sustainability

MDPI

Article

Innovation Policy and Sustainable Regional Development in Agriculture: A Case Study of the Stavropol Territory, Russia

Anastasia Chaplitskaya [1,2,*], Wim Heijman [1,3], Johan van Ophem [4] and Olga Kusakina [5]

1 Agricultural Economics and Rural Policy Group, Wageningen University and Research, 6706KN Wageningen, The Netherlands; wim.heijman@wur.nl
2 Foreign Languages Department, Stavropol State Agrarian University, 355017 Stavropol, Russia
3 Department of Economics, Czech University of Life Sciences, 165 00 Prague, Czech Republic
4 Urban Economics Group, Wageningen University and Research, 6706KN Wageningen, The Netherlands; johan.vanophem@wur.nl
5 Department of Economic Theory and Applied Economics, Economic Faculty, Stavropol State Agrarian University, 355017 Stavropol, Russia; kusolga@list.ru
* Correspondence: anastasia.chaplitskaya@wur.nl; Tel.: +7-928-304-7187

Abstract: This paper considers innovations as one of the factors of sustainable agricultural development of the Stavropol Territory. It focuses on the impact of state policy at the regional level in the field of innovations on the sustainable development of the region's agriculture. This paper tests whether the implementation of the policy in innovations increased the sustainable growth of agricultural development. To do so, a model with switch variables was used. Principle component analysis was used to calculate a composite sustainability index of selected socio-economic and environmental indicators. The hypothesis that the introduction of a state policy aimed at innovation has a positive impact on the sustainable development of the regional agriculture was corroborated. We also assessed the impact of implementing this policy within each dimension separately. The socio-economic indicator is more important than the environmental indicator.

Keywords: agricultural policy; innovations; principal component analysis; switching regression model; composite indicator; state program

check for updates

Citation: Chaplitskaya, A.; Heijman, W.; Ophem, J.v.; Kusakina, O. Innovation Policy and Sustainable Regional Development in Agriculture: A Case Study of the Stavropol Territory, Russia. *Sustainability* **2021**, *13*, 3509. https://doi.org/10.3390/su13063509

Academic Editor: Diego Giuliani

Received: 4 February 2021
Accepted: 15 March 2021
Published: 22 March 2021

1. Introduction

In modern society, innovations are the prerequisites for the development of agriculture. They not only have a positive impact on the competitiveness of the economy but are also of importance for implementing policies of import substitution of food products and maintaining a country's food security, an objective of Russian agricultural policy. Thus, innovations contribute to the dynamic sustainable development of agriculture. Sustainable development of agriculture remains very relevant both for the country as a whole as well as for its regions such as the Stavropol territory in the Caucasus [1].

When it comes to innovation within the agricultural sector of the region, the innovative sphere of the Stavropol Territory is at the initial stage of its development. Compared to the other regions of the North Caucasus Federal District, the Stavropol Territory is at a higher level of innovation, but it lags behind the average level of the Russian Federation, as evidenced by the data presented in various ratings, including the data of the rating made by the Association of Innovative Regions of Russia (AIRR) in 2017.

Agritourism can also be a key driver of innovations in many rural areas today. Agritourism is an integral element of sustainable rural development [2]. As this area is relatively new and promising in Russia, the rich tourism resources of the Stavropol Territory are not actively used.

There is also a significant effect on agricultural technology innovation and sustainable agricultural development in the region by rural financial efficiency. Improving the level of agricultural technology innovation is beneficial for rural economic development [3,4]. Sustainable development of agriculture can be achieved if the reproduction of production potential, human resources and the natural environment are ensured for a longer period of time. State policy can play a decisive role in ensuring the balance of the economic, social and environmental components of sustainable development.

From this perspective, this paper has a double objective. First, we assess the agricultural sustainable development of the Stavropol Territory with a composite indicator. Specifically, we apply principal component analysis (PCA) to quantify the agricultural sustainability that covers three dimensions (economic, social and environmental) of sustainable development. Secondly, we test the hypothesis that the introduction of a state policy aimed at innovation has a positive impact on the sustainable development of the regional agriculture.

This paper is organized as follows: the theoretical orientation section discusses innovations in agriculture and gives a description of the state policy in the field of innovations. The data and methodology section presents the data and explains the method used to construct a composite indicator of agricultural development and presents the switching regression model (SRM). The following section illustrates the obtained results and the final section contains the discussion of the results and conclusions.

2. Theoretical Orientation

In recent decades, agriculture has been shown to be able to meet the challenge of the sustainability paradigm, with producers implementing principles of agro-ecological production, alternative food networks and local food systems together with productivity systems that have adhered to the principles of sustainability [5]. These innovative agricultural systems consist of either new technical or organizational solutions. However, the core issue in sustainable innovation is the kind of knowledge that is produced and shared. The collaboration and fostering of participation between scientific research, stakeholders, local actors, and policymakers should lead to process innovation [6,7].

According to Porter [8], innovation is a new way of doing things in a commercial setting. In this sense, innovation is all about turning ideas into cash. For the type of innovation needed to bring about a more sustainable development, the new ideas should not only contribute to cash but also to environmental and social quality. This needs an extra step that transforms a standard innovation. New arrangements in society itself can support new modes of agricultural production in order to lead to not only new industry and commerce, but also a new relationship with the surrounding environment.

