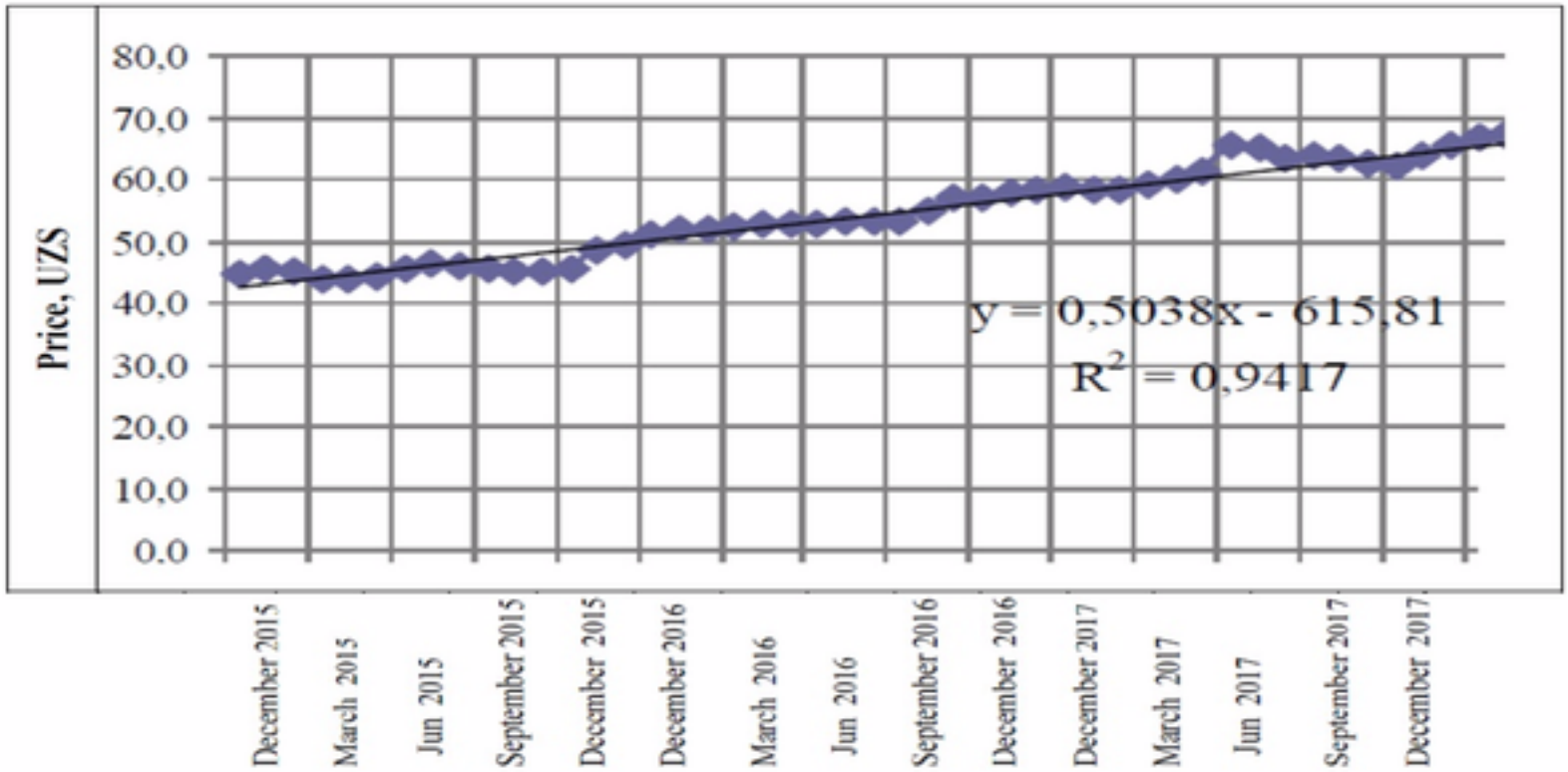


Figure 2
Average share of Uzbekistan citizen's income allocated
to the acquisition of greenhouse vegetable crops



$$Y=-0.0002x^4+0.0057x3-0.0626x2+0.2221x+0.4127 \qquad (1)$$

Preliminary analysis allows us to conclude that the above dependence (1) has a clear tendency to decrease, and also that this dependence can be easily approximated by means of a fourth-degree polynomial with a high level of result reliability, a determination coefficient R2.

