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Determinants of spatial concentration of short food supply chains on example of marginal, localized and restricted activities in Poland

Determinanty przestrzennej koncentracji krótkich łańcuchów dostaw na przykładzie podmiotów marginalnych, lokalnych i ograniczonych w Polsce

Abstract. The article analyses spatial concentration of marginal, localized and restricted activities creating local food systems in Poland regarded as short supply chains. Local food systems in Poland can take the forms of direct sale, direct deliveries, agricultural retail as well as marginal, localized and restricted activities. Short food supply chains play crucial role in case of local economy, environment and society. Thus, article rises issue connected with sustainability, alternatives for mass produced and distributed food, spatial diversity of local activities. Empirical part of the article focus on marginal, localized and restricted activities. The first part of the article contains a characteristic of the analyzed activities and their spatial distribution. The second part identifies factors that have the strongest influence on the formation of marginal, localized and restricted activities with the application of nonparametric models of regression trees. It is reported that spatial and environmental factors occur most frequently in the process of recurrent division of the data set and, thus, constitute the strongest determinant of marginal, localized and restricted activities.

Key words: local food systems, short food supply chains, spatial concentration, marginal localized and restricted activities, nonparametric regression trees

Synopsis. W artykule analizie poddano koncentrację przestrzenną podmiotów marginalnych, lokalnych i ograniczonych tworzących lokalne systemy żywnościowe w Polsce i utożsamianych z krótkimi łańcuchami dostaw. Lokalne systemy żywnościowe w Polsce mogą przybierać formy organizacyjno-prawne takie jak: sprzedaż bezpośrednia, dostawy bezpośrednie, rolniczy handel detaliczny oraz działalności marginalną, lokalną i ograniczoną. Krótkie łańcuchy dostaw żywności odgrywają kluczową rolę w lokalnej gospodarce, środowisku i społeczeństwie. W artykule poruszono zatem problematykę związaną ze zrównoważonym rozwojem, alternatywami dla masowo produkowanej i dystrybuowanej żywności, przestrzennym zróżnicowaniem lokalnych podmiotów. Część empiryczna artykułu oparta jest na analizie podmiotów marginalnych, lokalnych i ograniczonych. W pierwszej kolejności dokonano charakterystyki analizowanych podmiotów i ich rozmieszczenia

przestrzennego. Następnie, wykorzystując nieparametryczne modele drzew regresji, zidentyfikowano czynniki, które najsilniej wpływają na powstawanie podmiotów marginalnych, lokalnych i ograniczonych. Dostrzeżono, że czynniki przestrzenno-środowiskowe występują najczęściej w procesie rekurencyjnego podziału zbioru danych, a tym samym stanowią najsilniejszą determinantę działalności marginalnej, lokalnej i ograniczonej.

Słowa kluczowe: działalność marginalna, lokalna i ograniczona, nieparametryczne modele drzew regresji

Introduction

The approach to production, sale and consumption of agri-food products is undergoing dynamic changes. This is influenced by many factors such as the development of production techniques, interference with the transport vulnerability of agri-food products, social trends in consumption or random events such as cataclysms and pandemics. Observing the agri-food sector, it is possible to identify two main trends in its development. The first development trend takes on the character of agriculture and industrial processing. Industrialism changed the structure of production factors in agriculture and increased the scale of economic profitability of production [Woś and Zegar 2002]. The agrarian structure of farms has changed. There have been processes of consolidation, specialization and concentration of agricultural production. There has been a mass approach to the production of agri-food products with an impact on, e.g. their unification, high degree of processing and loss of nutritional values. Nevertheless, there are many indications that local food systems, which play a particularly important role in the times of pandemics, are a very strong, opposing trend in the development of the sector [Malak-Rawlikowska et al. 2019, Michel-Villarreal et al. 2019]. Local food systems are based on short food supply chains gaining on prominence in the debate regarding farm competitiveness in European Union [Cesaro et al. 2020]. In Poland, local food systems can take the form of:
– direct sales,
– direct deliveries,
– agricultural retail,
– marginal, localized and restricted activities.

