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An Assessment of Food Value Chains to Identify Gaps and Make Recommendations for Further Development: A Slovenian Case Study

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Abstract: The content of this paper presents the research results of a three-year research project in which a multi-criteria evaluation model (according to the DEX methodology) was developed for the evaluation of three different food sectors (represented by a cattle breeding chain, a pig farming chain, and a milk production chain) with added value in Slovenia. Indicators for the assessment of the economically, socially, and environmentally sustainable development of food chains were taken into account. The data for the analysis, such as prices and costs of food, wage levels by sector, food miles and others, were obtained from various public services between 2020 and 2023. The final qualitative assessment of the food sectors was uniform ("average"), while the longest analysis of the results using the plus-minus-1 analysis method showed the reasons for such an assessment in individual sectors (such as the ratio between the price of agricultural products and the price of agricultural inputs is poor, the ratio between average gross salary in the individual food sector and gross salary in the agricultural sector is poor, etc.). In addition to the results already mentioned, recommendations or suggestions for building a sustainable food chain were made using the results of the modelling. The research results contributed to a better understanding of the importance of stable relationships between different groups of indicators and later showed their importance for improving the functioning of agri-food chains. The results of the research will help various stakeholders (such as the agricultural advisory service, decision-makers at the level of agricultural policy, researchers in further analyses, and especially the international professional public interested in various case studies from EU countries) to further analyse and plan for the organisation of the agricultural sector.

Keywords: food sectors; value added; DEX methodology; plus-minus-1 analysis; Slovenia

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1. Introduction

In recent years, various actors in food supply chains, especially representatives of the primary sector (farmers), have recognised various problems in their farms or businesses that hinder the further development of individual agri-food chains [1–3]. These problems mainly relate to the non-functioning and ineffectiveness of the connection of actors along the chains, which has influenced the decline in the successful development of individual chains in Slovenia or the establishment of new chains [4]. As a result, self-sufficiency in certain sectors decreased, which had many other negative effects on agriculture and rural development (social, economic, and environmental aspects) [2,5–9].

From the definitions made by various Slovenian and foreign authors, we can summarise that agri-food chains with added value are those chains that maximise the production value for the individual actors in the chain. Consumers recognise agricultural products or food from such agri-food chains as high quality, having been produced on the basis of environmentally friendly production systems, and having a positive indirect and direct contribution to the local economy and the community as a whole [4,10–15]. The business relationships between the actors in a value chain are correct and fair and are based on trust, which means that rights and obligations are distributed equally and fairly, and all parties involved successfully solve mutual problems of mistrust and disconnection [1,16–19]. In practice, added value can, therefore, also be expressed in agricultural products or foodstuffs with a clearly proven origin, in protected food labelling, and in a network of correct business relationships between the individual players in the food chain [10,18,20].

In the initial phase of the study, it was necessary to define the added value that is and will be expressed in the food supply chains typical for the Slovenian agricultural system. At this point, it should be emphasised that it is impossible to generalise the values in comparison to other EU member states simply because of the specificities of agricultural production in Slovenia [21–24]. It was necessary to define and establish indicators that express the added value of agricultural and food chains without deviating too far from recognised and established definitions from internationally recognised literature.

The assessment of the individual chains (cattle breeding chain, pig farming chain, and chain with milk production) was therefore carried out in different ways depending on the sectors analysed and the different added values. The selected agricultural sectors were chosen because they represent the most important agricultural branches in livestock production, make a large contribution to the agricultural budget, are so heavily dependent on state support, and have to adapt quickly to changes in agricultural markets. In addition, pig farming is one of the most threatened sectors at the self-sufficiency level in Slovenia. We separated the basic (statistical) methods, which are specific to the evaluation or assessment of individual value chains [25,26], and the supporting method of multi-criteria decision analysis (DEX) [27], with which we categorised the chain according to the hierarchical success scale (it means there are three options of final assessment: "poor", "average", and "good") depending on the type of production [10,28,29]. In addition, based on the defined criteria, the DEXi multi-criteria decision analysis method allowed us to identify the main gaps in the realisation of added value in the individual agri-food chains at the aggregate level [28,30,31].

The article presents the main results of a targeted research project (V4-2010 entitled "Evaluation of value-added based food chains with the aim of identifying the 'bottlenecks' and preparing recommendations for further development in Slovenia"), which was funded by the Ministry of Agriculture, Forestry, and Food of the Republic of Slovenia and the Agency for Research Activities of the Republic of Slovenia, in the duration between November 2020 and November 2023. The aim of the project was to evaluate individual agri-food sectors according to the existence of added value. The assessment of individual cases at an aggregate level was carried out using indicators of added value, which we defined or developed on the basis of scientific theories (described in Section 2.1), statistical research methods, and accessible statistical data. These indicators were crucial for the creation of a set of added value indicators and the development of the DEXi multi-criteria decision model itself, whose assessment parameters were divided into three groups, namely economic, social, and environmental [25,26]. The DEXi multi-criteria decision model thus enabled an assessment of agri-food chains based on the identification of economic, social, and environmental added value.

The scientific and professional contribution of the paper is primarily an assessment of the entire agricultural and food sector and not just the "closed" short food supply chains, as has been the case in practice to date. At the same time, a methodological approach was used that has already proven its worth and is useful for a clear explanation of the operation of the agri-food sector with added values.

The aim of the study is to evaluate different agricultural sectors using the recognised methodology of multi-criteria decision-making and to identify the weaknesses in the functioning of each agricultural sector. The assessment was carried out on the basis of economic, social, and environmental indicators developed to reflect the added value of the food sector, in line with the descriptions of the added values in Section 2.1.

The paper is structured into a standard format with methodology description, a results and discussion section, and a conclusion. The authors explain the study's limitations and future challenges for using and upgrading the developed model for solving related rural sociology issues.

2. Materials and Methods

2.1. Context Analysis of Added Value in Food Supply Chains

When analysing the context of value creation in food supply chains, we started from the simple and common assumption that the Slovenian farmer/producer values stability and security in agricultural production. Furthermore, the satisfaction of all stakeholders in the food chain is of central importance. Consequently, this contributes to the creation of trust in agri-food chains, regardless of their length and the number of actors involved. Such chains are referred to as value-added agri-food chains or quality agri-food chains. The objectives we want to achieve by creating and establishing such chains are the following [1,4,13,18,32]:

- Trust between the stakeholders (producers, processors, traders, and consumers) along the agri-food chains;
- The price of the end product evenly distributed among all participants (with slight variations depending on the costs in the process);
- Increased market orientation in terms of supplying locally produced food and increasing demand for it.

There are various definitions of agri-food chains with added value in the literature, which differ from author to author in certain details. Some of these definitions are listed below. Stevenson and Pirog [33] and Pirog and Bergendahl [34] state that value added is expressed in three ways:

- Through agricultural products or foods made from raw materials, which demonstrate the origin of the food and thus the added value and consequently a higher price on the market;
- Through protected food names that express either the geographical location, the higher quality of the raw materials and/or food safety;
- As a network of proper business relationships and interactions between the different actors in the food chain.
- In the following, Stevenson and Pirog [33], Pirog and Bregendahl [34], and Stevenson et al. [35] have developed a definition that defines agri-food chains with added value. The definition is mainly based on a description of the differences between chains that do not express added value and those that do. One can speak of value-added agri-food chains if the following important principles are taken into account and differ from conventional agri-food chains in these segments:
- The business relationships between the strategic partners in the chain are based on common principles that are primarily based on trust. In the chain, one of the strategic partners stands out and makes a major contribution to the good and organised functioning of the chain.
- In the chain, the growers/farmers are treated equally as strategic partners with all rights and obligations in terms of risk-taking, management, and decision-making.
- The obligations and rights in the chain apply equally to all participants in the chain.
- The coordination of the actors in the chain is effectively coordinated at the local, regional, national, and/or international levels.

In addition to the primary positive impact of agri-food chains with added value on the relationships in the chain, we can conclude that this type of chain also has a positive impact on the socio-economic status of the actors involved in the chain and, thus, on the wider local environment.

To summarise, high-quality agrifood chains or value-added chains are those that maximise the production value for the individual partners (participants) in the chain. Consumers of agricultural products or food from such agrifood chains that are recognised as high quality, having been produced on the basis of environmentally friendly production systems, and having a positive indirect and direct contribution to the local economy and to the community as a whole [10,12,14,16,18,25,35]. An important position in such chains is also occupied by the primary producer or farmer himself, who is seen as an important and equal strategic partner, taking risks, and participating in management or decision-making. The business relationships between the actors in each chain must be correct, fair, and based on trust, which means an equal and fair distribution of obligations and rights [1,13,18,19,32].

Using various qualitative methods, foreign authors have come to the conclusion that consumers are convinced that by buying locally produced food, they are supporting local producers and thus helping to improve their socio-economic situation [36] and that the income of primary producers is 40–80% higher when selling agricultural products or food within short agri-food chains [37].

2.2. Research Methodology

The analysis of the individual agri-food chains, the aim of which was to determine the added value in three different agri-food chains (which represent sectors), was carried out in three research phases:

1. Collecting statistical data and recalculating the data according to the methodology of each indicator
2. Analysis and assessment of case studies using the DEXi model based on defined criteria or constraints
3. Plus-minus-1 analysis of the case studies based on the boundaries of the DEXi model

The plus-minus-1 analysis shows the change in the score of each indicator by one level up or down, independently of other criteria, or how this change in a particular indicator by one level up or down is reflected in the final score of the chain (model), provided that the scores of the other indicators remain unchanged. With this analysis, we wanted to find out how the final rating of the food supply chain with added value changes if we systematically worsen or improve the rating of one of the individual indicators by one level up or down. In the event that changing the score of a particular indicator by one level in a negative or positive direction (assuming that the scores or ratings of the other indicators do not change) changes the score of the chain itself, this can be a very important indication of which indicator should usefully be given more attention. Both should be considered in the sense of improvement, if this improvement would contribute to a better assessment of the entire chain, and in the sense of avoiding deterioration, and if the deterioration of the assessment of a particular indicator would influence the change or deterioration of the assessment of the entire chain.

2.3. Model Development Theory

DEX is a hierarchical multi-parameter decision method. It was developed in 1988. DEX comes from the English name "Decision EXpert" and is based on the multi-parameter decision methodology DECMAK (DECision MAKing) and artificial intelligence. DECKMAK and DEX were developed at the Jožef Štefan Institute in cooperation with the University of Maribor, Faculty of Organisational Sciences [38]. The special feature of the DEX method is that it is used to build qualitative multi-parameter models in which all variables are symbolic (discrete, not numerical), and aggregation is based on decision rules defined by an expert in the form of tables [39]. DEX is used to support decision-makers in solving complex decision-making problems, both in the business and private spheres. Compared to other multi-criteria systems, DEX has two special features:

- DEX uses qualitative discrete criteria; values are usually described in words (qualitative values), rarely in numbers or numerical intervals;
- Utility functions are defined by simple decision rules of the type "if—then".

The approach on which DEX is based emphasises the role of people in the decision-making process. DEX is the shell of an expert system, i.e., it does not have a ready-made database or knowledge, but the user builds it himself with the help of the tools offered by DEX. The DEXi programme is based on the DEX methodology and works in the MS Windows environment. In contrast to DEX, it does not have the option of checking decision rules for inconsistencies in real time.

The DEXi software (version 5.05) tool supports a theory based on multi-parameter decision-making that emphasises the role of the decision-maker in the decision-making process. The tool encourages the decision maker to learn and investigate the decision problem. The decision maker analyses the problem by determining the important criteria and their values. The decision maker makes a decision based on the predefined criteria and qualitative descriptions of their values.