Visual analysis of the moving average graph is shown in Figure 2. It enables to conclude that there is not only a rather natural upward trend in the time series, which is linear, in our opinion, but also there are quite distinct seasonal price fluctuations.

The trends in seasonalized and deseasonalized price changes over time were determined using the statistical functions of the package Ms Office Excel TENDENCY (), CORREL (), etc. To obtain an idea of how close the trend was to the initial data without seasonality taken into account, a correlation was determined between the values of the trend and the actual reference prices. The correlation value of 0.19 (and the corresponding value of R2, approximately 0.15) indicates that the conventional trend does not describe the behavior of the data very well. This shortcoming was eliminated by including the seasonality factor in the model. The inclusion of seasonal factors and their analysis was carried out in the following stages:

1. For each month, seasonal indices were calculated that characterize the seasonality impact.

2. These indices were used to calculate the deseasonalized seasonal adjustment for each month.

3. The trend was determined based on the deseasonalized values.

4. The actual trend was calculated by adding seasonal indices to the calculated values at the previous stage of the trend. Indices were added to the trend when an additive data model was investigated, that is, when the value is the sum of the trend value and the seasonal variation.

Table 1
Calculation of monthly seasonal Indices

Months	Average Ratio	Seasonal index	Indices 2013	Indices 2014	Indices 2015	Indices 2016	Indices 2017	Indices 2018
Jan.	167.5	162.8	131.4	200	209.6	164.8	269.6	162.57
Feb.	188.4	183.1	184.1	191.9	212.6	164.8	271.1	170.75
Mar.	155.6	151.3	159.7	170.9	151.6	140.4	216.2	139.80
April	132.4	128.7	136.9	135.3	141.5	116	186.75	119.41
May	106.1	103.1	117.1	107.5	109.7	91.1	145.95	95.23
June	63.7	61.9	70.2	63.3	64.7	56.7	89.05	57.33
July	54.1	52.6	49.7	56.9	41.3	68.7	89.35	50.99
Aug.	48	46.6	47.8	43.5	36.7	63.9	82.25	45.69
Sept.	43.6	42.4	35	32.1	44.6	62.8	85.1	43.27
Oct.	66.4	64.6	66.3	60.3	72.1	67.1	103.15	61.49
Nov.	92.2	89.6	99.6	88.3	102.4	78.5	129.7	83.08
Dec.	116.7	113.4	114.5	97.7	157.5	104.4	183.15	109.54
Total	1234.8	1200	each index = the actual value for the month/12 month’s moving average					
Adjusted by 1.0290								

The presented spreadsheet (Table 1) made it possible to calculate the relations for each month during the entire history of the data. After that, the average value for each month was calculated in the “Average ratio” column. However, in order to obtain the final values of the seasonal indices, an amendment was made: the sum of the indices should be 1200 (an average of 100 for each month); then they really will represent a percentage difference in the values. Each average value was reduced by 1.0290 times (= 1234.8/1200). This amendment was applied in the “Seasonal index” column containing the correct values of seasonal indices for each month.