Defining and measuring innovation performance with regard to sustainability goals in the real world requires reliable evaluation tools to understand the direction in which changes should be oriented [4,9]. Sustainable innovation can be considered as "any new or significant improvement of products, services, technological or organizational processes, commercialized or internally implemented, that not only provide economic benefits but also generate positive social and environmental impacts" [1] (p.135).

Innovation in agriculture means the use of new varieties of plants, breeds of farm animals, production technologies in crop production, livestock and agricultural processing. Innovative processes in the agricultural sector have their own characteristics. They differ in the variety of regional, branch, functional, technological and organizational features. The conditions and factors contributing to the innovative development of the agricultural sector are the availability of natural resources, significant scientific and educational potential, a domestic food market and the ability to produce environmentally friendly, natural food.

That is why the environmental innovations occupy a special place in the system of innovations applied in agriculture because at present the main limitation of economic growth of agriculture is the continually increasing ecological requirements to the process of production, quality of agricultural products.

Environmental innovations ("eco-innovations") are the innovations carried out within the framework of the technological, organizational or marketing innovations, contributing to the reduction in or prevention of the negative impact on the environment, balancing economic, environmental and social interests [10].

There are different types of environmental innovations implemented in agriculture: product, process, organizational, marketing, social and systemic.

In order to achieve sustainable growth in agricultural productivity, the use of natural resources must be carried out by ecological requirements. Organic agriculture, as an innovative technology, aims for the following objectives:

- preservation and possible improvement of soil fertility;
- cultivation of healthy plants and animals without chemical means and forage additives;
- the production of physiologically complete products in sufficient quantity and quality and at affordable prices;
- minimize consumption of nonrenewable natural resources;
- ensuring a safe environment [11].

Unfortunately, the desire to increase the effectiveness and efficiency of agriculture, including extensive farming, irrational use of land and other natural resources, has led to negative environmental consequences, such as environmental degradation, increasing health hazards and changes in landscapes. The specific features of agriculture as a complex economic, ecological and sociobiological systems are poorly taken into account when reorganizing and choosing the directions of agrarian transformations in agricultural production [12,13].

Analysis of the socioeconomic situation in Russia in the agricultural sector in recent years shows a decrease in automation of agricultural work. The intensity of the process of development and introduction of innovative agricultural machinery and technologies by large farms and small farmers has declined [14]. At best, modern farms prefer to purchase imported models of machinery and introduce foreign technologies, but the majority of enterprises use rather badly worn out and obsolete equipment. All this aggravates the degradation of the complex's industries, which leads to an increase in the cost price and low competitiveness of products, hindering the socio-economic development of rural areas and sharply reducing the quality of life in the countryside [15]. So, there is room for improvement. Innovation can contribute to achieve this. Measures for the transition to a new level of agricultural production should be substantially supplemented by projects focused on the formation of a unified environment that stimulates innovative transformation of agrarian territories using the most advanced technological capabilities of human potential development and its effective use. It is very important that the whole complex of infrastructure that accompanies modern business in agriculture is formed.

Today's global food systems are entering a fundamentally new stage of technological development called Agriculture 4.0. Moreover, it is based on the introduction of "smart" solutions (robotics, precision farming, Internet of Things (IoT)), biotechnology, alternative technologies and raw material sources.

The development of scientific potential and implementation of innovative solutions becomes critical (in the period of transition) to ensure competitiveness and further develop Russia's agro-industrial complex. Otherwise, in the next decade, the gap with developed countries may significantly increase, and many markets will cease to exist for Russian agro-industrial complex products.

Further technological development of the Russian agro-industrial complex could take place in the following directions:

- strengthening its fundamental base of productivity growth: technologies of breeding and improvement of genetic potential in conjunction with technologies to ensure the best realization of this potential;
- the introduction of digital technologies and cross-platform solutions in the agro-industrial complex;
- diversification of the assortment of food products with a priority of high margin segments of healthy, functional and personalized nutrition, deep processing of agricultural raw materials;

- development of the agro-industrial complex waste recycling sector: the current situation in the sphere of their formation and utilization is becoming critical in many Russian regions.

One of the areas of the organization's strategy is to disclose information about its environmental, social and economic impacts, which is a prerequisite for analyzing and monitoring the impact of sustainability change on its business performance. This will ensure effective management of the organization, increase competitiveness, justify investments, and respect stakeholders' interests. According to Gamerschlag et al. [16], the most profitable organizations are associated with greater environmental disclosure.

The Global Reporting Initiative (GRI) Sustainability Reporting Guidelines defines key sustainability reporting indicators. In early 2015, the GRI launched the Reporting 2025 project to encourage international discussion about the future of nonfinancial reporting. In this way, both financial and nonfinancial reporting, as sources of information, aim to meet stakeholders' interests by providing financial, economic, social and environmental indicators of an organization's performance and efficiency. For example, environmental performance indicators include energy conservation, water conservation, waste, transport, environmental assessment of suppliers, and greenhouse gas emissions [17,18]. Specifically, this guide now includes an indicator of clean production (EN30) that identifies the costs of prevention and environmental management based on extra expenditures required to install clear technologies or for green purchases [19].

An extremely low level of innovation activity is connected with, among other things, imperfections in the organizational and economic mechanism for mastering innovation. When there are no well-developed mechanisms of innovative activity (a system of scientific and technical information corresponding to a market economy), there is no approved effective scheme for interaction between scientific institutions and innovation structures [20,21].