Such a method of knowledge acquisition is used in many expert systems and artificial intelligence software tools. Applied to the DEXi software tool, this approach proves to be very flexible, as the programme allows the user to delve deeper into the decision-making process [40].

DEXi essentially consists of two parts [41]:

1. Knowledge acquisition and preparation: it helps the user to create a tree of criteria and decision rules for the problem under consideration; it is a process of structuring a decision problem and expressing preferences, where the consistency of the given decision rules is also checked by the computer on the fly.
2. Evaluating and analysing variants: The acquired knowledge base is used to evaluate and analyse variants.

At the beginning, each variant is described with criteria values that represent the leaves of the tree. DEXi evaluates each variant according to the knowledge base, i.e., the criteria tree and the decision rules. We obtain a suitability rating for each variant. This procedure is followed by an analysis of the results, which consists of one or more activities [41,42]:

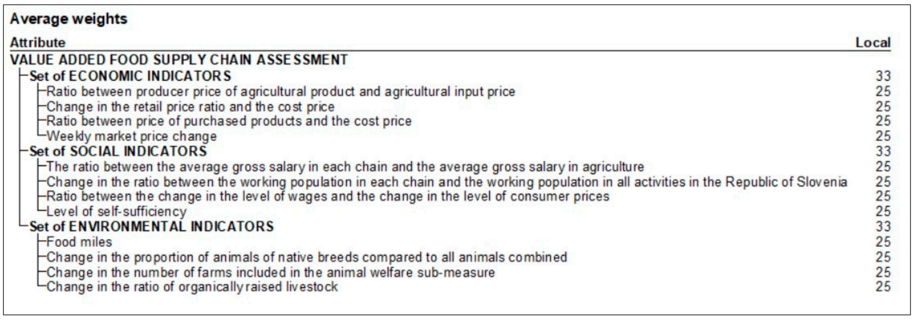
- Explanations of the assessment: DEXi is able to explain how each individual assessment was arrived at based on the criteria values and the decision rules used.
- "What-if" analysis: it is performed interactively by changing the description of the variants, re-evaluating them and comparing the results obtained with the original (reference) results.
- Selective interpretation of variants: DEXi finds and outputs the sub-criteria trees that reflect the strongest or weakest features of each variant, extracting only the most relevant information.

The representation of knowledge is based on the combination of a multi-criteria decision-making approach with an expert system, where DEXi also incorporates machine learning and soft logic [41,42]. This enables the user to make decisions more simply and easily, as the knowledge about decision-making is expressed simply and directly with words, rules and hierarchically arranged criteria.

In creating the multi-criteria DEXi model, we focussed on the livestock and meat production sector and created a model for evaluating the agro-food chain of cattle and pig breeding and the milk production chain. The decision in favour of the livestock sector is primarily due to the availability of the data themselves, as we did not collect quality data for individual chains (fruit, vegetables, . . .) in the crop production sector.

As already stated and explained in the introduction, the added value of chains is a comprehensive concept that concerns different aspects of sustainable development (economic, social, and environmental). These three aspects of sustainability were also key in the construction of the DEXi multi-criteria model itself, whose assessment parameters were divided into three groups: Economic, Social, and Environmental.

In the DEXi model, the "tree boot" thus expresses the benefit of the variant or the final evaluation, which in our case is the "evaluation of added value in the agricultural and food chain". This benefit is then "branched" into a benefit function whose basic task is to summarise all the values of the individual parameters for the final evaluation or benefit of the variant itself. The utility function is also characterised by the fact that it can serve as a weighted sum of individual preferences, which means that it can favour a particular parameter, which consequently has a greater influence on the final evaluation [43]. In our case, all three parameters are equally important, so this weighted sum of individual preferences is not particularly important. Parameters are those variables that represent the sub-problems of the decision problem, i.e., those factors that define the quality of the variants [43]. In our case, these parameters represent the three aspects of sustainability listed and presented above, namely the economic, social, and environmental aspects. These three parameters are, in turn, made up of individual indicators that, depending on their content or area, belong to a single parameter. Inventory values must be defined for all indicators in the "assessment tree" of the model (Figure 1), on the basis of which the evaluation is carried out. Each variant is described using the values of the basic indicators, i.e., those on the "leaves of the tree". This description is possible after a preliminary investigation of the variants and the corresponding quality of the data collected [43]. At the beginning, each variant is described with the values of the indicators that represent the leaves of the tree. DEXi evaluates each variant using the knowledge base, i.e., the "tree" of criteria and decision rules. For each variant, we obtain a suitability score.



Average weights

Attribute	Local
VALUE ADDED FOOD SUPPLY CHAIN ASSESSMENT	
Set of ECONOMIC INDICATORS	33
Ratio between producer price of agricultural product and agricultural input price	25
Change in the retail price ratio and the cost price	25
Ratio between price of purchased products and the cost price	25
Weekly market price change	25
Set of SOCIAL INDICATORS	33
The ratio between the average gross salary in each chain and the average gross salary in agriculture	25
Change in the ratio between the working population in each chain and the working population in all activities in the Republic of Slovenia	25
Ratio between the change in the level of wages and the change in the level of consumer prices	25
Level of self-sufficiency	25
Set of ENVIRONMENTAL INDICATORS	33
Food miles	25
Change in the proportion of animals of native breeds compared to all animals combined	25
Change in the number of farms included in the animal welfare sub-measure	25
Change in the ratio of organically raised livestock	25

Figure 1. The "assessment tree" of the DEXi model; the figure shows a schematic representation of the model (economic, social, and environmental parameters, and a group of indicators for each parameter with weights).

We have decided to select four indicators for each type of parameter (economic, social, environmental). All four indicators that make up a single parameter have the same weight in the final assessment, i.e., the weighted sum is distributed equally across all four indicators. The same applies to the influence of the individual parameters on the final score. In our case, all three parameters are equally important, so this weighted sum of the individual preferences is not particularly important. The weighting between the individual parameters here is 33%, which means that all parameters are equally important in the final assessment of each chain.

When describing the individual indicators, the methodology behind the indicator itself is particularly important, as our aim is for the model itself to be useful for analysing data in different time periods in the future, not just those we have used in this. The value set for each parameter and indicator is defined in three levels: GOOD, AVERAGE, and POOR. The utility function for each parameter is evenly distributed among the individual indicators, as each indicator contributes 25% to the final score of the individual parameter (4 indicators = 1 parameter). Based on the three-stage value set for each indicator, 81 variants or combinations are possible in the final evaluation of each parameter, whereby 15 variants are rated as good, 51 as average and 15 as poor based on the decision rules. At the top of the model "tree", in which all three parameters (economic, social, and ecological) are combined, the utility function is determined for 27 different variants, of which 4 are rated as good, 19 as average and 4 as poor (Figure 2).

Decision rules

Set of ECONOMIC INDICATORS	Set of SOCIAL INDICATORS	Set of ENVIRONMENTAL INDICATORS	VALUE ADDED FOOD SUPPLY CHAIN ASSESSMENT
33%	33%	33%	
POOR	POOR	POOR	POOR
POOR	POOR	AVERAGE	POOR
POOR	POOR	GOOD	AVERAGE
POOR	AVERAGE	POOR	POOR
POOR	AVERAGE	AVERAGE	AVERAGE
POOR	AVERAGE	GOOD	AVERAGE
POOR	GOOD	POOR	AVERAGE
POOR	GOOD	AVERAGE	AVERAGE
POOR	GOOD	GOOD	AVERAGE
AVERAGE	POOR	POOR	POOR
AVERAGE	POOR	AVERAGE	AVERAGE
AVERAGE	POOR	GOOD	AVERAGE
AVERAGE	AVERAGE	POOR	AVERAGE
AVERAGE	AVERAGE	AVERAGE	AVERAGE
AVERAGE	AVERAGE	GOOD	AVERAGE
AVERAGE	GOOD	POOR	AVERAGE
AVERAGE	GOOD	AVERAGE	AVERAGE
AVERAGE	GOOD	GOOD	GOOD
GOOD	POOR	POOR	AVERAGE
GOOD	POOR	AVERAGE	AVERAGE
GOOD	POOR	GOOD	AVERAGE
GOOD	AVERAGE	POOR	AVERAGE
GOOD	AVERAGE	AVERAGE	AVERAGE
GOOD	AVERAGE	GOOD	GOOD
GOOD	GOOD	POOR	AVERAGE
GOOD	GOOD	AVERAGE	GOOD
GOOD	GOOD	GOOD	GOOD

Figure 2. Decision rules (the utility function in the final assessment of the model is evenly distributed between individual parameters, as each parameter contributes 33% to the final assessment of the model.

2.4. Descriptions of the Indicators Used in the DEXi Model

Table 1 describes the individual indicators by group that were included in the DEX model. The indicators are described in more detail later in the section (meaning, calculation method and data source).

2.4.1. Description of the Indicators of Economic Parameter

(a) The average ratio between the producer price index for agricultural products and the price index for agricultural inputs on an annualised basis

This indicator shows how the prices of agricultural products change in comparison to the prices of agricultural inputs on an annualised basis. Added value or a positive economic position for the primary producer arises when the prices of agricultural inputs rise more slowly than the prices of agricultural produce for producers. All ratios greater than 1.00 mean added value for the primary producer.

Methodology of the indicator

On the basis of annual data on the development (indices) of the prices of agricultural products for producers and the prices of agricultural inputs, the ratios between the prices of agricultural products for producers (as a share), and the prices of agricultural inputs (as a divisor) are calculated for each individual year. The average coefficient for the period from 2012 to 2021 is then calculated on the basis of these annual coefficients. The value set for the DEXi model is defined in three levels. For this indicator, all coefficient values less than or equal to 0.99 are defined as POOR (no added value), AVERAGE 1.00, and GOOD (added value). All coefficient values are equal to or greater than 1.01.

Data used

The data for the calculation of the ratios come from the database of the Statistical Office of the Republic of Slovenia (hereinafter SISTAT), i.e., the time series of data from 2012 to 2021 are used for the calculation of the ratios. For the prices of agricultural products of producers, data for cattle (111,000 cattle), pigs (112,000 pigs) and cow's milk (121,100 milk, cows) from the database are used: producer price indices of agricultural products (average 2015 = 100) by agricultural product, year and measures [44]. In the case of prices of agricultural inputs, data on the development of total input prices (220,000 TOTAL input 1 + input 2) from the database: agricultural input price indices (average 2015 = 100) by goods and services, year, and measures [45].

(b) Average annual change in the ratio of the average retail price of agricultural products to the farm-gate price (in per cent)

This indicator shows the average annual change in the ratio between the average retail price of agricultural products and their own price (presents the production cost per unit of the product), only in the period between 2018 and 2021, expressed as a percentage (%). There is added value in the chain if the average value of the change in the ratio is positive or greater than 0. In this case, the ratio between the retail price of agricultural products and the own price changes in such a way that the retail price of the products increases more than the own price.

Methodology of the indicator

Annual coefficients (quotients) are calculated for the individual retail chains on the basis of the average annual retail prices (in the quotient) and own prices (in the divisor). These coefficients form the basis for calculating the annual changes in the quotients. The change compared to the previous year is expressed as a percentage and calculated as follows: ((year x − year x_{-1})/year x_{-1}) × 100. Based on the values of the changes compared to the previous year expressed as a percentage, the average change compared to the previous year is then calculated as a percentage: ((ratio year x_1 + ratio year x_2 +. . .ratio year x_n)/n). The value of the average change in the ratio at the annual level is defined to two decimal places. For this indicator, it is essential that data are available for at least two years, as otherwise, it is not possible to calculate inter-annual changes. For the purposes of the DEXi model, the average annual change in the ratio between sales price and own price in the period between 2018 and 2021 is calculated on the basis of the individual annual changes, expressed as a percentage.