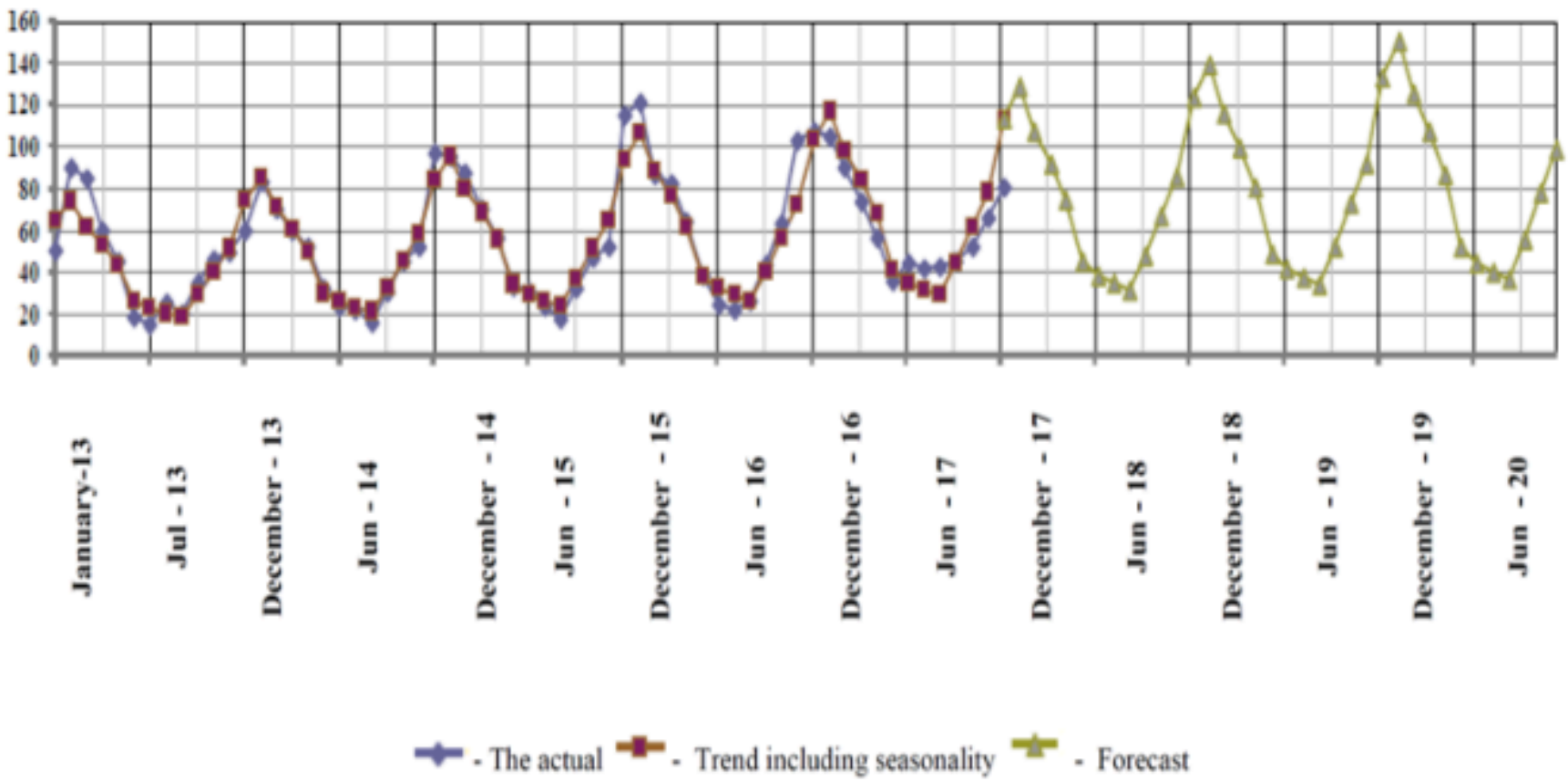
The seasonal indices obtained were used to seasonalize or deseasonalize data from which seasonal factors were removed. Using the function MS Office Excel TREND, a trend was defined based on new deseasonalized values. To obtain the true value of the trend, the deseasonized trend and the seasonal component were summed. A correlation value of 0.93 indicates that the new trend optimally simulates the original data.

To obtain forecast values for the product costs, including seasonality factors, an additive model was developed for the time series of the form Y = T + S + E, (2) where T is a trend, S - seasonal and E - random components of time series.

For the objectivity of the evaluation, the research combines techniques enabling to calculate the usual forecast trend and the rescheduled historical trend. Figure 3 shows a graph that compares the actual value of greenhouse products and the seasonalized trend, as well as seasonalized forecast values.

Increases in seasonal price occur throughout the winter months, and especially in the early spring. And, on the contrary, the seasonal decline in prices occurs in the summer and early autumn. Amplitude of seasonal price fluctuations in the range from the most "expensive" (February) to the "cheapest" month (September) is very significant – about 100%. The value of the coefficient of determination R2 = 0.93 indicates that the dynamics of prices for greenhouse crops in the period of 2013-2018 is determined by a linearly increasing trend and additive seasonal fluctuations.

Figure 3
Modeling the price for agricultural products (greenhouse cucumbers)



Import supplies of greenhouse agricultural products influence on the price level, but the cucumber takes a small share in the import of agricultural products, because this product is more “tender” and does not tolerate long-term storage and transportation.

Recently, a program for the development of greenhouse vegetable farming has begun in the country. Currently, the total area of greenhouses amounts to 9 thousand hectares, while the

annual production of greenhouse horticulture crops exceeds 600 thousand tons (UzDaily.com, 2018). In 2019 it is expected to attract USD 200 million from the World Bank, the Asian Development Bank, the International Fund for Agricultural Development and other international financial institutions for financing the creation of greenhouse complexes (Spot.uz, 2018).