Innovation in agriculture can be fostered by state policy. The Russian Federation, for example, has implemented a policy that is aimed at long-term socio-economic development and includes a phased transition to an innovative development path for the period until 2020 (State program 2013–2020). The main modernization task of the government is the replacement of the developed model of economic growth. Instead of "oil growth" it is necessary to move to an "innovative" one.

The innovation policy in agriculture should lie in the main directions of its development in the short and long terms. The main trends can include: the stimulation of scientific and technological activities and formation on this basis of effective agroindustrial production; material and technical support of the industry, ecological agriculture, improvement of economic and land relations, rationalization of the production and management structure. Additionally, implementing a social policy is conducive to creating decent living conditions for the rural population.

The state innovation policy in the agro-industrial complex is the creation and assistance of appropriate mechanisms and techniques that guarantee the promotion of high-tech resource-saving projects, the promotion of the incorporation of scientific and technical developments into production and the stimulation of innovative activity of companies, nanotechnology. Through the implementation of this program the largest innovative projects are commodity farms, meat processing plants, vegetable hothouses, super technology hothouses, drip irrigation systems, etc.

The development of innovations in the agro-industrial sector of the Stavropol Territory is carried out in accordance with the strategy for the development of innovative activities in the region for the period until 2020 (Federal Law 2015) and "On Amendments to the Federal Law" On Science and State Science and Technology policy [22].

There is another subprogram in the State Program, titled "Development of innovative, investment and technological activities in agriculture", focused on the development of agriculture in the Stavropol Territory for the period 2014–2020 [23]. This subprogram is implemented at the regional level. The expected results of the implementation of the Subprogram are presented in the program's passport [24].

The scope of the implementation of the Subprogram is an innovative base (machine-technological complex) of agricultural production in the Stavropol Territory, it regulates the volume, quality and economic characteristics of the agricultural products in the Stavropol Territory and the adoption of highly efficient and resource-saving technologies. The use of high-tech agricultural machinery and equipment is necessary to preserve the production of agricultural products in the Stavropol Territory and ultimately to solve the food security of the Russian Federation.

We consider the hypothesis that the introduction of a state policy aimed at innovation has a positive impact on the sustainable development of the regional agriculture based on the experience of the Stavropol Territory. In this paper, we study both of the aforementioned state programs because they focus on the same objectives, and the regional target program is based on the federal one.

3. Data and Methods

We used principal component analysis (PCA) for constructing a composite sustainable index (CSI) to evaluate the sustainability of agricultural development of the region. The composite indicator is an effective instrument for policymakers and public connection in different areas such as economy, society, environment and technological evolution [22].

We consider the following dimensions of sustainability in the analytical framework: economic, environmental and social. The selection of the indicators has been mentioned in the studies [25]. Set of indicators at the regional level in the Stavropol Territory based on sustainable agriculture principles which are mentioned in the Federal Law “On the Development of Agriculture” [26], Federal target program “Sustainable Rural Development for 2014–2017 and the period up to 2000” [27], current economic situation and literature review.

Data for each indicator were taken from the official website of the Federal State Statistics Service of the Russian Federation and the website of the Department of the Federal State Statistics Service for the North Caucasus Federal District. Software for statistics and Data Science-Stata 17 was used for the calculations.

Within these three dimensions, information was complete for 16 years of observation (2000–2016). Table 1 presents an overview of the indicators used in the analysis.

Table 1. The set of indicators (acronyms between brackets).

Type of Dimension	Indicators	The Unit of Measurement
Economic	Agricultural GDP (agrgdp)	RUB
	Land productivity (landprod)	RUB/ha
	Labor productivity (labourpr)	RUB/per capita
Environmental	Organic fertilization (forganic)	tonn
	Soil cover for agriculture (soil)	ha
	Emissions of most air pollutants from stationary sources (emairpoll)	tonn
Social	Proportion of rural population (ruralpop)	%
	Share of rural and residents’ income (wageshare)	%

Source: author’s own construction.

In our case, the Kaiser–Meyer–Olkin (KMO) coefficient value is 0.673, which is acceptable because the minimum sufficient value is 0.500. The set of individual variable explains 88% of the variance. We can use them for the building of two main components.

Table 2 demonstrates two main extracted components from the combination of variables. We label them the economic-social and environmental component.

Table 2. Rotated component loading by principal component analysis (PCA).

Indicators	Economic-Social	Environmental
AGRGDP	*0.738*	0.561
RURALPOP	*−0.972*	−0.137
LANDPROD	*0.956*	0.226
LABOURPR	*0.962*	0.226
WAGESHARE	*0.921*	−0.285
FORGANIC	*0.888*	−0.349
SOIL	*0.056*	0.862
EMAIRPOLL	−0.077	*−0.835*
Explained variance	0.62	0.26
Proportion of Variance	0.71	0.29

Source: Extraction method: principle component analysis (Varimax rotation).

The weights of each indicator were obtained by PCA from the factor loading rotation matrix in Table 3. Their weights led to the determination of the CSI.

Table 3. Weights of indicators by PCA.