For this indicator, the values for the DEXi model are defined in three levels. All values lower than −0.01 or negative are defined as POOR, as in this case, in the period between 2018 and 2021, the annual average ratio between the retail price and the own price increases in favour of the own price, which represents a negative economic situation for the individual players in a given chain. The value 0 is defined as AVERAGE, which means that no changes have taken place. All average changes in the ratio that are higher than 0.01 are defined as GOOD.

Data used

The data used to calculate the individual annual quotas come from the SISTAT database (SORS) and from model calculations (AIS). A time series of data from 2018 to 2021 is used to calculate the quotas. For the retail prices of agricultural products, data for beef with bone (meat; beef with bone (kg)), pork with bone (meat; pork with bone (kg)) and UHT whole milk (milk, cheese and eggs; milk, UHT whole milk (L)) from the database are used: Average retail prices of goods and services by goods and services, measures and year [46]. For own prices, data from AIS model calculations are used for milk (6500 L/cow), young fattening cattle (29 heads) and fattening pigs (combined feed 250 heads) [47].

(c) The average ratio between the average prices of purchased agricultural products and the own price

This indicator shows the relationship between the average prices of purchased agricultural products and their own price, i.e., the price required for the actual production or preparation of these products. As the aim of every farmer is to make a profit, it is very important that the sales revenue is higher than the production costs. The added value for the primary producer is given if the prices of the purchased agricultural products are higher than their own price or if the value of the ratio is greater than 1.

Methodology of the indicator

On the basis of the annual data on the average prices of purchased agricultural products and own prices, the ratios between the prices of purchased agricultural products (in the numerator) and own prices (in the divisor) are calculated for each individual chain and each individual year. The average quotient for the period between 2018 and 2021 is then calculated on the basis of the calculated annual quotients. The values of the calculated quotients are defined to two decimal places.

The set of values for the DEXi model is defined in three levels. For this indicator, all average values of the quotient that are less than or equal to 0.99 are defined as POOR (represents no added value), AVERAGE of 1.00, and GOOD (represents added value). All values of the quotient that are greater than or equal to 1.01.

Data used

The data used to calculate these ratios are taken from the SISTAT database (SORS) and from model calculations (AIS). A time series of data from 2018 to 2021 is used to calculate the ratios. For the average prices of purchased agricultural products, data for bulls (slaughter animals, bulls), fattening pigs (slaughter animals, fattening pigs 50–150 kg) and milk (milk, cow's milk) from the database are used: Quantities and average prices of purchased agricultural products by agricultural product, year and measures [48]. For own prices, data from AIS model calculations are used, namely for milk (6500 L/cow), young fattening cattle (29 heads) and fattening pigs (combined feed 250 heads) [47].

(d) Average weekly change in the market price of the product on a representative market in %

This indicator shows the average weekly change in the market price (on a representative market) for agricultural produce or foodstuffs in 2020 and 2021, whereby the change between two consecutive weeks is expressed as a percentage. The market price of the previous week is always used as the basis for calculating the change. The average weekly price change in 2020 and 2021 is calculated on the basis of all weekly price changes, expressed as a percentage (%). Added value is given if the average change in market prices is positive or greater than 0.

Methodology of the indicator

In each individual chain, the prices for the quality class of meat or milk that was predominant in terms of volume are taken into account. Weekly changes in per cent are calculated based on the previous week's prices, i.e., ((price week x − price week x_{-1})/price week x_{-1}) × 100. For the purposes of the DEXi model, the average weekly price change in 2020 and 2021 is calculated based on all weekly changes for each individual agricultural product or foodstuff. The average value of the weekly change is defined to two decimal places. The values set for the DEXi model are defined in three levels, where all quotient values less than or equal to −0.01 are defined as POOR. Ratio values between 0.00 and 0.09 are defined as AVERAGE, and all values greater than or equal to 0.10 are defined as GOOD.

Data used

The data used to calculate the average weekly change in market prices comes from the weekly market reports of the Agency of the Republic of Slovenia for Agricultural Markets and Rural Development, which use a weekly time series from January 2020 to December 2021. Data for beef (beef, class A-R3), pork (pork, class S), and milk (sterilised or UVT milk (≥3.5% M)) were used to calculate the weekly price changes [49].

2.4.2. Description of the Indicators of Social Parameter

(a) The average ratio between the average gross wage in each production chain and the average gross wage in agriculture

This indicator shows the ratio between the average gross wage of primary producers (breeders) in each production chain and the average gross wage in agriculture in the Republic of Slovenia. The added value for primary producers in each chain is given if the value of the calculated ratio is greater than 1. A monthly time series of data for the period from January 2014 to December 2021 is used to calculate the ratios, i.e., for a period of 8 years.

Methodology of the indicator

Based on the monthly average gross wage of primary producers in each chain and the average gross wage in agriculture, the monthly ratio between the average gross wage in each chain (in the numerator) and the average gross wage in agriculture (in the divisor) is calculated for each of the chains considered. The average monthly ratio for the period from January 2014 to December 2021 is then calculated on the basis of the individual monthly ratios.

The value set for the DEXi model is defined in three levels, whereby all average values of the ratio that are less than or equal to 0.99 are defined as POOR, i.e., the average wage in the chain under consideration is lower than the average wage in agriculture. A quotient value of 1 is defined as AVERAGE, and all quotient values greater than or equal to 1.01 are defined as GOOD.

Data used

The data used to calculate the ratios are taken from the SISTAT database (SORS), specifically from the sub-database: Average monthly earnings and index of average monthly earnings (nace rev. 2) by activity, month, earnings, and measures [50]. The monthly data on average wages are used for agriculture (agriculture and hunting, forestry, and fishing), cattle breeding (raising of other cattle and buffaloes), pig farming (raising of swine/pigs), and milk production (raising of dairy cattle).

(b) The average change in the proportion of the economically active population engaged in a single agricultural activity compared to all activities combined in a single year (based on the proportion in 2012)

This indicator shows the change in the annual ratio between the number of active populations in primary production of each of the considered chains (cattle breeding, pig farming, and milk production) and the number of total active populations in the Republic of Slovenia in a single year compared to the situation in 2012. The proportions calculated for each year form the basis for calculating the annual changes in the indicators themselves, starting from the value of the indicator in 2012, which shows us the trend of change in the share of the active population in each chain. The added value for the chain is given if the average annual change is positive or greater than 0.

Methodology of the indicator

Based on the annual data on the number of persons employed in primary production in each production sector and the number of total persons employed in the Republic of Slovenia, the ratio between the number of persons employed in primary production for each individual year in the respective production chain (in the divisor) and the total number of all persons employed in the Republic of Slovenia (in the numerator) is calculated. The calculated quotients or shares form the basis for calculating the annual changes in the quotients themselves, based on the value of the ratio in 2012, which shows us the trend of change in the share of the labour force in each chain. This change in each year is expressed as a percentage and calculated as follows: ((proportion in year x − proportion in year 2012)/proportion in year 2012) × 100. The value (expressed in %) of these annual changes gives the difference between each successive year: (year x − year x_{-1}). The average value of these differences between the individual years ultimately represents the average annual change in the ratio in the period since 2012, i.e., by how much the ratio itself has changed on average each year compared to the situation in 2012. The average annual change in the ratio is expressed as a percentage and expressed to two decimal places. The value stock for the DEXi model is defined in three levels. POOR is defined as a change in which the percentage decreases, i.e., all values equal to or less than -0.01. AVERAGE is defined as a value of 0, which means that there has been no change. GOOD is defined as a change in which the proportion increases, i.e., when the value is greater than or equal to 0.01.

Data used

The data for the calculation of the key figures come from the SISTAT database (SORS), specifically from the sub-database: persons by activity, year, and persons in employment [51]. Annual data on the labour force are used in cattle breeding (raising of other cattle and buffaloes), pig farming (raising of swine/pigs), and milk production (raising of dairy cattle). An annual time series of data from 2012 to 2021 are used.

(c) The average ratio between the wage index in each agricultural activity and the consumer price index

This indicator shows the relationship between changes in wages in each agricultural activity and changes in consumer prices. The development of wages and the development of consumer prices are expressed by indices. All indices are calculated as a quotient between the month in question and the previous month (previous month). The added value for the primary producers in each chain is given if their wages rise faster than the prices for consumer goods or if the value of the ratio is greater than 1. The average value of the monthly quotient, which is used in the DEXi model, is calculated from the individual monthly quotients.

Methodology of the indicator

Based on the monthly data on the changes (indices) of wages in each chain (cattle, pigs, and milk) and consumer prices (total), the ratios between the average monthly wage indices (in the numerator) and the consumer price indices (in the divisor) were calculated for each chain for a single month. The average quotient for the period from January 2014 to December 2021 is then calculated on the basis of these monthly quotients. The values of the calculated quotients are defined to two decimal places.

The values for the DEXi model are defined in three stages, whereby all quotient values that are less than or equal to 0.99 are defined as POOR, i.e., the average salary in the chain under consideration rises more slowly than the average cost of consumer goods rises or falls faster than the average cost of consumer goods falls. AVERAGE is defined as a ratio value of 1.00, while GOOD is defined as all ratio values greater than or equal to 1.01.

Data used

The data used to calculate the ratios come from the SI-STAT database (SORS). A time series of data for the eight-year period from January 2014 to December 2021 is used. The data on the indices of average monthly wages for cattle breeding (raising of other cattle and buffaloes), pig farming (raising of swine/pigs), and milk production (raising of dairy cattle) are obtained from the sub-database: average monthly earnings and index of average monthly earnings (nace rev. 2) by activity, month, earnings and measures [50]. The data on consumer price indices (TOTAL) are taken from the sub-database: consumer price indices (ecoicop) by consumer products, month, and measures [52].

(d) Average degree of self-sufficiency for individual products (between 2012 and 2021)

This indicator shows the degree of self-sufficiency in beef, pork and milk in the Republic of Slovenia. The degree of self-sufficiency indicates the extent to which domestic production (from the domestic primary product) covers domestic consumption (consumption for animal feed, food, and consumption in industry).

Methodology of the indicator

Based on the annual data on the degree of self-sufficiency for the period of the last 10 years (from 2012 to 2021), expressed as a percentage, the average degree of self-sufficiency in this period is calculated.

The stock of values for the DEXi model is defined in three levels. POOR is defined as a level of self-sufficiency with a particular foodstuff that is below 50%, and AVERAGE is a level of self-sufficiency between 50 and 75%. The degree of self-sufficiency with a particular product or foodstuff that is higher than 75% is defined as GOOD.

Data used

The data for all three chains come from the annual reports on the State of agriculture, food, forestry, and fisheries, which are compiled by the Slovenian Agricultural Institute [53–62].

2.4.3. Description of Indicators of Environmental Parameter

(a) Food miles—average route/distance of imports in the last 10 years, route or distance between Ljubljana and the capital of each country (between 2012 and 2021)

Defining this indicator is a challenge, as, unfortunately, no data on average food miles (for imports and exports) are available for individual products or agri-food chains. For the purposes of the DEXi model, the focus is only on imports or the average distance required to import a particular product. The indicator or criterion itself is defined based on the share of imports of a given product from each country and the distance between the capital of that country and the capital of Slovenia (Ljubljana). The total import of a given product from all countries together equals 100%, whereby the share of imports from each country is calculated on the basis of the quantities imported from each country. These shares are then multiplied the distance between the capital of that country and Ljubljana, the capital of Slovenia. The sum of all products (imports from all countries) is divided by 100 to calculate the (approximate) average distance required to import a particular product.