The latter group is the activity of great local importance, both in economic, social and environmental terms. Therefore, in this article, the author takes up a research problem related to marginal, localized and restricted activities (MLR). The main aim of this article is to identify factors that affect the spatial concentration of MLR activities. A considerable diversity can be observed both in terms of the activity profile and spatial distribution of the above mentioned organizational and legal forms. It is pointed out in literature that the diversity of spatial distribution of business activities may attributed to many very different factors [Godlewska-Majkowska 2013]. The processes of concentration (localization) of business activities observed in the geographical space provide valuable information on the functioning of regional economies and the directions of their development. Moreover, nowadays, spatial analyses seem to be an integral part of economic analyses. Thinking in spatial terms is considered to be a more comprehensive and

modern approach to account for interdependent phenomena [Suchecki 2010]. Thus, the research conducted will enhance the concept of development of activities within local food systems in spatial systems and provide information on the factors determining local activity in a given region. The specific objectives of the undertaken research problem assume the characteristics of marginal, localized and restricted activities in Poland and their spatial structure. To solve the research problem, nonparametric models of regression trees constructed in the "R program" were used. The specific objectives were achieved through a literature study and statistical analysis of secondary data published by the General Veterinary Inspectorate as of January 1st 2018.

Theoretical background of marginal, localized and restricted activities in Poland as a part short food supply chains

Trends in the agribusiness sector, which indicate reorganization of conventional supply chains, a return to direct producer-consumer relations and regionalization of food production, are called local food systems. The growing popularity of local food systems is associated with a crisis of public trust in the mass agri-food industry. This is due to increased epidemics of diseases, such as swine and avian influenza, BSE, ASF, as well as concerns about the use of genetic modifications or food preservatives. In addition, public awareness of the environment and concern for its sustainability are increasing, which contradicts the industrial approach to the agribusiness sector [Blouin et al. 2009]. The role of local systems can also be seen during the COVID-19 pandemic. Operating within local food systems yields independence from global food chains and, thereby, increases the chances of survival in times of crisis. The main idea of local food systems is to eliminate intermediaries in the supply chain, which creates a sense of security and facilitates access to food.

As at January 1st 2018, there are 12,765 entities in Poland engaged in the production, processing and sale of animal products operating locally. A possible form of undertaking activity within the local food systems is running marginal, localized and restricted (MLR) enterprises. Registration of MLR enterprises in Poland has been available since 2007. The scope of activity of such enterprises is the production and sale of processed and unprocessed products of animal origin to the final consumer and the supply of produced food to retail establishments for the final consumer [Rozporządzenie Ministra Rolnictwa i Rozwoju Wsi z dnia 30 września 2015 r.]. Marginal, localized and restricted activities provide an opportunity for small businesses entities and family production establishments, offering products with specific, unique characteristics, to produce, process and sell. The MLR activity is identified with a strategy of supporting local production by enabling business activities with relaxed technical, organizational and fiscal requirements. The territorial range of MLR activity is limited to an area of one voivodeship or an area of adjacent poviats, located within the areas of other voivodeships. The processing and sale of products manufactured by marginal, localized and restricted activities may take place in a special building intended for production, in an adapted room (e.g. "summer kitchen") or in the rooms of residential houses where the food is prepared. The equipment of the premises should meet the requirements specified in Regulation (EC) No. 852/2004. In addition, the