Indicators	Weight Score (w_i)	Resulting Weight ($\sum w_i$=1)
AGRGDP	0.044	0.051
RURALPOP	0.135	0.154
LANDPROD	0.131	0.149
LABOURPR	0.132	0.151
WAGESHARE	0.121	0.138
FORGANIC	0.113	0.128
SOIL	0.104	0.118
EMAIRPOLL	0.097	0.111

Source: author's own calculation.

The CSI model (Model 1) tests if a structural change of the model takes place while its parameters change. In this case a state policy is the extra parameter. Model testing can test our hypothesis about the influence of the state policy on innovations on the sustainable agricultural development of the region. We applied the switching regression model (SRM) [28–30], which integrates the vectors of parameter regimes that could change due to the structural change. This method considers the assumption of a structural change to the CSI model, where a state policy is expected to stimulate the CSI dynamics.

Model 1 describes the changes in sustainable agricultural development over time.

$$\mathrm{CSI}_t = \alpha + \beta t + \gamma P_t + \delta W_t + \varepsilon_t \quad (1)$$

where:

CSI—value of the composite sustainable indicator of the agricultural development at the t-th moment;

α—constant;

t—time variable;

P_t—switch variable (0,1) that indicates the presence or absence of a policy, where $P_t = 0$ for $t < t_s$ and $P_t = 1$ for $t > t_s$;

t_s—year of introducing a state policy;

W_t—switch variable P at time t, where $W_t = 0$ for $t < t_s$ and W_t = t for $t \geq t_s$; the W coefficient indicates the speed of agricultural development if a switch took place;

β—regression coefficient that identifies the time in the CSI model;

γ—regression coefficient that identifies the change in the CSI model dynamics because of a policy change;

δ—regression coefficient that identifies the change of tempo in the CSI model;

ε_t—t-th residual.

The CSI model (Model 1) allows us to test for a positive trend development after the introduction of the state policy in the region. The change of the CSI variable depends on the results of the switch variables (P and W), as it can grow quicker or slower. If the P coefficients are significant, then a structural change in the CSI model occurs and the state policy will change the CSI over time. The W coefficient indicates the speed of agricultural development if there is a structural change.

After testing Model 1 on the CSI we decided to assess how the implementation of the state policy affected the two components (socio-economic and environmental) separately. This has led to Models 2 and 3.

$$\underline{\text{Model 2}}\ EconSocial_t = \alpha + \beta t + \gamma P_t + \delta W_t + \varepsilon_t \quad (2)$$

where:

Econ-Social—value of the economic-social development indicator of the at the t-th moment;

α—constant;

t—time variable;

P_t—switch variable (0,1) that indicates the presence or absence of a policy, where $P_t = 0$ for $t < t_s$ and $P_t = 1$ for $t > t_s$;

W_t—switch variable P at time t, where $W_t = 0$ for $t < t_s$ and $W_t = t$ for $t \geq t_s$; the W coefficient indicates the speed of economic-social development if a switch took place;

β—regression coefficient that identifies the time in the EconSocial model;

t_s—year of introducing a policy;

γ—regression coefficient which identifies the change in the EconSocial model dynamics because of a policy change;

δ—regression coefficient which identifies the change of tempo in the EconSocial model;

ε_t—t-th residual.

$$\underline{\text{Model 3}}\ Env_t = \alpha + \beta t + \gamma P_t + \delta W_t + \varepsilon_t \quad (3)$$

where:

Env—value of the environmental development indicator at the t-th moment;

α—constant;

t—time variable;

P_t—switch variable (0,1) that indicates the presence or absence of a policy, where $P_t = 0$ for $t < t_s$ and $P_t = 1$ for $t > t_s$;

W_t—switch variable P at time t, where $W_t = 0$ for $t < t_s$ and $W_t = t$ for $t \geq t_s$; the W coefficient indicates the speed of economic and social development, if a switch took place;

β—regression coefficient that identifies the time in the Env model;

t_s—year of introducing a policy;

γ—regression coefficient which identifies the change in the Env model dynamics because of a policy change;

δ—regression coefficient which identifies the change of tempo in the Env model;

ε_t—t-th residual.

4. Results

For the period 2000–2016, the computation of composite sustainable indicators (CSIs) of agricultural development was made. Figure 1 represents CSI scores for the 16-year period. The CSI has increased over the 2000–2016 period, especially after 2012.

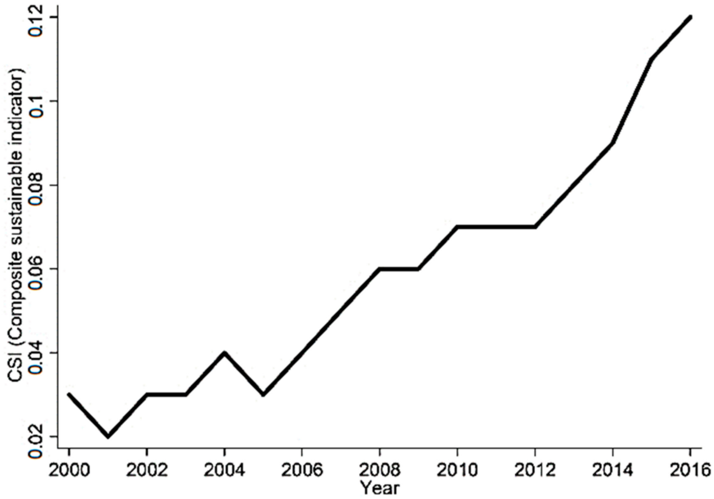

Figure 1. Results of the agricultural composite sustainable indicator (CSI) in the Stavropol Territory.