Methodology of the indicators

Based on the data on the annual import volumes in each chain (total import in each chain = volume of imported fresh meat + volume of imported frozen meat; volume of imported milk) in the period 2012–2021, the average annual import from each country is calculated (sum of total annual imports in each chain in x years/x years). This average annual import from each country, which shows the situation over a ten-year period, is the basis for calculating the average total import in each chain, i.e., the average import from all countries combined (sum of average annual imports from all countries). This figure represents 100% of the imports in each chain. From the average total import in each chain, which equals 100%, the share of imports from each country is then calculated using the ratio (average import from country X/average total import from all countries). These shares form the basis for calculating the average transport route in each chain. The share of imports from each country is multiplied by the distance corresponding to the distance between the capital of the respective country and Ljubljana. To calculate the average transport distance in a single chain, all these products (import share × distance) are added together and divided by 100, thus calculating the average transport distance over a period of 10 years in a single chain. As the actual distances between the first and last link in the chain are not used, it should be emphasised that these are only approximate average distances. We have used an annual time series of import data for the ten-year period from 2012 to 2021. The value stock for the DEXi model is defined in three tiers and is based on the definition of local food established in the American Food, Conservation and Energy Act of 2008. Local food is defined as food that has travelled no more than 400 miles from the place of primary production to the place of purchase by the consumer or food that is consumed in the same country in which it was produced. To translate this definition to Slovenian conditions, the definition of stock values for the DEXi model is as follows: POOR (over 600 km), AVERAGE (between 300 and 600 km), and GOOD (less than 300 km). This definition is based on converting the distance from miles to kilometres (400 miles equals 643.7 km) and taking into account the distance between the outermost points of Slovenia, which is about 300 km (the distance between Lendava and Koper is 309 km).

Data used

All data on imports are taken from the SISTAT database (SORS), namely from the sub-database: exports and imports by imports/exports, country, combined nomenclature, year, and unit [63]. Data on the cattle chain (meat of bovine animals, fresh or chilled; meat of bovine animals, frozen), the pig chain (meat of swine, fresh, chilled or frozen), and the dairy chain (milk and cream, not concentrated and without added sugar or other sweeteners) are taken into account. Information on the distances between the main cities can be found on the GOOGLE MAP.

(b) Average annual change in the proportion of all indigenous breeds of a single species compared to all livestock of a single species in %

This indicator shows the average annual change in the proportion of indigenous breeds in the total breed composition of a particular livestock species. In the cattle, pig, and dairy cattle chain, the analysis focuses on the change in the share of "Cika" cattle in the total cattle population and "Krškopoljski" pigs in the total pig population in Slovenia. The shares of the two indigenous breeds in the total population are calculated on an annual basis. Differences or changes in the values of the quotient between individual years indicate whether the proportion of animals of indigenous breeds of a particular species in the total population of a particular species is increasing or decreasing. The average annual change in the ratio in the period between 2014 and 2021 is expressed as a percentage. The specific added value of an individual chain is given if the value of the average change is positive, which means that the proportion of indigenous breeds in the individual chain is increasing.

Methodology of the indicators

Annual quotas (quotients or proportions) are calculated for individual chains on the basis of annual data on the number of indigenous animals of a particular species (in the numerator) and data on the number of all animals of a particular species (in the divisor). These quotients or proportions form the basis for calculating the inter-annual changes in the quotients themselves, which provide us with the trend of change in the proportion of indigenous breeds of a particular livestock species in the total population of that livestock species. This change in individual years is expressed as a percentage and calculated as follows: ((proportion year x − proportion year x_{-1})/proportion year x_{-1}) × 100. Based on the value of the individual inter-annual changes, the average inter-annual change in the period between 2014 and 2021 is calculated, i.e., by how much the ratio or proportion (of indigenous animals of a particular species compared to the total population of that species) has changed on average each year. For this indicator, it is important that we have access to at least two years of data; otherwise, it is not possible to calculate changes or determine the trend of changes. If the average annual change, expressed as a percentage, is positive, this means that the proportion of animals of indigenous breeds or the number of animals of indigenous breeds is increasing compared to the number of all animals of a particular species. The values of the calculated changes expressed as percentages are defined to two decimal places. The value set for the DEXi model is defined in three levels, where all average annual changes that are negative or less than or equal to −0.01 are defined as POOR. AVERAGE is defined as annual average changes in the ratio between 0.00 and 5.00%. GOOD is represented by all values of the average annual change in the ratio that is greater than or equal to 5.01%.

Data used

The data used to calculate the annual changes in the proportion come from the SISTAT database (SORS), specifically from the sub-database: number of livestock by species and year [64]. Data on the number of all animals of a single species (cattle, pigs) are obtained from this database. Data on the number of animals of domestic breeds of each species are taken from the register of breeds with zootechnical evaluation. This register is available on the Open Data of Slovenia website, which is maintained by the Ministry of Public Administration [65]. A certain shortcoming of this attribute is simply that it is not possible to separate the data for the cattle breeding chain and the milk production chain, which means that the DEXi model uses the same data for both chains (cattle breeding and milk production chain) or the results when evaluating the individual chains.

(c) Average annual change in the number of livestock farms included in the animal welfare sub-measure, in %

This indicator shows the change in the number of livestock farms included in the animal welfare sub-measure. The changes compared to the previous year are calculated by comparing for each year the changes in the number of farms included in the sub-measure with the number of farms included in the sub-measure in the previous year. The changes in the number between the individual years are expressed as a percentage (%). It is an added value in the chain if the value of the average changes compared to the previous year is positive, which means that the number of farms included in the animal welfare sub-measure in the individual chain is increasing.

Methodology of the indicator

Based on annual data on the number of farms in each chain (cattle and pig farming) included in the animal welfare sub-measure, the inter-annual changes in the number of these farms are calculated for each year. The inter-annual changes for each individual year are calculated on the basis of the number of farms included in the sub-measure in the previous year. These changes for each year are expressed as percentages and calculated as follows: ((number in year x – number in year x_{-1})/number in year x_{-1}) × 100. The value of the individual inter-annual changes is then used to calculate the average inter-annual change in the period from 2015 to 2016 and in 2021, i.e., by what percentage has the number of farms included in the animal welfare sub-measure changed on average each year. For this indicator, it is important that we have access to data for at least two years, as otherwise, it is not possible to calculate changes or recognise a trend. The value stock for the DEXi model is defined in three levels, whereby all average annual changes that are negative or less than or equal to −0.01 are defined as POOR. Average annual changes in value between 0.00 and 5.00% are defined as AVERAGE. GOOD is represented by all values of the average annual change in the share that are greater than or equal to 5.01%.

Data used

An annual time series of data is used for the period from 2015 for the pig farming chain and from 2016 for the cattle and dairy farming chain, as this sub-measure did not exist before these years for all three chains analysed. Again, similar to the previous indicator, the biggest shortcoming of the indicator itself is that it is not possible to separate the data for the cattle breeding chain and the milk production chain, which means that the same data or results are used in the DEXi model for both chains (cattle breeding and dairy) when evaluating the individual chains. The data used to calculate these changes come from the annual reports on the State of agriculture, food, forestry, and fisheries, which are compiled by the Slovenian Agricultural Institute [53–62].

(d) Average annual change in the proportion of organically reared animals of a single species compared to all reared animals of that species in % (based on the situation in 2012)

This indicator shows the change in the proportion of organically reared animals of a particular species compared to all reared animals of that species by year. The aim of this indicator is to calculate how much the proportion of organically reared animals of a particular species changes on average each year compared to the total population of that species. The added value in a single chain is given if the value of these average annual changes is positive, which means that the proportion of organically reared animals increases compared to the total population of a particular reared animal species.

Methodology of the indicator

Based on the annual data on the number of organically reared animals of a specific animal species (cattle, pigs) and the data on the number of all reared animals of a specific animal species (cattle, pigs), the ratio between the number of organically reared animals (in the fraction) and the number of all reared animals of a specific animal species (in the divisor) is calculated by type. These individual quotients form the basis for calculating the inter-annual changes in the quotients themselves, from which the trend in the change in the proportion of organically reared animals of a particular species in the total population of that species is derived. This change in the proportion in the individual years is expressed as a percentage and calculated as follows: ((proportion year x – proportion year x_{-1})/proportion year x_{-1}) × 100. Based on the value of the individual annual changes, the average annual change in the period between 2012 and 2021 is then calculated, i.e., by how much the ratio or proportion itself has changed on average each year. If the changes expressed as a percentage are positive, this means that the proportion of organically reared animals of a particular species is increasing compared to the number of all reared animals of a particular species. The value set for the DEXi model is defined in three levels, where all average annual changes that are negative or less than or equal to −0.01 are defined as POOR. AVERAGE is defined as annual average stock changes between 0.00 and 5.00%. GOOD is represented by all values of average annual share change that are greater than or equal to 5.01%.

Data used

An annual time series of data for the period from 2012 to 2021 is used. Again, the main shortcoming of the indicator is that it is not possible to separate the data for the cattle chain and the dairy chain, which means that the same data or results were used in the DEXi model when evaluating individual chains for both chains (cattle and dairy). The data used to calculate these changes come from the annual reports on the state of agriculture, food, forestry, and fisheries, which are compiled by the Slovenian Agricultural Institute [53–62].

3. Results

3.1. DEXi Model Results of Cattle Breeding Sector

With the help of the DEXi model, the cattle breeding chain was evaluated as an average agricultural and food chain on the basis of the defined indicators and criteria (Figure 3). Two of the three parameters (economy and environment), which are made up of individual indicators and together make up the overall rating of each chain, were rated as average, while the social parameter was rated as good (Figure 3).

Attribute	Cattle
VALUE ADDED FOOD SUPPLY CHAIN ASSESSMENT	AVERAGE
Set of ECONOMIC INDICATORS	AVERAGE
Ratio between producer price of agricultural product and agricultural input price	0.99 and less
Change in the retail price ratio and the cost price	0.01 and more (positive value)
Ratio between price of purchased products and the cost price	0.99 and less
Weekly market price change	0.10 and more
Set of SOCIAL INDICATORS	GOOD
The ratio between the average gross salary in each chain and the average gross salary in agriculture	0.99 and less
Change in the ratio between the working population in each chain and the working population in all activities in the Republic of Slovenia	0.01 and more (positive value)
Ratio between the change in the level of wages and the change in the level of consumer prices	1.01 and more
Level of self-sufficiency	More than 75 %
Set of ENVIRONMENTAL INDICATORS	AVERAGE
Food miles	More than 600 KM
Change in the proportion of animals of native breeds compared to all animals combined	More than 5.01 %
Change in the number of farms included in the animal welfare sub-measure	Between 0 and 5.00 %
Change in the ratio of organically raised livestock	More than 5.01 %

Figure 3. Final assessment of the cattle breeding chain with the DEXi model (assessments of individual parameters and indicators).

As regards the economic aspect of the added value in the cattle breeding chain, this was determined as follows:

- Evolution of the ratio between the retail price (beef on the bone) and the price for own processing (young beef cattle, herd of 29 animals);
- Change in the market price for beef (beef quality A-R3) on a representative market.

In the cattle breeding chain, the average annual change in the ratio between retail prices for non-deboned beef and the own price for young fattening cattle was positive and amounted to 8.27%, which means that the average retail price for non-deboned beef increased more than the own price for the preparation of young fattening cattle. The development of price changes included in the indicator was in favour of retail prices for bone-in beef during the period under review. There was a clear difference between the changes in the value of the coefficients in the individual years. The largest positive change compared to the previous year was calculated for 2020 when the ratio coefficient increased by 12.46% compared to 2019, and the smallest for 2021, when the value of the quotient increased by 1.47% compared to the value of the quotient in 2020. In the period between 2018 and 2021, there were no negative changes in the quotient value in the cattle breeding chain compared to the previous year.