plant should develop HACCP rules and apply good practice principles. Products offered as a part of MLR activities should comply with the requirements set for microbiological criteria, storage temperatures and the so-called cold chain. As with other entities processing animal products, MLR activities are registered and supervised by the General Veterinary Inspectorate. In January 2018, there were 2157 registered MLR entities in Poland. Figure 1 presents, in absolute terms, the distribution of MLR entities in Poland.
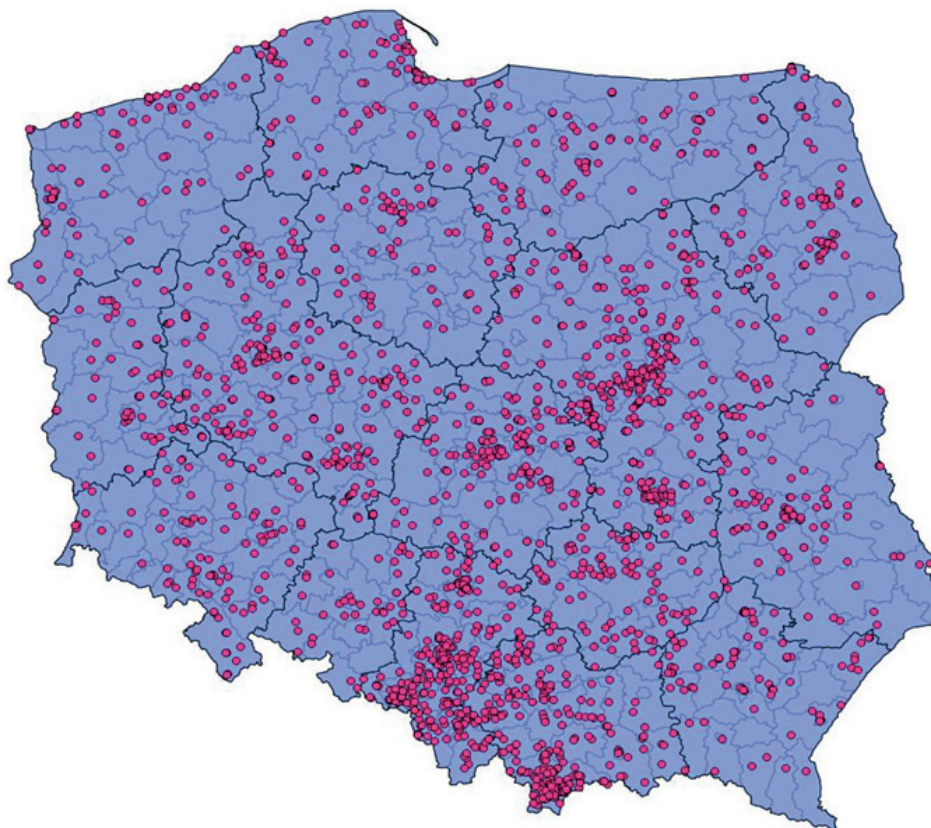

Figure 1. Entities involved in marginal, localized and restricted activity (as of January 2018)
Rysunek 1. Podmioty zaangażowane w działalność marginalną, zlokalizowaną i ograniczoną (stan na styczeń 2018 roku)

Source: [Główny Inspektorat Weterynarii 2018] own study in OGIS programme.

The largest number of MLR enterprises operate in the following voivodeships: Mazowieckie (Żyrardów and Radom poviats) i.e. central-east of Poland, Małopolskie (Nowy Targ and Tatra poviats),i.e. south of Poland and Śląskie (Cieszyn and Wodzisław poviats), i.e. south of Poland. 40% of all MLR activities in Poland are located within the area of these three voivodeships. Voivodeships with the smallest number of MLR activities include: Lubuskie (Żary, Sulęcin poviats), Kujawsko-Pomorskie (Bydgoszcz, Radziejów poviats) and Opolskie (Prudnik, Namysłów poviats).

Purpose and methodology

The main objective of the analysis was to identify the determinants of spatial concentration of marginal, localized and restricted activities. To this end, two nonparametric regression models were built. This method makes it possible to select, from among the variables characterizing a given region, those which significantly affect the analyzed local activities. Non-parametric regression models are a data mining tool that has recently been gaining in popularity. Literature contains a wide range of areas where analyses based on nonparametric regression models are used [Strojny 2010, Trzęsiok 2013, Chrzanowska and Drejerska 2015a, b, Pudełko 2015]. The undoubted popularity of the method stems from its properties (flexibility and good matching to data) [Gatnar 2008]. The model building process uses, among other things, a recurring division algorithm. As a consequence, the final model consists of local models built in each of the K-sectional segments into which the multidimensional space of variables is divided. Nonparametric models of regression trees may be of predictive nature, i.e. they are made to predict future values of explained variables, or verifying nature, i.e. describing an already existing data set. In the case of this study, the constructed models were used to verify which of the explained variables have a significant impact on the functioning of selected local activities in a given location. The analytical model was constructed at the poviat level to investigate, with the greatest possible precision, which factors determine this activity. Thus, a set of 380 observations resulting from the administrative division of the territory of Poland into poviats and cities with poviat rights was used to create nonparametric regression models. For the spatial units elected in this manner, the variables were adjusted in the form of a number of marginal, localized and restricted activities expressed in relative terms, i.e. per 1000 inhabitants. As predictors – explanatory variables – the indicators characterizing a given region were selected due to different characteristics assigned to groups of factors: spatial and environmental, economic, socio-cultural as well as technical and technological, listed in Table 1. The indicators were selected on the basis of the author's subjective evaluation of available local data. Each of the indicators included is justified by the theory of local food systems or refers to the results of pilot studies conducted by the author [Drejerska et al. 2019]. The explanatory variables used are also expressed in relative values so that they characterize individual poviats in the most relative manner that is practicable.