The presence of modern greenhouse complexes in the republic, their technological opportunities and innovative technologies used are the most significant factors in the pricing of the final product. The geographical location of the greenhouse complexes directly affects the production volumes, profitability and competitiveness of the products. Regular delivery of vegetable crops to the places of consumption is estimated by certain costs, which occupy a significant share in the costs of production and sales of products. The program for the development of greenhouse vegetable crops and the Government's resolutions on the support of domestic producers, will undoubtedly affect the consumer price for these goods.

3.1. Discussion

Based on the analysis and synthesis of domestic and foreign experience in the study of the problem of markets, enterprises and industries, the authors offer theoretical and methodological provisions for the sustainable development of the greenhouse vegetable market. The conceptual approaches are formulated, including refined concepts of market structure, its potential and features, indicators, risks, principles and factors of sustainable greenhouse farming, expressed in the effective interaction of interconnected elements, with regard to the characteristics of the market under study.

A structural and logical scheme and methodology for assessing the sustainable development of the market allows determining the main parameters of the activities of economic entities. It provides managing from the viewpoint of optimizing the selected parameters to achieve a rational effect of the perspective capabilities of the enterprise and the market. The main principles of determining the sustainability parameters include the assessment of the enterprise efficiency in the main areas of development, their ranking with weight coefficients, the calculation of the reduced economic and parametric indices and aggregated indicators. The generalization of these data enables to determine the strategic capabilities of enterprises on the basis of their differentiation and obtain a comprehensive integral indicator of sustainable development of the market.

The organizational and economic mechanism for the sustainable development of the greenhouse farming market includes a set of methods exerting scientific and technological, socio-economic, organizational, production regulatory and legal impacts on market participants. It allows identifying the most effective tools and conditions for development, interaction and consistency of the system elements taking into account external and internal factors.

The peculiarities and tendencies of functioning of the organizational and economic mechanism of economic management in the greenhouse vegetable market are revealed: structuredness and level of development, competition intensity, influence of concentration and specialization on production efficiency. The main shortcomings that hamper the development of the greenhouse vegetable market is expressed in the absence of a rational market infrastructure, dependence on imported resources, the prevailing share of obsolete thermal structures and technologies that do not allow for effective competition with foreign producers of greenhouse vegetables and determine the reserves of import substitution and the stability of producing greenhouse vegetable crops in Uzbekistan.

The basic elements of the organizational and economic mechanism of sustainable development of the greenhouse farming market are substantiated, aimed at the integrated introduction of qualitatively new technologies that radically increase the efficiency of greenhouse farming in Uzbekistan. It was proposed to create an innovative coordinating center of an intersectoral nature, encompassing general research, marketing, production, innovative spheres of activity of participants in communication interaction and cooperation on the basis of the unification of all market entities.

The concept of the theoretical and methodological model of the greenhouse farming market is developed, based on the introduction of innovative technologies, taking into account state regulation that influences the main market parameters and includes strategic directions for increasing the effectiveness of greenhouse vegetable cultivation based on product quality differentiation (highly competitive, medium-competitive and low-competitive), aimed at increasing the sustainable development of the market, taking into account its segmentation and consumer preferences. Trends are determined and forecast scenarios for the development of the greenhouse vegetable market are developed (basic, compromise, intensive ones), depending on the level of state support and incentive mechanisms on the basis of an analysis of the actual indices of its capacity, which allow determining the level of self-sufficiency and import substitution, taking into account the cluster-territorial approach, realization of a set of organizational and economic measures that increase the performance efficiency of greenhouse vegetable farming.

4. Conclusions

The applied econometric approach accurately reflects the dynamics of the greenhouse cucumber price. Also the approach can be used for preliminary forecasting of the average price for other greenhouse vegetable crops, at least for the nearest calendar period. The calculated correlation coefficient (k = 0.93) between the actual data and the simulated trend, taking into account the seasonal and random components, indicates a sufficiently high degree of adequacy. For a more accurate price forecast for greenhouse vegetables, it is necessary to consider the qualitative composition of costly and other external factors for the theoretical construction of the response function. Modeling the pricing of domestic greenhouse products will make it possible to increase the predictability of the demand for greenhouse vegetables and to achieve certain uniformity in their production and sales, producing a stable profit.

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