The changes in the weekly market price for beef (class A-R3) on the representative market showed that the price increased by an average of 0.14% per week in 2020 and 2021. The largest positive weekly change in the market price of beef on a representative market in the cattle chain was calculated for the 35th week of 2020, when the meat price increased by 5.26% compared to the previous week, and the largest negative weekly change in the market price was the 34th week in 2020 when the price fell by 4.92% compared to the previous week.

Two indicators were categorised as poor, i.e., indicators that represent a certain discrepancy with the presence of added value in the livestock production chain:

- The average ratio between the prices of agricultural products (cattle) and the prices of agricultural inputs;
- The average ratio between the prices of purchased products (bulls) and the farm's own price.

The average value of the quotient between the change in prices for agricultural products (cattle) and the change in prices for agricultural inputs was 0.98 in the period 2012 to 2021, with the primary producer (farmer) being the worst performer in 2020 with a ratio of 0.92 and the best performer in 2017 with a ratio of 1.02. The average value of the quotient, which is below 1, means that in the cattle breeding chain during the period under review, the prices for cattle among producers have risen less sharply than the prices for agricultural inputs.

The average value of the quotient between the prices of purchased products (bulls) and the own price of production in the cattle chain in the period between 2012 and 2021 was 0.70, which means that the average price of purchased bulls accounts for 70% of the total cost of production of young beef cattle themselves. The highest annual ratio was calculated for the years 2019 and 2021 at 0.72 and the lowest for 2020 at 0.68. The calculated value of the average quotient in the period under consideration means that the primary producers, on average, did not cover all the costs of the actual production or processing through the sale of bulls.

As far as the social aspect of value creation in the cattle breeding chain is concerned, this was determined in the following:

- Average changes in the share of the working population in the primary agricultural activity in each chain (cattle breeding) compared to the total working population in all activities in the Republic of Slovenia;
- The average ratio between the change in the level of wages in a single agricultural activity (cattle breeding) and the change in the prices of consumer goods (total consumer goods);
- Degree of self-sufficiency (beef).

The value of the ratio between the labour force in cattle breeding and the labour force in all economic sectors combined in the Republic of Slovenia has increased by an annual average of 1.6% since 2012, which means that the value of the ratio in 2021 has increased by 14.2% compared to the situation in 2012. This increase in the proportion of the labour force engaged in cattle breeding in the period between 2012 and 2021 is important for maintaining the number or proportion of the population engaged in beef production and thus ensures that domestic beef production is maintained, thus reducing the risk of a significant decline or change in the level of self-sufficiency in beef. Increasing the proportion of the working population in the cattle breeding chain also plays an important role in maintaining rural employment or in the preservation and development of rural areas themselves.

For the average ratio between the change in the wage level in the cattle breeding chain and the change in the level of consumer prices overall, it was found that the value of the quotient in the cattle breeding chain changes significantly between the individual months, but the average value of the quotient in the period under consideration is around 1, which means that the situation of cattle breeders in this period does not improve or deteriorate significantly in relation to the average cost of consumer goods or that the changes in average gross wages and the changes in the prices of consumer goods are aligned. In the period between 2014 and 2021, the average value of the calculated monthly quotient was 1.01 and thus slightly above the value of 1.00, where the increase in the wage level and the prices of consumer goods are proportional or harmonised. The primary producers or breeders in the cattle chain were in the worst position in July 2014, when the ratio was 0.71, and in the best position in February 2014, when the ratio was 1.60.

The average level of self-sufficiency in beef was 107.2% between 2012 and 2021, which means that we at least theoretically cover the needs of the domestic market with domestic agriculture or create a surplus in agriculture itself.

In contrast to all three indicators described above, the cattle chain did not achieve a positive score or did not show any added value for the indicator:

- the average ratio between the average gross wage in the beef sector and the average gross wage in agriculture (agriculture as a whole)

For the ratio between the average gross wage in livestock farming and the average gross wage in agriculture, it was typical in the period between 2014 and 2021 that the values of the ratio changed noticeably between the individual months. The average value of the monthly coefficients was 0.80, which means that the salary in the beef sector was around 20% lower than the average salary in agriculture in the period under review. The lowest value of the ratio was calculated for the month of August 2019, when it was 0.62, and the highest for the month of February 2014, when the ratio was 1.24.

As far as the environmental aspect of added value in the cattle breeding chain is concerned, it was analysed through the following:

- Average annual change in the proportion of all animals of indigenous breeds of a single species (cattle) compared to all bred animals of that species (cattle);
- The average annual change in the proportion of organically reared animals of a single species (cattle) compared to all reared animals of that species (cattle).

In the cattle breeding chain, we have an indigenous breed of cattle, the "Cika" cattle. The ratio between the number of "Cika" cattle and the number of all cattle breeds increased by an average of 8.11% annually between 2014 and 2020. The proportion of "Cika" cattle in the total population of breeding cattle increased from 0.72% to 1.14% during this period, which means that the value of the ratio itself improved by 59.2%.

For the cattle breeding and milk production chain, it was found that the proportion of cattle in organic farming compared to the total cattle population increased by an average of 5.48% per year between 2012 and 2021. In ten years, the share of organic cattle in the total cattle population increased from 5.0% to 8.0%, which means that the share of organic cattle increased by 61.1%.

The following indicators were categorised as poor or as representing a certain gap in the cattle value chain:

- Average food miles due to imports (beef, fresh, chilled, and frozen)

In the cattle breeding chain, the average import distance of fresh, chilled, and frozen meat in the period between 2012 and 2021 is 797 km. The top three countries from which most imports are made are Italy (41.4%), Austria (13.9%), and Poland (11.7%).

As for the fourth indicator used to determine the environmental aspects of the added value in the cattle breeding chain, the cattle breeding chain received an average score given the constraints established in the DEXi model. It is an indicator of the change in the number of farms included in the animal welfare sub-measure. For the cattle breeding chain and the milk production chain, it was determined that the number of farms included in the animal welfare sub-measure increased by an average of 2.94% per year in the period from 2016. In the period from 2016, the number of cattle farms included in the animal welfare sub-measure increased from 6832 to 7885, i.e., the number of farms included increased by 15.4%.

Results of Plus-Minus-1 Analysis

In the evaluation of the cattle chain, there are two indicators that, depending on the constraints set in the DEXi model, could affect the final evaluation of the cattle chain itself or the final evaluation of the model, with a positive or negative change in the evaluation, i.e., a change of one level up or down (Figure 4).

Plus-Minus-1 analysis

Attribute	-1	Cattle		+1
VALUE ADDED FOOD SUPPLY CHAIN ASSESSMENT		AVERAGE		
Ratio between producer price of agricultural product and agricultural input price	[	0.99 and less		
Change in the retail price ratio and the cost price		0.01 and more (positive value)	]	
Ratio between price of purchased products and the cost price	[	0.99 and less		
Weekly market price change		0.10 and more	]	
The ratio between the average gross salary in each chain and the average gross salary in agriculture	[	0.99 and less		
Change in the ratio between the working population in each chain and the working population in all activities in the Republic of Slovenia		0.01 and more (positive value)	]	
Ratio between the change in the level of wages and the change in the level of consumer prices		1.01 and more	]	
Level of self-sufficiency		More than 75 %	]	
Food miles	[	More than 600 KM		GOOD
Change in the proportion of animals of native breeds compared to all animals combined		More than 5.01 %	]	
Change in the number of farms included in the animal welfare sub-measure		Between 0 and 5.00 %		GOOD
Change in the ratio of organically raised livestock		More than 5.01 %	]	

Figure 4. Plus-minus-1 analysis for the cattle chain.

Such indicators are the following:

- Indicator for the average food kilometres for the import of products (imports of fresh, chilled, and frozen meat)
- Indicator for the average annual change in the number of livestock farms included in the animal welfare sub-measure (corresponding to the situation in 2016)

Should the assessment of the average food miles indicator change or be corrected from poor to average, the assessment of the entire cattle chain would improve from average to good. This means that, based on the indicators included in the model itself and on the basis of which the analysis of the individual chains was carried out, this indicator is one of the key indicators that the entire chain did not receive a better rating. In practice, this means that the import of beef, in which we are at least theoretically and statistically self-sufficient, and above all, the average distance travelled in this import, is one of the main reasons why the added value of the beef chain itself is reduced according to the established model. Improving the assessment of this indicator by reducing the distances travelled in the average individual imports in the cattle chain is the key to increasing the value added in the chain itself.

In the case of the second indicator, which could correct the final evaluation of the cattle breeding chain due to the constraints set in the model, the evaluation of the indicator itself should be corrected from average to good. In practice, this means that the number of cattle farms included in the animal welfare sub-measure should increase faster on average on an annual basis than in the period between 2016 and 2021. In this period, the number of farms included increased by an annual average of 2.94%, which does not meet the criteria for a good score that we have set in the DEXi model itself. This criterion is met if the average annual increase in the number of farms included is more than 5%.

3.2. DEXi Model Results of Pig Farming Sector

Using the DEXi model, the pig farming chain was assessed as an average agricultural and food chain on the basis of the defined indicators and the set boundaries (Figure 5).

Attribute	Pigs
VALUE ADDED FOOD SUPPLY CHAIN ASSESSMENT	AVERAGE
├Set of ECONOMIC INDICATORS	AVERAGE
│├Ratio between producer price of agricultural product and agricultural input price	*1.01 and more*
│├Change in the retail price ratio and the cost price	*0.01 and more (positive value)*
│├Ratio between price of purchased products and the cost price	0.99 and less
│└Weekly market price change	−0.01 and less (negative value)
├Set of SOCIAL INDICATORS	AVERAGE
│├The ratio between the average gross salary in each chain and the average gross salary in agriculture	*1.01 and more*
│├Change in the ratio between the working population in each chain and the working population in all activities in the Republic of Slovenia	−0.01 and less (negative value)
│├Ratio between the change in the level of wages and the change in the level of consumer prices	1.00
│└Level of self-sufficiency	Less than 50 %
└Set of ENVIRONMENTAL INDICATORS	*GOOD*
├Food miles	More than 600 KM
├Change in the proportion of animals of native breeds compared to all animals combined	*More than 5.01 %*
├Change in the number of farms included in the animal welfare sub-measure	*More than 5.01 %*
└Change in the ratio of organically raised livestock	*More than 5.01 %*

Figure 5. Final assessment of the pig farming chain with the DEXi model (assessments of individual parameters and indicators).

The groups of economic and social indicators, representing the economic and social parameters, were assessed as average, while the assessment of the environmental parameters was good.

The economic aspect of added value in the pig farming chain was determined as follows:

- The average ratio between price changes in agricultural products (pigs) and price changes in agricultural inputs
- The evolution of the ratio between retail prices (bone-in pork) and the price of own production

The average value of the ratio between the changes in prices for agricultural products (pigs) and the changes in prices for agricultural inputs was 1.03 in the period between 2012 and 2021, with the primary producer (farmer) performing best in 2019 and 2020 with a ratio of 1.11 and worst in 2021 with a ratio of 0.93. The average value of the ratio, which is greater than 1, means that in the pig farming chain during the period under consideration, the prices for pigs at the producers have changed (increased) more intensively than the prices for agricultural inputs (overall). In the pig farming chain, the average annual change in the ratio between retail prices for non-deboned pork and the own price for fattening pigs was positive and amounted to 3.34%, which means that the average retail price increased more than the own price for fattening pigs. A clear difference was observed between the changes in the value of the coefficients in the individual years. The largest positive annual change in the pig industry was calculated for 2020, when the coefficient increased by 17.44% compared to 2019, and the largest negative annual change was calculated for 2021 when the coefficient decreased by 7.85% compared to 2020.

Two indicators were categorised as poor or as representing a certain gap in the pig farming value chain:

- The average ratio between the prices of purchased products (fattening pigs 50–150 kg) and own price
- The development of market prices for pork (class S) on the representative market.

