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EXPLORING THE FACTORS OF FARMLAND ABANDONMENT – A CASE STUDY OF THE CHOSEN POLISH METROPOLITAN AREAS[1]

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Słowa kluczowe: wyłącznie gruntów z produkcji rolnej, czynniki urbanizacyjne, obszary metropolitalne, Polska

JEL codes: Q15, R23

Abstract. The main aim of this paper was to assess the factors of farmland abandonment in selected metropolitan areas in Poland. The research used secondary research material, including data from the Main Statistical Office (Polish GUS) and academic literature. Analyses were conducted by means of the method of regression trees, among other things. The research found out that nearly 16% of farmland in Polish metropolitan areas had been abandoned. The factor that most affected set-aside was the share of small farms with an area of less than 5 ha of agricultural land. In communes with the majority of small farms, almost 30% of agricultural land was set aside. Entrepreneurship indicator, population density and net migration were also significant in explaining the phenomenon discussed in the paper. High values of these measures correlated with more advanced processes of farmland abandonment.

Introduction

Dynamic changes in the use of farmland in urban and peri-urban areas are a global phenomenon [Mazzocchi et al. 2013]. They mainly involve conversion of farmland for uses connected with the development of cities and their functional zones [Xie et al. 2014]. In Poland, like in other European countries, we observe increasing processes of suburbanisation and population growth in peri-urban areas [Heffner 2016]. This results in a large pressure on agriculture and rural areas, leading to a shrinking area of agricultural land [Piorr et. al. 2007]. While this process is well-explored in academic literature, and typical of most highly-developed countries, in Poland, as well as in some other Eastern and Central European countries, apart from conversion of farmland for uses other than agricultural one, a very clear process of adandoning the cultivation of farmland in urban and peri-urban areas can be observed [Grădinaru et al. 2015].

In Poland in 2010, in urban communes, the share of abandoned agricultural land, i.e. agricultural land not maintained in a good agricultural condition, set-aside land and meadows and pastures not used for production, ranged from 20% in cities with population under 20,000 to 37% in the largest cities [Sroka 2015]. Similarly, in the functional areas of provincial capital cities, the share of land not used for agricultural production was from nearly 15% in gminas directly bordering large cities to 13% in territories located further away from cities.

Academic literature highlights that the reasons for farmland abandonment are multidimensional. Drivers are usually grouped into either natural constraints, socio-economic factors, demographic structure, and the institutional framework [Terres et al. 2015] or socio-economic reasons and reasons related to unadapted agricultural systems, including in particular land fragmentation [Wojewodzic 2017, Satoła et al. 2017]. Studies of peri-urban areas additionally take into consideration the effect of the urbanisation process and related functional transformations

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of peri-urban communes [Mazzocchi et al. 2013], so in this paper special attention was paid to urbanisation factors.

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Research material and methodology

The subject matter scope of the analyses covered abandonment of the farmland located in selected metropolitan areas of Poland. The spatial scope was limited to six metropolitan areas: a large one – Warsaw; medium-sized – Kraków, Tri-City, Wrocław, Poznań, and a small one – Lublin. These areas were also selected based on location, so that they could represent the territory of southern, central, northern, eastern and western Poland. In this way, huge diversity across the different parts of Poland could be factored in, as differences in the level of agriculture development due to historical reasons are visible to this day. The delimitation of the metropolitan areas was based on planning documents (e.g. urban development plans or studies) drawn up in each of the 6 metropolitan cities. The total number of the entities qualified for studies of metropolitan areas was 283 communes, including 6 central cities of metropolises. 3 communes (Hel, Jastarnia and Puck), where the share of agricultural land in the overall area was negligible or there was no farmland, were excluded from the studies.

The main sources of data included results of the national agricultural census conducted in 2010, information available in the Main Statistical Office's Local Data Bank and academic literature. The paper presents results of agricultural censuses, including the seat of an farms, with the research covering the land of individual farms.

General (deductive, reductive reasoning, comparisons) and quantitative methods were used in the paper. Classification and Regression Trees (CART) as one of the most popular methods of regression trees were applied to evaluate factors of farmland abandonment. CART is a binary regression tree algorithm capable of processing continuous or categorical predictor or target variables. It works recursively: data is partitioned into two subsets to make the records in each subset more homogeneous than in the previous subset; the two subsets are then split again until the homogeneity criterion or some other stopping criteria is satisfied [Breiman et. al. 1984]. The process starts at the root node (which encompasses the entire dataset) and ends at the terminal nodes. A C&RT algorithm-based tree searches for a set of logical "if-then" split conditions, which are analogous to the decisions made by farmers while managing their holdings [Gellrich et al. 2008]. In choosing the best splitter, the program seeks to maximize the average "purity" of the two child nodes. For each node, variance is estimated, which is its impurity measure. The aim is for average values in nodes to have the smallest possible variance [Dacko, Szajdecka 2015]. A detailed description of the procedure for building a tree can be found, among other things, in studies by Mariusz Dacko and Katarzyna Szajdecka [2015].

In our work all calculations were performed with the use of STATISTICA 13 software.

Research findings

The starting point in cause and effect research is creation of a concept map, also called a map of variables. The list of variables explaining the differentiation in the percentage of abandoned farmland was compiled based on both theoretical considerations and empirical studies conducted by other authors [Mazzocchi et al. 2013, Wojewodzic 2017]. A broad range of variables, representing location-related, natural, socio-economic and agricultural structure factors were qualified for initial analysis (tab. 1). The share of abandoned farmland (sum of agricultural land not maintained in a good agricultural condition, set-aside land and meadows and pastures not used for production) in the overall area of the agricultural land of individual farms in a given communes in 2010 was treated as the external variable. The presented list of primary data is not exhaustive, but the research material did not allow a larger number of variables to be identified.