Table 4 shows the results of using Model 1 for the agricultural development of the Stavropol Territory. Figure 2 represents the actual results plot of the CSI obtained by principal component analysis (PCA) and the fitted plot of regression Model 1.

Table 4. Model 1 results for the agricultural development of the Stavropol Territory.

Region	Variable	Regression Coefficient Estimator	*t*-Statistic	*p*-Value	R-Squared	D-W Statistic
Stavropol Territory	α (constant)	−9.0018	−9.19	0.000	0.9542	1.76
	β	0.0045	9.24	0.000		
	γ	0.0176	2.94	0.012		
	δ	1.13×10^{-06}	0.75	0.466		

Source: author's own calculation.

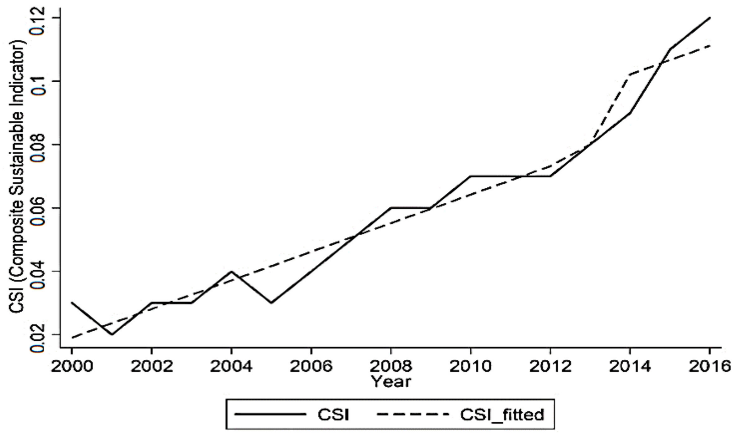

Figure 2. Actual and fitted plots of the switch regression model for the Stavropol Territory.

A significant switch in the sustainable agricultural development model is related to the years 2012 and 2013. Considering the year of introduction of the state program On the Development of Agriculture (subprogram development of innovative, investment and technologic activity in the agricultural production), it sped up the sustainable agricultural development. Both the actual and fitted CSIs reflect the switch in the sustainable agricultural development and show the rapid increase in the variable CSI, whereas δ is insignificant—the value is very small. Only γ and δ are significant.

After testing Model 1 in the CSI, we decided to assess how the implementation of the state policy affected the two components (socio-economic and environmental) separately. Table 5 demonstrates the results of Model 2 for the socio-economic component and Model 3 for the environmental component with regards to the agricultural development of the Stavropol Territory. Figures 3 and 4 represent the actual results plot of the socio-economic and environmental dimension reached by PCA and the fitted plots of the regression model.

Table 5. Model results for the dimensions (socio-economic and environmental).

Dimension	Variable	Regression Coefficient Estimator	t-Statistic	p-Value	R-Squared	D-W Statistic
Economic-Social	α (constant)	−7.5845	−10.12	0.000	0.9582	1.83
	β	0.0038	10.18	0.000		
	γ	0.0291	4.58	0.001		
	δ	-1.38×10^{-06}	−0.94	0.363		
Environmental	α (constant)	−12.9283	−6.99	0.000	0.8966	1.26
	β	0.0064	7.01	0.000		
	γ	0.0037	0.71	0.490		
	δ	6.17×10^{-08}	0.02	0.988		

Source: author's own calculation.

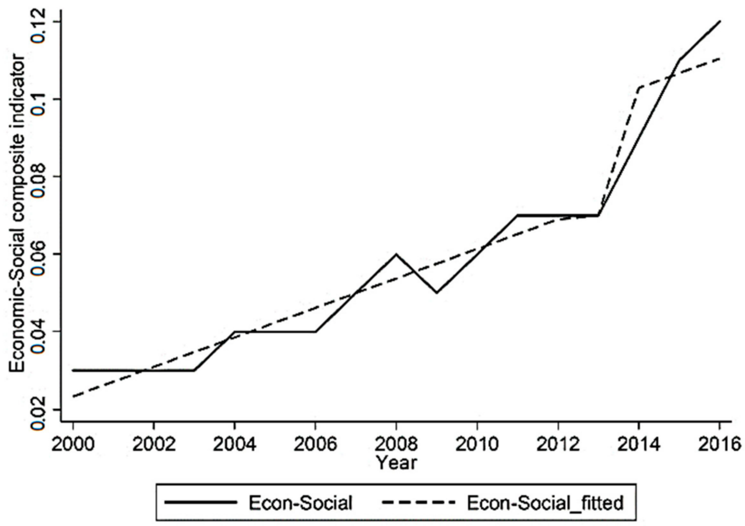

Figure 3. Actual and fitted plots of the switch regression model for the socio-economic component.

As we can see from Figures 3 and 4, the state policy had a great impact on the socio-economic and environmental dimension. The introduction of the state policy increases the positive development trend. This relationship is responsible for the switch in the socio-economic development in agriculture and shows the rapid increase in the variable EconSocial. At the same time, Model 3 observes the near absence of the switch in the Env (environmental) indicator structure in relation to the state policy in 2012. We also can notice that in that case W is not significant. There is no double switch of development speed in Model 3. The result of the Durbin–Watson statistical tests is relatively low in Models 1 and 3, but it is still above the critical value of the statistical test. This result is only a potential value since the indicators connected with the environment were mentioned less in the state policy than social and economic ones.