In the average relationship between the prices of purchased agricultural products (fattening pigs 50–150 kg) and their own price, it was found that the primary producers could not cover all the costs they had with the preparation itself with the income from the sale of fattening pigs on average. In the pig farming chain, the value of the average coefficient was 0.96, which means that the average price of purchased fattening pigs accounts for 96% of the total production costs. The highest annual coefficient was calculated for 2019 at 1.03 and the lowest for 2018 and 2021 at 0.92.

The changes in the weekly market price for pork (class S) on the representative market showed that the price fell by an average of 0.23% per week in 2020 and 2021. The largest positive weekly change in the market price of pork on a representative market in the pig chain was calculated for the 11th week of 2021, when the meat price increased by 5.39% compared to the previous week, and the largest negative weekly change in the market price was the 29th week in 2020 when the price fell by 6.39% compared to the previous week.

As far as the social aspect of value creation in the pig farming chain is concerned, it was determined as follows:

- The average ratio between the average gross wage in each chain (pig farms) and the average gross wage in agriculture (total).

In the period between 2014 and 2021, it was typical for the relationship between the average gross wage in pig farming and the average gross wage in agriculture that the values of the coefficient changed noticeably between the individual months. The average value of the monthly coefficients was 1.05, which means that the average salary in pig farming was higher than the average salary in agriculture in the period under consideration. In the pig farming chain, there was a clear difference between the values of the coefficients for the individual months. The lowest value of the ratio was calculated for the month of November 2015, when it was 0.89, and the highest for the month of February 2018, when the ratio was 1.27.

In the average ratio between the change in the level of wages in pig farming and the change in the price of consumer goods (total), the value of the average coefficient in the period between January 2014 and December 2021 was 1.00, which means that the changes in the level of wages and the changes in the level of consumer prices were on average proportional or coordinated, which is why this indicator was assessed as average. The lowest coefficient in the period under review was calculated for the month of October 2019 at 0.87 and the highest for the month of March 2020 at 1.15.

In contrast to the two indicators described above, the pig farming chain did not receive a positive evaluation or did not show any added value for the indicators:

- Average changes in the share of the labour force in the main agricultural activity in each chain (pig farms) compared to the total labour force in all activities in the Republic of Slovenia;

- Self-sufficiency rate (pork).

The value of the ratio between the labour force in pig farming and the labour force in all sectors of activity combined in the Republic of Slovenia has decreased on average by 0.6% since 2012, which means that the value of the ratio in 2021 has decreased by 5.4% compared to the situation in 2012. This decline in the share of the labour force in pig farming in the period between 2012 and 2021 and the continuation of this trend in the future may have additional negative consequences for ensuring the already very low level of self-sufficiency in pork.

The average level of self-sufficiency in pork in the period between 2012 and 2021 is 39.3%, which means that we cannot meet even half of the Slovenian market's demand with our own (domestic) breeding and are therefore dependent on imports.

As far as the environmental aspect of added value in the pig farming chain is concerned, it was analysed through the following:

- The average annual change in the proportion of all animals of indigenous breeds of a single species ("Krškopoljski" pig) compared to all farmed animals of that species (pigs);
- Average annual changes in the number of livestock farms included in the animal welfare sub-measure (pigs);
- Average annual changes in the proportion of organically reared animals of each species compared to all reared animals of that species (pigs).

There is one autochthonous pig breed in the pig farming chain, namely the "Krškopoljski" pig. The value of the ratio between the number of "Krškopoljski" pigs and the number of all pig breeds increased by an annual average of 13.82% between 2014 and 2020. The share of "Krškopoljski" pigs in the total population of breeding pigs increased from 0.51% to 1.10% during this period, which means that the value of the ratio itself improved by 115.0%.

As regards the indicator relating to the average annual changes in the number of livestock farms included in the animal welfare sub-measure, an average annual increase in the number of farms included in this sub-measure of 8.02% per year was observed in the pig farming chain for the period between 2015 and 2021. This means that the number of farms included increased from 169 farms in 2015 to 256 farms in 2021, or by 51.5%.

For the pig farming chain, it was found that the proportion of pigs kept organically compared to the total pig population increased by an average of 6.63% per year between 2012 and 2021. Within ten years, the proportion of organically reared pigs in the total pig population increased from 0.8% to 1.4%, which means that the proportion of organically reared pigs increased by 71.2%.

The following indicators have been identified as poor or as representing a certain gap in the pig farming value chain:

- Average food miles due to imports (fresh, chilled, and frozen pork)

In the pig farming chain, the average import distance of fresh, chilled, and frozen meat in the period between 2012 and 2021 was 812 km, which far exceeds the limits or criteria for a good or average rating of the indicator itself. The top three countries in terms of the volume of imports to Slovenia are Austria (31.5%), Germany (18.1%), and Spain and Italy (8.8% each).

Results of Plus-Minus-1 Analysis

In the evaluation of the social parameter (Figure 6) of the pig farming chain, there are two indicators that could affect the evaluation of the parameter itself if the evaluation of only one of these indicators were to change negatively, i.e., if the evaluation of one of these two indicators were to deteriorate by one level, the evaluation of the parameter itself would also deteriorate by one level.

Plus-Minus-1 analysis

Attribute	-1	Pigs	+1
Set of SOCIAL INDICATORS		AVERAGE	
The ratio between the average gross salary in each chain and the average gross salary in agriculture	POOR	1.01 and more	]
Change in the ratio between the working population in each chain and the working population in all activities in the Republic of Slovenia	[	−0.01 and less (negative value)	
Ratio between the change in the level of wages and the change in the level of consumer prices	POOR	1.00	
Level of self-sufficiency	[	Less than 50 %	

Figure 6. Plus-minus-1 analysis of the social parameter in the pig farming chain.

If the assessment of the indicator of the average ratio between the average gross wage in pig farming and the average gross wage in all economic sectors were to change or deteriorate from good to average, this would also affect the assessment of the parameter itself, which would change from average to poor. In practice, this means that it is important that the wage level in pig farming remains higher than the wage level in agriculture (as a whole), as otherwise, an additional gap would arise in the value of the pig farming chain itself. The same applies to the indicator of the average relationship between changes in wages in pig farming and changes in the prices of essential goods. On the basis of the data collected, this indicator is estimated to be average, which means that the level of wages and the prices of consumer goods change proportionally. If the prices for consumer goods were to change (rise) more than the wage level, this would mean a deterioration in the relationship and, at the same time, a change in the rating of the indicator from average to poor. If the rating of the indicator were to change from average to poor, the rating of the social parameter itself would also change from average to poor.

In the assessment of the environmental parameter (Figure 7) of the pig production chain, there are three indicators that, in the event of a negative change in the assessment of a single parameter, could influence the assessment of the parameter itself and thus also the assessment of the entire pig production chain.

Plus-Minus-1 analysis

Attribute	-1	Pigs	+1
Set of ENVIRONMENTAL INDICATORS		GOOD	
Food miles	[	More than 600 KM	
Change in the proportion of animals of native breeds compared to all animals combined	AVERAGE	More than 5.01 %	]
Change in the number of farms included in the animal welfare sub-measure	AVERAGE	More than 5.01 %	]
Change in the ratio of organically raised livestock	AVERAGE	More than 5.01 %	]

Figure 7. Plus-minus-1 analysis of the environmental parameter in the pig farming chain.

If the values determined for one of the indicators (average change in the number of pig farms included in the animal welfare sub-measure; average change in the proportion of indigenous breeds of a certain animal species in the total population of this animal species; average change in the proportion of organically reared animals in the total population of farm animals of this animal species) were to change in such a way that the rating of the indicator itself would change from good to average, this would also affect the rating of the environmental parameter, which would change from good to average. In order to maintain a good rating of the parameter itself, it is therefore necessary that the conditions described by these three indicators do not deteriorate in practice. A deterioration of the situation would affect the loss of the added value determined on the basis of the selected indicators or the constraints defined in the DEXi model.

3.3. DEXi Model Results of Milk Production Sector

Using the DEXi model, the milk production chain was assessed as an average agricultural and food chain on the basis of the selected and defined indicators and the boundaries set (Figure 8).

The groups of economic and social indicators (economic and social parameters) were rated as average, while the group of environmental indicators (environmental parameters) was rated as good.

Attribute	Milk (dairy)
VALUE ADDED FOOD SUPPLY CHAIN ASSESSMENT	AVERAGE
Set of ECONOMIC INDICATORS	AVERAGE
Ratio between producer price of agricultural product and agricultural input price	*1.01 and more*
Change in the retail price ratio and the cost price	−0.01 and less (negative value)
Ratio between price of purchased products and the cost price	0.99 and less
Weekly market price change	Between 0 and 0.09
Set of SOCIAL INDICATORS	AVERAGE
The ratio between the average gross salary in each chain and the average gross salary in agriculture	1.00
Change in the ratio between the working population in each chain and the working population in all activities in the Republic of Slovenia	−0.01 and less (negative value)
Ratio between the change in the level of wages and the change in the level of consumer prices	1.00
Level of self-sufficiency	*More than 75 %*
Set of ENVIRONMENTAL INDICATORS	*GOOD*
Food miles	Between 300 and 600 KM
Change in the proportion of animals of native breeds compared to all animals combined	*More than 5.01 %*
Change in the number of farms included in the animal welfare sub-measure	Between 0 and 5.00 %
Change in the ratio of organically raised livestock	*More than 5.01 %*

Figure 8. Final assessment of the milk production chain with the DEXi model (assessments of individual parameters and indicators).

With regard to the economic aspect of value creation in the dairy production chain, this was determined as follows:

- The average ratio between the prices of agricultural products (raw milk) and the prices of agricultural inputs

The average value of the quotient between the changes in the prices of agricultural products (raw milk) and the changes in the prices of agricultural inputs was 1.04 in the period between 2012 and 2021, with the primary producer (farmer) being the worst performer in 2016 with a quotient of 0.90 and the best performer in 2014 with a quotient of 1.19. The average value of the quotient, which is greater than 1, means that the prices for cow's milk in the milk production chain have risen or changed slightly more than the prices for agricultural inputs have risen or changed during the period under review.

The changes in the weekly market price for milk (sterilised or UVT milk (≥3.5% milk fat)) on a representative market were found to have increased by an average of 0.09% per week in 2020 and 2021, which is why this indicator was assessed as average due to the limits set in the DEXi model. The largest positive weekly change in the market price of milk on a representative market in the milk production chain was calculated for the 51st week of 2020, when the milk price increased by 16.65% compared to the previous week, and the largest negative weekly change in the market price was calculated for the 51st week of 2020 when the price fell by 14.81% compared to the previous week.

The following indicators were categorised as poor or as indicators that represent a certain gap in ensuring added value in the milk production chain:

- Change in the ratio between the retail price and the own price of production (milk 6500 L/cow);
- Average ratio between the prices of purchased products (raw milk) and own price (milk 6500 L/cow).

In the chain with milk processing, the average annual change in the ratio between the retail prices of full-fat long-life milk and the own price of milk processing was negative and amounted to minus 0.60%, which means that the own price of milk processing increased slightly more on average than the retail price of milk. The largest positive annual change in the milk processing chain was calculated for 2020 when the price quotient increased by 11.36% compared to 2019, and the largest negative annual change was calculated for 2021 when the price quotient increased by 11.36% compared to 2019 decreased by −15.24% in 2020.

The average value of the ratio between the prices of purchased products (cow's milk) and the price of own production (milk 6500 L/cow) in the milk production chain was 0.84 in the period between 2012 and 2021, which means that the average price of purchased cow's milk accounts for 84% of the total cost of the event itself. The highest annual ratio was calculated for 2020 at 0.90, and the lowest for 2018 and 2021 at 0.80.