All calculations and visualizations were generated in the R CRAN statistical environment using dplyr, rpart, party, rattle packages. The trees were constructed with two different algorithms. Using the first of these, the CART (classification and regression trees) algorithm, further nodes of the tree were created on the basis of a certain measure of information in order to maximize the intergroup sum of squares for the resulting group divisions [Breiman et al. 1984]. The second, the recursive division algorithm, was based on statistical permutation tests of the independence of explained and explaining variables to determine whether another tree node would be created [Hothorn et al. 2006]. Two types of outlier observations were identified in the models. The first type of outlier observations was identified before the beginning of the process of recurrent division. Outlier observations in the whole set were defined as observations that exceed the value of three estimated (with the use of asymptotically normal estimator) standard deviations of the population above the mean or less than the difference between the mean and the above mentioned deviation value. The decision was made not to remove them from the set due to high resistance of regressive trees to a small number of outlier observations. The sec-

Table 1. Indicators used to build nonparametric regression models
Tabela 1. Wskaźniki użyte do budowy nieparametrycznych modeli regresji

Factors	Indicators	Abbreviated name
Spatial and environmental factors	municipal waste collected selectively in relation to all municipal waste collected during the year	waste
	population density	population
	markets or places in streets and squares for seasonal sale per 1000 people.	markets season
	permanent markets in total per 1000 people	markets permanent
	capital expenditures in enterprises per 1 inhabitant [PLN]	expenditures
	support for local development under the LEADER initiative – support for the implementation of operations under the community-led local development strategy – RDP 2014–2020 commitments, December 31, 2017	leader
Economic factors	registered unemployment rate (the registered unemployment rate was calculated as the ratio of the number of registered unemployed to the number of economically active population)	unemployment
	average monthly gross salary [PLN]	salary
	capital expenditure in enterprises (agriculture, forestry, hunting, fisheries) per 1000 people [PLN]	RLLR expenditures
Socio-cultural factors	feminization rate	feminization
	old age indicator (percentage of people aged 65 and over)	old age
Technical and technological factors	gross fixed assets in enterprises per 1 inhabitant [PLN]	fixed assets
	Tourist accommodation facilities per 1000 inhabitants	accommodation

Source: Local Data Bank 2017, the author's own study.

ond type of outlier observations were outlier observations in subsets, after division into nodes. They were defined as observations exceeding 1.5 IQR (interquartile range) above the third quartile.

Factors determining spatial concentration of marginal, localized and restricted activities

First, a regression tree model was built using the CART algorithm. The operation of this algorithm is based on calculating the "measure of information" for each variable – the higher it is, the more the algorithm will "want" to split the tree in accordance with this variable. The resulting tree is a coherent graph, consisting of a root and branches that form successive nodes (leaves). The entire test sample (i.e. 380 observations) is concentrated at the very top of the graph, i.e. in the root. Depending on the division, the sample elements are moved down the graph through the branches to the node (leaf). The branches are a certain result of a logical condition determining whether a given sample meets the division condition (if yes, you should head left, if not – right).

Figure 2 shows that for the nodes numbered 2 and 3, the predictor discriminating the subsets was the population variable. Sets of 65 observations (node 2) and 315 observations (node 3) were distinguished on this basis. Node 3 was further divided due to the feminization variable, creating node 7, with 7 observations, and node 6, with 308 observations. The feminization variable was also the basis for distinguishing nodes 24 and 25. For the nodes numbered 12 and 13, the predictor discriminating the subsets was the accommodation variable. On the other hand, node 48, with 239 observations, and node 49, with 44 observations were created as a result of a division relative to the unemployment variable. Node 49 was further divided due to the markets permanent variable into nodes 98 and 99.