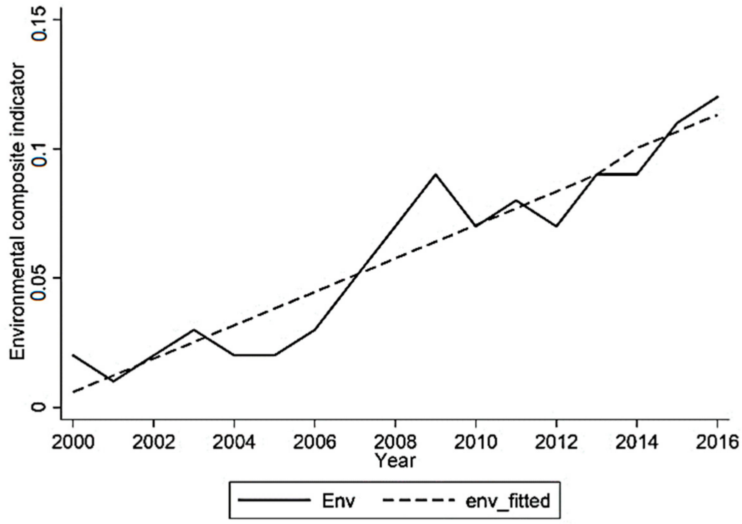

Figure 4. Actual and fitted plots of the switch regression model for the environmental component.

5. Conclusions and Discussion

The results of the three models allow us to make conclusions about whether the implementation of the policy on innovations increased the sustainable growth of agricultural development.

The switch regression model (SRM) helped to test the hypothesis that the introduction of a state policy aimed at innovation has a positive impact on socio-economic development.

In the first model tested (Model 1), the introduction of the state policy on innovations changed the structure of the sustainable agricultural development, leading to the conclusion that innovations are a significant and positive factor for the sustainable agricultural development of the Stavropol Territory.

We also assessed the impact of implementing this policy within each dimension separately. In general, results show a positive effect of the state innovation policy on socio-economic development (Model 2) of regional agriculture, but this does not significantly impact the environment (Model 3).

That is why the process of introducing ecological innovations in the sphere of agriculture should become one of the priority directions of state policy in the agrarian sphere. The main directions of the system of state support for the introduction of ecological innovations in agricultural production can be:

- improving the normative-legal base regulating the process of creation and implementation of innovations;

Enhancement of legislation at the federal and regional levels is sometimes outdated, but at the same time changes rapidly. Reducing the burden on the regulatory authorities (e.g., tax authorities and Russia's state veterinary and phytosanitary service) and improving judicial practice in patent law are also important. Development of cooperation in certification and licensing at the international level merely lacks at this stage.

- formation and implementation of effective economic and administrative mechanisms to stimulate and hold entrepreneurs accountable;

New incentives for the development of innovative activities could be: additional mechanisms for subsidizing scientific developments, including their transfer; provision of preferences to commercial organizations investing their funds in scientific developments and introducing innovative solutions. This could also include modification of state support criteria: adjusting terms, requirements and conditions of its provision to the actual practice of implementation of innovation projects in a particular area.

- creation of appropriate innovation infrastructure;

The government is the main initiator of such an innovation system and ensures its development by providing financial resources. The creation of a favorable environment for innovation is an important strategic development issue. This infrastructure may consist of organizations building up the local innovation environment to develop science and technology entrepreneurship. This infrastructure's elements could be specialized scientific centers and innovation organizations, science (innovation) parks and business incubators, new legislation, venture capital funds and others.

- promoting the integration of science, education and industry;

Modernization of the agricultural education system aims for improvement of educational programs' quality, timely education of new specialties and reductions in the current staff shortage, as well as the establishment of effective communications with science, systematic participation of business in the coordination of research areas and topics, and the formation of terms of reference for scientific organizations on new developments [31].

The development of practical activities in the field of implementation of ecological innovations directly connects with the possibility of obtaining many specific benefits in solving not only environmental but also economic and social problems, such as: increasing the competitiveness of products, access to foreign markets, environmental conservation, and improving the quality of life of rural areas.

The state program has positively affected the sustainable development of agriculture. However, there are difficulties in implementing the directions of modernization of the country's agriculture and that of its regions. An insufficient level of the financing of fundamental and applied agricultural science, the creation of scientific and technical developments and the presence of private and state investments exist. The mechanism of the development and stimulation of innovative activity are not fully developed. All these aspects in turn restrain the growth rates of agricultural production [32].

One solution could be the creation of a unified financial and nonfinancial reporting information system for agricultural business analysis by the Global Reporting Initiative (GRI) rules, based on stakeholder engagement. This reporting-based business analysis is one of the necessary procedures for improving the economic, social and environmental performance of an organization for the benefit of its customers.