The social aspect of added value in the milk production chain was calculated as follows:

- Degree of self-sufficiency (milk)

The average self-sufficiency rate for milk in the period from 2012 to 2021 was 127.2%, which means that we at least theoretically cover the needs of the domestic market with our own dairy farm or produce a surplus ourselves on the dairy farm.

In contrast to the positive or good assessment of the indicator for the degree of self-sufficiency in milk, the indicators for the average ratio between the average gross wage in the milk production chain and the average gross wage in agriculture and the average ratio between the wage index in milk production and the consumer price index were evaluated as average, which means that the situation represented by the two indicators remained unchanged.

For the ratio between the average gross wage in the dairy production chain and the average gross wage in agriculture, it was typical in the period between 2014 and 2021 that the values of the coefficient changed noticeably between the individual months. The average value of the monthly quotients was 1.00, which means that in the period under consideration, the wage in the milk production chain was, on average, equal to the average wage in agriculture. In the pig farming chain, there was a clear difference between the values of the coefficients for the individual months. The highest value of the ratio was calculated for the month of April 2014, when it was 1.10, and the lowest for the month of November 2018, when the ratio was 0.87.

In the average ratio between the change in the level of wages in the dairy production chain and the change in the level of consumer prices together, the value of the average quotient in the period between January 2014 and December 2021 was 1.00, which means that the changes in the level of wages and the changes in the level of consumer prices were on average proportional or coordinated, which is why this indicator was assessed as average. The lowest coefficient in the period under review was calculated for the month of January 2016 with a value of 0.91, and the highest for the month of January 2020 with a value of 1.12.

In contrast to all three indicators described above, the milk production chain did not achieve a positive score or did not show any added value for the indicator:

- Average development of the share of the economically active population in the main agricultural activity in each chain (milk production) compared to the total economically active population in all activities in the Republic of Slovenia.

The value of the ratio between the labour force in milk production and the labour force in all economic activities combined in the Republic of Slovenia has decreased on average by 5.9% since 2012, which means that the value of the ratio in 2021 has decreased by 53.2% compared to the situation in 2012. This average annual decrease in the proportion of employees working in milk production may have a negative impact on reducing the level of milk self-sufficiency, or, more importantly, it may have a negative impact on the preservation of rural jobs or on the preservation of the agricultural landscape and rural development itself.

The assessment of the environmental indicators in the dairy production chain is very similar to that in the beef production chain, as the same data are used for three of the four indicators. Different data are only used for the indicator when indicating the average food miles of imported products or, in the case of the dairy production chain, for the import of milk.

As far as the environmental aspect of value added in the milk production chain is concerned, this was determined through the following:

- The average annual change in the proportion of all animals of domestic breeds of a single species (cattle) compared to all breed animals of that species (cattle);
- The average annual change in the proportion of organically reared animals of each species compared to all reared animals of that species (cattle).

There is one indigenous breed of cattle in the dairy production chain, the "Cika" cattle. The value of the ratio between the number of "Cika" cattle and the number of all cattle reared increased by an annual average of 8.11% between 2014 and 2020. The proportion of

"Cika" cattle in the total population of reared cattle increased from 0.72% to 1.14% during this period, which means that the value of the ratio itself improved by 59.2%.

For the dairy production chain, it was found that the proportion of cattle in organic farming compared to the total cattle population increased by an average of 5.48% per year between 2012 and 2021. In ten years, the share of organic cattle in the total cattle population increased from 5.0% to 8.0%, which means that the share of organic cattle increased by 61.1%.

Due to the limitations of the DEXi model, the following indicators were rated as average:

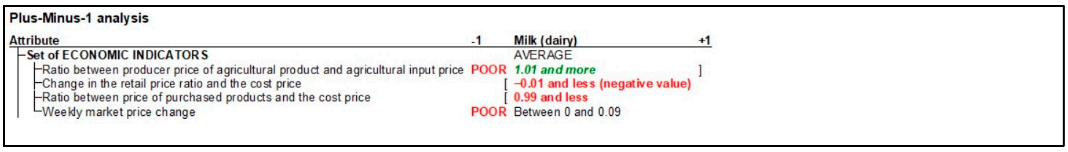
- Average food miles due to imports (milk and cream, not concentrated and without added sugar or other sweeteners);
- Average annual change in the number of livestock farms included in the animal welfare sub-measure (cattle).

In the milk production chain, the average distance of milk import between 2012 and 2021 is 541 km. The top three countries in terms of volume of imports to Slovenia are Austria (32.1%), Hungary (30.8%) and Germany (14.8%).

As for the indicator related to the average annual changes in the number of livestock farms included in the animal welfare sub-measure (based on the situation in 2016), the cattle dairy chain received an average score given the limits set in the DEXi model. For the cattle breeding and dairy production chain, the number of farms included in the animal welfare sub-measure was found to have increased by an average of 2.94% per year in the period from 2016. In the period from 2016, the number of cattle farms included in the animal welfare sub-measure increased from 6832 to 7885, which means that the number of farms included increased by 15.4%.

Results of Plus-Minus-1 Analysis

When evaluating the economic parameter (Figure 9) of the milk production chain, there are two indicators which, in the event of a negative change in the evaluation of only one of them, can influence the evaluation of the parameter itself and, thus, also the evaluation of the entire dairy production chain.


Plus-Minus-1 analysis

Attribute	-1	Milk (dairy)	+1
Set of ECONOMIC INDICATORS		AVERAGE	
Ratio between producer price of agricultural product and agricultural input price	POOR	1.01 and more	]
Change in the retail price ratio and the cost price	[	−0.01 and less (negative value)	
Ratio between price of purchased products and the cost price	[	0.99 and less	
Weekly market price change	POOR	Between 0 and 0.09	

Figure 9. Plus-minus-1 analysis of the economic parameter in the milk production chain.

This means that if the rating of one of the indicators changes by one level downwards, the rating of the economic parameter would also change by one level downwards. In this case, the assessment of the economic parameter would change from average to poor. In practice, such a change in the assessment would occur if the average ratio between the index of prices for agricultural products and the index of prices for agricultural inputs changed (the assessment of this individual indicator would fall by one level from good to average) or if the market price for milk on the representative market began to fall on average. In this case, too, the rating of this individual indicator would fall by one level, from average to poor, which would affect the rating of the economic parameter, which would change from average to poor.

When evaluating the environmental parameter (Figure 10) of the milk production chain, all four indicators are such that a negative change in the evaluation of just one of these parameters could influence the evaluation of the parameter itself and, thus, also the evaluation of the entire milk production chain.

This means that if the rating of one of the indicators were to change by one level downwards, the rating of the environmental parameter would also change by one level downwards. In this case, the rating of the environmental parameter would change from good to average. In practice, such a change in assessment would occur if the average distance for importing milk were to increase from just over 500 km to over 600 km, which would affect the change in the assessment of the indicator from average to poor or if the number of dairy farms included in the animal welfare sub-measure began to decrease annually. In this case, too, the assessment of this individual indicator would fall by one level, namely from average to poor, which would affect the assessment of the environmental parameter, which would change from good to average. The same applies to the other two indicators, which were rated as good and would become average if the rating were to change by one level. Should this only be the case for one of the four indicators of the environmental parameter, this would be sufficient to change the rating of the parameter itself by one level.

Plus-Minus-1 analysis

Attribute	-1	Milk (dairy)	+1
Set of ENVIRONMENTAL INDICATORS		*GOOD*	
Food miles	AVERAGE	Between 300 and 600 KM	
Change in the proportion of animals of native breeds compared to all animals combined	AVERAGE	***More than 5.01 %***	]
Change in the number of farms included in the animal welfare sub-measure	AVERAGE	Between 0 and 5.00 %	
Change in the ratio of organically raised livestock	AVERAGE	***More than 5.01 %***	]

Figure 10. Plus-minus-1 analysis of the environmental parameter in the milk production chain.

4. Discussion

Based on the anomalies identified in the generation of added value in the assessment sectors, proposals are presented below that could influence the improvement of the situation identified or contribute to increasing added value at individual stages of the chains.

Following the anomalies identified in all three chains analysed, we found that the primary production sector is most often directly or indirectly involved in socio-economic situations that pose a certain risk to those involved or that do not meet the objectives set, which indicate elements of value creation [66,67]. Primary producers are often not equal strategic partners within each chain, which makes it difficult for them to assert their own interests and rights [32,68,69]. They are exposed to various socio-economic risks, mainly in the form of an unstable market environment (low purchase prices, rising prices for agricultural inputs, fluctuating market prices, oversupply on the domestic and foreign market, rapid changes in labour costs, collapse of the wage ratio between individual members to the detriment of the primary sector) and unfair business practices (in economic cooperation with other actors in the chain, which has been identified in several cases by the Agency for the Protection of Competition) [70,71].

One of the possible proposals that could help to improve or eliminate the perceived anomalies is the promotion of sectoral cooperation or the association of producers in producer organizations (both at the same level in the chain and along the value chains) [69,72], which would allow primary producers to act as an equal strategic partner in the market due to collective linkage and cooperation [73]. At a time of low purchase prices for primary products and high costs, the association of primary producers and the creation of joint services and marketing are essential for the economic success and development of producers or suppliers. By integrating the services, production costs can be reduced, and sales margins increased [71]. The aim or main activity of such sectoral integration (producer organizations) is or should be to strengthen the bargaining position of producers and contribute to the concentration of supply and the joint placement of products (of their members) on the market. Another important aspect of sectoral integration concerns the possibility of reducing costs in various parts of the chain (the production itself) in the form of collective purchasing and management of inputs and means of production. Long-term contracts between primary producers and the buyers of their products (food industry representatives, wholesalers, retailers) and between the processing industry and distributors can be mentioned as ways of reducing the risks associated with the purchase of products or produce [74]. Long-term contracts could facilitate and rationalise the planning of the production and distribution process itself, as the parties involved at each stage or in each sector of the chain would already know the purchase and acceptance prices, the agreed quantities and estimated costs and the payment terms for each crop or product when the contract is concluded. This would, therefore, have the effect of coordinating supply and demand on the market more effectively, making it easier to avoid periods of surplus or shortage of a particular product on the market, which would indirectly translate into greater market stability and less price volatility [71,75,76].

With regard to the environmental component of the evaluation of added value and the identification of possible anomalies, it is essential that specific indicators are defined for each part of the agricultural sectors of the production chains, on the basis of which regular (national) monitoring is carried out. Given the specificities of each sector or chain, it would be useful to determine, based on expert judgement, which indicators in each sector or chain would be useful to monitor and which would express certain environmentally sound or sustainable practices. On the basis of regular monitoring and the data obtained, the evaluation of each chain and the search for anomalies in the realization of added value could be carried out. In the case of the interest of the State and other stakeholders involved, who wish to effectively evaluate individual chains in order to take more appropriate measures, it would be useful to develop a set and a methodology of indicators specifically established for each individual sector or specific agri-food chain. In doing so, it is necessary to emphasise the major technological differences between the various sectors of agriculture, food processing and distribution.

Examples of good practice teach us that the added value for individual actors in the chains (primary producers) is easier to recognise in short agricultural and food chains [32,66–68,70,73,77–79]. In other words, in cases where only a few actors are involved in the entire chain. A prime example of this is "face-to-face" sales, where the end customer meets the primary producer or comes into contact with the production process. As this type of sale is difficult for a wider range of buyers to accept, solutions need to be found to transfer these positive characteristics of short agri-food chains or value-added chains to the widest possible range of potential buyers.