When analyzing model 1 of the regression tree for MLR activities, the population, i.e. population density, was first indicated as a significant influence on this form of activity. This dependence provides the information that in the areas where the population density is lower, i.e. less than or equal to 553, there are more MLR activities (the value of MLR index, i.e. the number of MLR activities per 1000 inhabitants, is higher). Areas with higher population densities are generally metropolitan areas where service activities are the dominant form of activity. Thus, the resulting dependence seems to be the most appropriate, since marginal, localized and restricted activities involve the processing of animal products and are naturally linked to rural areas with a lower population density. Feminization (node 3), i.e. the coefficient informing about the number of women per 100 men, turned out to be another variable of importance for the functioning of MLR activities. The relationship between MLR and feminization indicators is positive, which means that there is a higher density of MLR activities in strongly feminized areas. On the other hand, only 2% of the examined activities are located (node 7) where there are fewer women per 100 men. The variable showing influence on the location of MLR activities also appeared to be the number of tourist accommodation facilities per 1000 inhabitants of a given poviat (node 6). This dependence is also positive, i.e. the majority of MLR activities are, in relative terms, located in the areas with a higher rate of accommodation facilities, provided that the previous conditions are met. The model also indicated the dependence between the unemployment rate and the MLR indicator. This dependence provides information that in areas with a higher unemployment rate (≥ 5) there is a higher
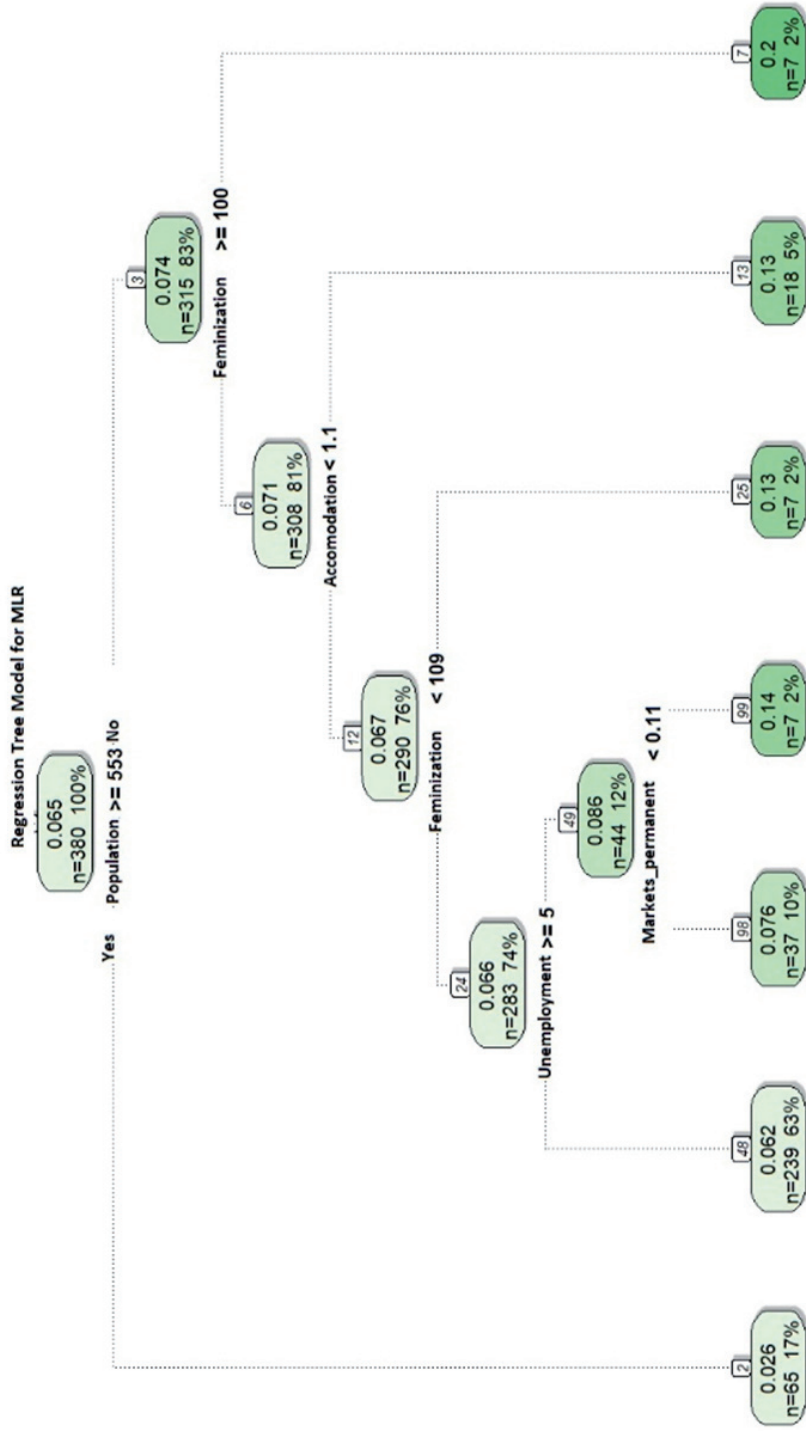
Figure 2. A regression tree model for MLR variable built with CART algorithm