The indicators that were used in the state program allowed us to directly and indirectly estimate the results of the implementation of innovative activities in the industry. One of the most crucial needs is to develop a system of indicators that objectively and fairly yet fully describe the innovative processes that take place in agriculture. The programs contain only a plan for subsidizing innovative projects and not the main areas of innovative development. In general terms, they speak about biotechnology, the weakness of the domestic innovation system and the low rates of renewal of the machine park at the expense of domestic technology, yet the problem of the insufficient financing of innovations is unanalyzed. There are no measures stimulating an increase in demand for innovations and mechanisms of state support for the transfer of innovations.

An analysis of the innovation policy of the Stavropol Territory shows that the creation of conditions in the region for the growth of high-tech production, including for the sustainable development of agricultural enterprises, has been successful. Indicators of efficiency are flagship enterprises, most of which have achieved average grain yields above 80 centners/ha. Additionally, there are trends in the industry towards introducing precision farming technologies based on satellite navigation systems; satellite monitoring of crop development and electronic mapping of agricultural land are being introduced. Technology is continually being improved by using new crop protection technologies, replacing pesticides with biologicals and implementing new approaches in cultivating crops without tillage (the no-till technology). Large-scale innovation projects are also intensively developed and implemented in the Stavropol Region to develop the agricultural sector on an intensive growth basis and at a mass scale. The formation of an integrated innovation policy in the region and specific mechanisms for its implementation will create the conditions for not only accelerating economic development but also for a purposeful impact on the commercial utilization of science and technology. One of the measures to stimulate innovation in the sector is the development of rural infrastructure (social, transport, information) and this in turn is one of the most important objectives of state policy. The problem of population outflow from rural areas is important not only for the agricultural sector, but also for the country as a whole. The main task is to create and promote a positive image of modern life in rural areas and work in the agricultural sector. Further research is needed to investigate the theme of complex assessment of conditions of sustainable development of separate territories (rural and urban). This will be carried out by analysis of mutual influence of satisfaction with social, economic and environmental conditions of living and readiness of community to live and work (to contribute to sustainable development, respectively) in a given territory. The main reason for migration from rural to urban areas is the higher standard of living and well-being. We assume the key indicators for representatives of different generations will differ significantly due to value and meaning life attitudes, lifestyle and life strategies of rural population. In addition, differences will be determined at the level of the types of settlements: industrial cities and resort towns; large rural settlements, including municipal centers and small rural settlements.

At the same time, sustainability should not be forgotten in a wide range of relations, including relations with the natural environment. The new paradigm in environmental protection, which is based on the concept of sustainable development, proceeds from the realization of the need to abandon the current consumer's relationship with the natural environment and to build partnership relations between them. It is not only about the transition to eco-friendly and resource-saving technologies, which will have an impact on the economy, environment and society, it is also a necessary formation of environmental ethics and respect for the environment. This has to be achieved in the next decades.

Author Contributions: Conceptualization, W.H., J.v.O., and A.C.; methodology, W.H. and J.v.O.; software, A.C.; validation, A.C., O.K. and W.H.; formal analysis, A.C.; investigation, A.C.; resources, A.C.; data curation, W.H., J.v.O., and A.C.; writing—original draft preparation, A.C.; writing—review and editing, W.H., J.v.O.; visualization, O.K.; supervision, W.H. and J.v.O.; project administration, A.C. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Used data can be found in the relevant references [22–24].

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Chupryakova, A.G. Sustainable Development of Agriculture: The Reengineering Approach. In Proceedings of the Issues of Education and Science: Theoretical and Methodical Aspects: Collections Based on the Materials of the International Scientific and Practical Conference, Tambov, Russia, 30 July 2015; pp. 134–137.
2. Roman, M.; Roman, M.; Prus, P. Innovations in Agritourism: Evidence from a Region in Poland. *Sustainability* **2020**, *12*, 4858. [CrossRef]
3. Liu, Y.; Ji, D.; Zhang, L.; An, J.; Sun, W. Rural Financial Development Impacts on Agricultural Technology Innovation: Evidence from China. *Int. J. Environ. Res. Public Health* **2021**, *18*, 1110. [CrossRef] [PubMed]
4. Boon, W.; Edler, J. Demand, challenges, and innovation. Making sense of new trends in innovation policy. *Sci. Public Policy* **2018**, *45*, 435–447. [CrossRef]
5. De Luca, A.I.; Falcone, G.; Stillitano, T.; Iofrida, N.; Strano, A.; Gulisano, G. Evaluation of Sustainable Innovations in Olive Growing Systems: A Life Cycle Sustainability Assessment Case Study in Southern Italy. *J. Clean. Prod.* **2018**, *171*, 1187–1202. [CrossRef]
6. Faure, G.; Coudel, E.; Soulard, C.T.; Devautour, H. Reconsidering innovation to address sustainable development. In *Renewing Innovation Systems in Agriculture and Food: How to Go towards More Sustainability?* Coudel, E., Devautour, H., Soulard, C.T., Faure, G., Hubert, B., Eds.; Wageningen Academic Publishers: Wageningen, The Netherlands, 2013; pp. 17–34.