One of the options offered is the introduction of a new label or quality scheme that includes products or products whose entire production and distribution chain takes into account the principles of sustainable management of all sectors involved or products whose chain is based on a fair distribution of rights and obligations as well as benefits and burdens among all actors involved. Quality labels or schemes enable transparent and direct communication between the different sectors of the chain and the end consumer. The use of ICT technology is another innovative way of improving communication between stakeholders and increasing the visibility of the new quality label. The positive economic, social and environmental characteristics of value-added chains could be presented to the end consumer with a quality label, which, given the functioning of other already established quality schemes, could create a positive trend in the demand phase for certain products and, with an equal or fair distribution of socio-economic benefits between the different sectors in the chain, could lead to an increase in supply. A very important and positive feature of quality schemes is that they can be used to educate or sensitise the end customer about the positive characteristics of a specific product, which may relate to specific actors in a single chain (positive socio-economic and environmental consequences for individual actors in the chain) or to the customer himself (information about the origin and specific characteristics of the product, sustainable and environmentally and health-friendly production practices, . . .). The specificity of this new label or quality system is that, unlike other systems, it does not only refer to the quality and characteristics of the product itself or to specific production methods in a given sector of the chain but expresses the economically, socially, and environmentally acceptable or favourable working practices of all actors involved in vertically linked sectors of the chain on the basis of defined criteria that would be a prerequisite for obtaining the label. The advantage of such a label or quality scheme could be the possibility to sensitise consumers to the positive (socio-economic) characteristics of individual chains that are usually overlooked or hidden but represent a significant added value for the individual chain. When developing the criteria for obtaining the label, which would express the added value in the individual sectors of the chain, it would be useful to use already defined indicators or targets.

In the future, these indicators are to be supplemented by generally recognised indicators of value creation, which could not be used due to the unavailability of data on the analysed chains in public databases. The members of the research group of the Faculty of Agricultural and Life Sciences will try to extend all the knowledge gained from this project through the theoretical design of the label or quality system "Sustainable product" or "Product with added value". The basic guidelines for the theoretical design of the label will be as follows: trust and honesty between the actors along the individual chain, equal distribution of the price of the final product among all actors in the chain, and sustainable operation of all sectors involved.

5. Conclusions

The paper presents the results of a multi-year study analysing the agricultural sector and assessing its performance in the identified weaknesses. The DEXi multi-criteria decision-making method was used as the assessment method. The performance of agri-food chains was assessed using various economic, social, and environmental indicators.

It was found that all agricultural sectors assessed (cattle breeding chain, pig breeding chain, and dairy production chain) received the same final score of "average" out of a possible three of "poor", "average", and "good". An additional analysis was used to determine which indicators could improve the rating and which pose a risk for the deterioration of the situation in the agricultural and food chains. For example, in the cattle chain, there are two environmental indicators that can improve the sector's final score (e.g., reducing imports of live animals and increasing the farm's compliance with animal welfare standards). In addition, similar environmental indicators were identified in the pig and dairy chains that can influence the situation of the sectors. While two additional social indicators were recognised for the pig breeding chain (both related to the relationship between payments in the agricultural sectors), two economic indicators were recognised for the dairy production chain, indicating the risk of high production costs that may lead to a risk position in the sectors.

The limitations of the study, which, in addition to some minor methodological limitations, are related to the number of utility functions and, later, not too many attributes in the decision tree, were mainly identified during the collection of the data. We realised that we do not collect enough high-quality data at the national level in Slovenia that would allow us to analyse the agricultural sector at the micro level. We have filled certain gaps with data from Eurostat, but we believe that it would be useful to tackle the renewal of the database in the field of agriculture in Slovenia, as this study has also shown at the end.

The study leaves some research questions unanswered that would be useful to address in the future. With this study, we have successfully demonstrated how and with which appropriate method one can approach the objective assessment of complex problems related to rural development. We expect that by implementing the results in the future, we will create a proposal for a sustainable model of food chain development with added value, which we assume will be applicable to the wider area of the European Union member states. At the same time, this also represents a future research challenge.

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Appendix A

Table 1. Descriptions of the indicators used in the DEXi model.

Economic Parameter				
Indicator	**Indicator Description**	**Meaning of Indicator**	**A Stock of Value**	**Source of Data**
The ratio between the prices of agricultural products and the prices of agricultural inputs	Average (multi-year) ratio between the producer price index of agricultural products and the annual agricultural input price index (between 2012 and 2021) Z = average (multi-year) ratio X (Ratio) = Crop Price Index/Total Input Price Index $Z = (X_1 + X_2 + \ldots + X_n)/n$	Added value or a positive economic situation for the primary producer (farmer) occurs if the prices of inputs rise more slowly than the prices of agricultural products for growers. All ratio values greater than 1.00 represent a positive economic position for the primary producer.	POOR—≥0.99 AVERAGE—1 GOOD—≤1.01	SORS
Change in the ratio between retail price and own price	Average year-on-year change in the ratio between the average retail price of agricultural products and the own price, on an annual basis, in % Z = average year-on-year change in ratio X (ratio) = retail price/own price Y (year-on-year change in ratio) = $((X - X_{-1})/X_{-1}) \times 100$ $Z = (Y_1 + Y_2 + \ldots + Y_n)/n$	Added value or a positive economic situation for the primary producer (farmer) occurs if the prices of inputs rise more slowly than the prices of agricultural products for growers. All ratio values greater than 1.00 represent a positive economic position for the primary producer.	POOR—≥0.01 AVERAGE—0 GOOD—≤0.01	SORS AIS (Model calculations)
The ratio between the prices of purchased products and the own price	Average (multi-year) ratio between average prices of purchased agricultural products and own price (between 2018 and 2021) Z = average (multi-year) ratio X (ratio) = purchase price/own price $Z = (X_1 + X_2 + \ldots + X_n)/n$	Added value, or a favourable economic position for the primary producer, occurs when the prices of purchased agricultural products are higher than their own price. Considering that the goal of every grower is to make a profit, it is very important that the sales revenue is higher than the production costs.	POOR—≥0.99 AVERAGE—1 GOOD—≤1.01	SORS AIS (Model calculations)
Weekly market price change	Average weekly change in product market price in % Z = average weekly change Y (weekly price change) = $((X - X_{-1})/X_{-1}) \times 100$ $Z = (Y_1 + Y_2 + \ldots + Y_n)/n$	Added value or a positive economic position for the primary producer occurs if the average weekly price change is positive over a significant period of time.	POOR—≥0.10% (more than 0.10) AVERAGE—0 0.09 (between 0 and 0.09) GOOD—≤0 (less than 0)	MAFF ARSAMRD
Social Parameter				
Indicator	Indicator Description	Meaning of Indicator	A Stock OF Value	Source of Data

Table 1. *Cont.*

Economic Parameter				
Indicator	**Indicator Description**	**Meaning of Indicator**	**A Stock of Value**	**Source of Data**
The ratio between the average gross salary in each chain and the average gross salary in agriculture	Average (multi-year) ratio between the average gross salary in each production chain and the average gross salary in the Republic of Slovenia (between 2014 and 2021) Z = average (multi-year) ratio X (ratio) = gross wage in each chain/gross wage in agriculture in total $Z = (X_1 + X_2 + \ldots + X_n)/n$	It shows how much the primary producers in the considered chains are financially rewarded compared to the average payment in agriculture, which, in the case of an above-average payment in the individual considered chain (cattle, pigs, and dairy), indicates a certain added value of these chains.	POOR—≥0.99 AVERAGE—1 GOOD—≤1.01	SORS
Change in the ratio between the working population in each chain and the working population in all activities in the Republic of Slovenia	Average annual change in the ratio between the working population in each chain and the working population in all activities in the Republic of Slovenia together, in % (based on the situation in 2012) Z = average annual change in the ratio X (ratio) = number of DAP in each activity/number of DAP in all activities together Y (change in ratio over the years in %) = $((X_n - X_{2012})/X_{2012}) \times 100$ $Z = Y/n$	It shows the trend of changing the share of the working population in each chain compared to the entire working population in the Republic of Slovenia. Added value is given if the trend of changing the share is positive in relation to the state or value of the ratio in 2012.	POOR—≥0.01 AVERAGE—0 GOOD—≤0.01	SORS
The ratio between the change in the level of wages and the change in the level of consumer prices	Average (multi-month) ratio between the wage index in individual agricultural activity and the consumer price index (between 2014 and 2021) Z = average (multi-year) ratio X (ratio) = wage index in individual activity/consumer price index $Z = (X_1 + X_2 + \ldots + X_n)/n$	This criterion expresses a certain added value for subjects in individual agricultural activities if their wages rise faster than the prices of consumer goods.	POOR—≥0.99 AVERAGE—1 GOOD—≤1.01	SORS
Level of self-sufficiency	Average level of self-sufficiency with individual products or with products from individual sectors (between 2012 and 2021)	The degree of self-sufficiency shows the extent to which domestic production (from domestic of the basic product) covers domestic consumption (consumption for fodder, food and consumption in the industry)	POOR—>50 AVERAGE—≤50 and >75 GOOD—≤75	SORS AIS
Environmental Parameter				
Indicator	Indicator Description	Meaning of Indicator	A Stock OF Value	Source of Data

Table 1. *Cont.*

Economic Parameter				
Indicator	**Indicator Description**	**Meaning of Indicator**	**A Stock of Value**	**Source of Data**
Food miles	Food kilometres—the average route/distance of imports in the last 10 years; the route or distance is calculated based on the distance between Ljubljana and the capital of the individual country of import and based on the share of imports from the individual country (between 2012 and 2021)	The route or distance travelled during the average transport when importing products in an individual chain is an important indicator of the sustainability of the chain itself, as transport has a significant impact on CO_2 emissions, the well-being of livestock in transport, the freshness of products, etc.	POOR > 300 AVERAGE—≤300 and >600 GOOD—≤600	SORS GOOGLE MAPS
Change in the proportion of animals of indigenous breeds compared to all animals combined	Average year-on-year change in the share of all indigenous breeds of an individual animal species compared to all farmed animals in an individual species in % (between 2014 and 2021) Z = average year-on-year change in ratio X (ratio) = number of indigenous animals (individual species)/total number of animals (individual species) Y (change in ratio between individual consecutive years, in %) $= ((X - X_{-1})/X_{-1}) \times 100$ $Z = (X + X_{-1} + \ldots + X_n)/n$	The added value of an individual chain is given if the value of the average change is positive, which means that the share of indigenous breeds in an individual chain is increasing in the period between 2012 and 2021.	POOR > 0.00 AVERAGE—≤0.01 and ≥5.00 GOOD—≤5.01	SORS MAFF
Change in the number of farms included in the animal welfare sub-measure	Average year-on-year change in the number of livestock farms included in the animal welfare sub-measure, in % (between 2015/2016 and 2021, respectively) Z = average year-on-year change in the number of farms (in %) X = number of farms included in the sub-measure Y (change in the number of farms between individual consecutive years, in %) $= ((X - X_{-1})/X_{-1}) \times 100$ $Z = Y/n$	The added value in a certain chain is given if the value of the average annual changes is positive, which means that in the period between 2015 and 2016 and 2021, the number of farms that are included in the animal welfare sub-measure in each chain increases.	POOR > 0.00 AVERAGE—≤0.01 and ≥5.00 GOOD—≤5.01	AIS
Change in the share of organically raised livestock	Average year-on-year change in the share of organically raised livestock of a particular species compared to all farmed animals of that species in % (between 2012 and 2021) Z = average annual change in ratio X (ratio) = number of ECO animals (individual species)/number of all animals (individual species) Y (change in ratio between individual consecutive years, in %)) $= ((X - X_{-1})/X_{-1}) \times 100$ $Z = (X + X_{-1} + \ldots + X_n)/n$	The added value in an individual chain is given if the value of these average annual changes is positive in relation to the period in question, which means that the share of organically raised animals is increasing compared to the entire population of a certain raised animal species.	POOR > 0.00 AVERAGE—≤0.01 and ≥5.00 GOOD—≤5.01	AIS

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