Rysunek 2. Model drzewa regresji dla zmiennej MLR zbudowany przy użyciu algorytmu CART

Source: [Główny Inspektorat Weterynarii 2018] Local Data Bank 2017, the author's own study in R CRAN programme.
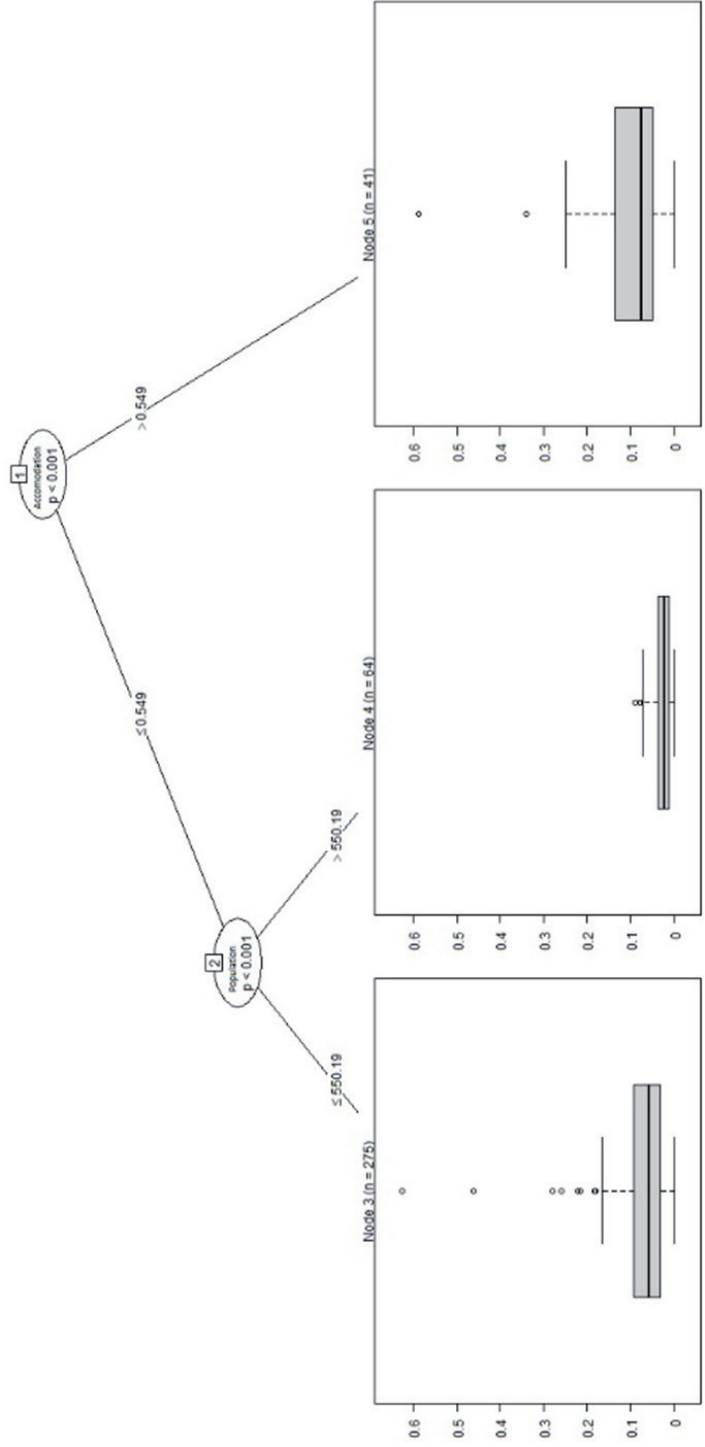
Figure 3. A regression tree model for MLR activities built with ctree algorithm