7. Triomphe, B.; Rajalahti, R. From concept to emerging practice: What does an innovation system perspective bring to agricultural and rural development? In *Renewing Innovation Systems in Agriculture and Food: How to Go towards More Sustainability?* Coudel, E., Devautour, H., Soulard, C.T., Faure, G., Hubert, B., Eds.; Wageningen Academic Publishers: Wageningen, The Netherlands, 2013; pp. 57–76.
8. Porter, M.E. *On Competition*; Harvard Business Press: Boston, MA, USA, 1998.
9. Calik, E.; Bardudeen, F. A measurement scale to evaluate sustainable innovation performance in manufacturing organizations. *Procedia CIRP* **2016**, *40*, 449–454. [CrossRef]
10. Ozusaglam, S. Environmental innovation: A concise review of the literature. *Vie Sci. Enterp.* **2012**, *2*, 15–38. [CrossRef]
11. Zakharova, E.N.; Kerashev, A.A. Key competences as a leading factor in ensuring the competitiveness of the agroindustrial complex of the region [Electronic resource]. *Bull. Adyg. State Univ. Ser. 5* **2009**, *1*, 161–169.
12. Chavas, J.P.; Nauges, C. Uncertainty, Learning, and Technology Adoption in Agriculture. *Appl. Econ. Perspect. Policy* **2020**, *42*, 42–53. [CrossRef]
13. Dolmatova, L.G. Interrelation of Economic and Ecological Foundations of Land use in the Conditions of Market Relations. *Terra Econom.* **2010**, *8*, 48–53.
14. Goncharov, P.V. Retrospective analysis of the concept of innovative activity, its role in the development of agrarian enterprises. *Mod. Manag. Technol.* **2016**, *3*, 6302.
15. Polushkina, T.M. State regulation of the development of organic agriculture: Foreign experience and domestic practice. *Reg. Econ. Manag. Electron. Sci. J.* **2016**, *4*, 4830. Available online: https://eee-region.ru/article/4830/ (accessed on 10 September 2019).
16. Gamerschlag, R.; Moller, K.; Verbeeten, F. Determinants of voluntary CSR disclosure: Empirical evidence from Germany. *Rev. Manag. Sci.* **2011**, *5*, 233–262. [CrossRef]
17. Global Reporting Initiative—4G. 2018. Available online: http://www.globalreporting.org?Pages?default.aspx (accessed on 18 November 2020).
18. Tarquinio, L.; Raucci, D.; Benedetti, R. An Investigation of Global Reporting Initiative Performance Indicators in Corporate Sustainability Reports: Greek, Italian and Spanish Evidence. *Sustainability* **2018**, *10*, 897. [CrossRef]
19. Alonso-Almeida, M.D.M.; Llach, J.; Marimon, F. A closer look at the 'Global Reporting Initiative' sustainability reporting as a toolto implement environmental and social policies: A worldwide sector analysis. *Corp. Soc. Responsib. Environ. Manag.* **2014**, *21*, 318–335. [CrossRef]
20. Litvinenko, I.L.; Kijanova, L.D. Providing innovative development of regional AIC: Problems and solutions. *Reg. Econ. Manag. Electron. Sci. J.* **2017**, *2*, 5012. Available online: https://eee-region.ru/article/5012/ (accessed on 15 September 2020).
21. Wan, B.R. Scientific and Technological Innovation: The Fundamental Way out for China's Agriculture. *China Coop. Econ.* **2012**, *17*, 35–37.
22. Federal Law of the Russian Federation No. 254-FZ «On Amendments to the Federal Law» on Science and State Science and Technology Policy. Available online: http://base.consultant.ru/ (accessed on 17 November 2016).
23. State Program for Development of Agriculture and Regulation of Markets of Agricultural Products, Raw Materials and Foodstuffs for 2013–2020. Available online: http://www.mcx.ru/navigation/docfeeder/show/342.html (accessed on 14 May 2020).
24. State Program of the Stavropol Territory for Development of Agriculture for 2014–2020. Available online: http://www.mshsk.ru/industry-information/the-state-program/index.php?ELEMENT_ID=5473 (accessed on 14 May 2020).
25. Chaplitskaya, A.; Heijman, W.; van Ophem, J. Composite indicators and sustainable development of regional agriculture applied to the Stavropol Territory. *Appl. Stud. Agribus. Commer.* **2017**, *11*, 81–88. [CrossRef] [PubMed]
26. Federal Law. On the Development of Agriculture, 12.02.2015, No. 11-FL. *Legal Information System 'Consultant-Plus'*. 2015. Available online: http://base.consultant.ru (accessed on 20 November 2019).
27. Federal Target Program. *Sustainable Rural Development for 2014–2017 and for the Period up to 2020, Decree of the Russian Federation of 8 November 2012, No.2071-p*. 2012. Available online: http://mcx.ru/documents/document/show/16518.htm (accessed on 20 November 2019).
28. Davis, R.A.; Lee, T.C.M.; Rodrigues-Yam, G.A. Structural break estimation for nonstationary time series models. *J. Am. Stat. Assoc.* **2006**, *101*, 223–239. [CrossRef]
29. Goldfeld, S.M.; Quant, R.E. The estimation of structural shift by switching regressions. *Ann. Econ. Soc. Meas.* **1973**, *2*, 475–485.
30. Kurek, K.A.; Heijman, W.; van Ophem, J. Geothermal spas as a local development factor, the case of Poland. *Geothermics* **2020**, *85*, 101777. [CrossRef]
31. World Bank. *Agricultural Innovation Systems: An Investment Sourcebook*; World Bank: Washington, DC, USA, 2012.
32. Khodos, D.V. Innovation activity in regional agriculture: Assessment approaches and development priorities. *Krasn. State Agrar. Univ. Bull.* **2013**, *6*, 43–48.