Rysunek 3. Model drzewa regresji dla działań MLR zbudowany przy użyciu algorytmu ctree

Source: [Główny Inspektorat Weterynarii 2018] Local Data Bank 2017, the author's own study in R CRAN programme

density of MLR activities (node 24), also provided that the previous criteria are met. The reason for such correlation may be the fact that it is an alternative form of activity, giving the opportunity to do business in areas with less industrial potential. The lowest impact strength among the selected indicators was found in the markets permanent index, which informs about the number of permanent marketplaces per 1000 inhabitants of a given poviat. In this case, the dependence proved to be negative, i.e. the relative value of MLR activities (node 49) increases with lower density of permanent markets.

Taking into account Figure 3 obtained with the use of ctree algorithm, only two variables, i.e. accommodation (value of $p = 0.001$) and population, i.e. population density (value of $p = 0.001$) turned out to be statistically significant (assuming the value of $p = 0.10$). In model 2, it can be seen that, for the nodes numbered 2 and 5, the predictor discriminating the subsets was the accommodation variable. Node 2 was further divided due to the population variable, creating node 3, with 275 observations, and node 4, with 64 observations.

As mentioned above, the initial division was made on the basis of the accommodation variable, i.e. the number of tourist accommodation facilities per 1000 inhabitants. In the case when higher density of accommodation facilities is observed the MLR indicator is also higher. It can be concluded that tourists are a potential customer group of MLR activities. In addition, MLR activities are allied with traditions and specific characteristics of various regions. Regions with distinctive traditions are attractive to tourists, hence the positive dependence between these variables seems to be right.

Conclusions

Summing up, as a result of modelling using the rpart algorithm, dependencies were indicated between the explained variable, i.e. the number of MLR activities per 1000 inhabitants of a given poviat, and the variables: population, feminization, accommodation, unemployment, permanent markets. In the case of the ctree algorithm, the accommodation and population variables proved to be statistically significant. The indicator that is most often involved in the process of recurring division is the feminization coefficient. The feminization coefficient was used 32 times during the modelling. The second indicator in terms of the frequency of use in the process of dividing the set was an indicator from the spatial and environmental category, i.e. population density. This indicator was involved 25 times in the process of recurring division of the set. The index with the lowest prediction value was the index of markets or places in streets and squares for seasonal sale per 1000 people, gross value of fixed assets in enterprises per 1 inhabitant and capital investments in enterprises per 1 inhabitant. Summarizing the ranking of prediction importance at a higher level of indicator aggregation, it can be seen that spatial and environmental as well as socio-cultural factors were the most important ones (see Table 2).

The spatial and environmental factors were involved 40 times in the process of recurring division of the set. The socio-cultural factors were used slightly less, i.e. 36 times. On the other hand, the factors that had the smallest share in the division process were technical and technological factors. The specificity of local food systems presupposes a close dependence between the products manufactured and the area where production takes place. This dependence results, among other things, from the legally limited territorial range within

Table 2. The sum of the importance of predictions for individual groups of factors in the model of marginal, localized and restricted activities
Tabela 2. Suma ważności prognoz dla poszczególnych grup czynników w modelu działalności marginalnej, zlokalizowanej i ograniczonej

Factors	Sum of the importance of predictions
Spatial and environmental	40
Socio-cultural	36
Economic	13
Technical and technological	11

Source: the author's own study.

which production and sale may be carried out, but also from the raw materials available in a given area (e.g. Małopolska, production of sheep and goat cheese), traditional and site-specific production methods or, for example, the non-use of preservatives, which makes transport over long distances impossible. Without a doubt, these conditions are of spatial and environmental nature and are key for the concentration of local food system activities. The research carried out as part of this paper allowed for a multi-aspect analysis of the concentration of marginal, localized and restricted activities comprising local food systems. All information obtained may be used to explain the mechanisms of locating activities and may provide developmental guidance to individual regions.

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