The program Statistica 13.0 used in the analysis generated a set of 34 regression trees with a varying degree of complexity, from a tree where all the elements belonged to one leaf, to a tree with very complex branches. One of the methods for selecting the optimal tree is monitoring of cross-validation (CV) costs and resubstitution costs, i.e. assessment of the rate of incorrect classifications in the training set. It allows for a compromise between complexity and accuracy, measured by costs of cross-validation and resubstitution. In accordance with the one deviation principle stating that you should choose the tree of the smallest size whose cross-validation costs differ insignificantly (by one standard deviation) from minimum costs of this validation in a sequence of trees [Dacko, Szajdecka 2015], tree number 30, comprising 7 terminal nodes, was selected for further analysis. With its moderate degree of complexity, it preserved the desired interpretative and predictive capability (relatively low costs of cross-validation).

In the examined communes located in Poland's metropolitan areas, 15.8% of agricultural land was abandoned on average, with large differentiation observed. However, the analysis of the structure of the regression tree that was built shows that one of the most important variables differentiating this percentage was the share of small farms, i.e. those with less than 5 ha of

Table 1. A set of predictors used in the process of modelling
Tabela 1. Predyktory wykorzystane w procesie modelowania

Factors/ *Czynniki*	Variable name/ *Nazwa zmiennej*	Variable definition and the units/ *Definicja zmiennej oraz jednostki*	Range of variation/ size/*zakres zmienności/liczebności*
Location-related/ *Lokalizacyjne*	distance to the metropolis/*dystans do metropoli*	distance from the centre of the commune to the centre of the metropolis's core/*odległość od centrum gminy do centrum rdzenia metropoli [km]**	min. = 0 max. = 79.1
	direct border with the metropolis/ *bezpośrednie sąsiedztwo z metropolią*	including gminas that share the border with the metropolis's core (qualitative variable: yes/ no/core)/*zaliczono gminy, które mają wspólną granicę z rdzeniem metropolii (zmienna jakościowa: tak/nie/rdzeń)*	yes/*tak* – 73 communes/*gminy* no/*nie* – 199 communes/*gminy* core/*rdzeń* – 8 communes/*gmin*
	population density of a commune/ *gęstość zaludnienia gminy*	population density of a commune – average for the period 1995-2010 [person/km^2]/ *gęstość zaludnienia gminy* – średnia *dla okresu 1995-2010 [os./km^2]*	min. =12.3 max. = 4027.4
	commune type/ *typ gminy*	*commune type – as of 2010, qualitative variable (urban commune – 1, rural commune – 2, urban-rural commune – 3)/*typ gminy – stan na 2010 rok, zmienna jakościowa (gmina miejska – 1, gmina wiejska – 2, gmina miejsko-wiejska – 3)	urban commune/ *gmina miejska* – 44, rural commune/*gmina wiejska* – 161, urban-rural commune/ *gmina miejsko-wiejska* – 75
Natural/ *Naturalne*	agricultural production space valuation ratio – APSVR/*wskaźnik waloryzacji rolniczej przestrzeni produkcyjnej – WWRPP*	agricultural production space valuation ratio [point]/*wskaźnik waloryzacji rolniczej przestrzeni produkcyjnej [pkt]*	min. = 36.2 max. = 108.6
	protected areas/ *obszary chronione*	share of protected areas in the area of communes (average for 1996-2010)/*udział obszarów chronionych w powierzchni gmin (*średnia *1996-2010) [%]*	min. = 0 max.= 72.9

Tabela. 1. Cd/*Table 1. Cont.*

Factors/ *Czynniki*	Variable name/ *Nazwa zmiennej*	Variable definition and the units/ *Definicja zmiennej oraz jednostki*	Range of variation/ size/*Zakres zmienności/liczebności*
Socio-economic/ *Społeczno-gospodarcze*	unemployment rate/*stopa bezrobocia*	share of registered unemployed people in the working age population – average for 2003-2010/ *udział bezrobotnych zarejestrowanych w liczbie ludności w wieku produkcyjnym* – średnia *2003-2010 [%]*	min. = 2.5 max. = 19.2
	large enterprises/ *duże przedsiębiorstwa*	economic entities employing over 50 people per 10,000 working age people – average for 2002-2010 [entities/10,000 people]/ *podmioty gospodarcze zatrudniające powyżej 50 osób w przeliczeniu na 10 tys. osób w wieku produkcyjnym – średnia dla okresu 2002-2010 (podmioty/10 tys. osób)*	min. = 0 max. = 47.4
	entrepreneurship/ *przedsiębiorczość*	economic entities per 10,000 working age people – average for 2002-2010 [entities/10,000 people]/ *podmioty gospodarcze w przeliczeniu na 10 tys. osób w wieku produkcyjnym – średnia dla okresu 2002-2010 [podmioty/10 tys. osób)*	min. = 631.9 max. = 5475.4
	net migration/ *saldo migracji*	internal net migration per 1000 people – average for 2003-2010/*saldo migracji wewnętrznych na 1000 ludności –średnia dla okresu 2003-2010 [%]*	min. = -8.8 max. = 37.3
	commuting to work/*dojazdy do pracy*	number of people coming in to work per 1 person going out to work – (2006)/*liczba osób przyjeżdżających do pracy przypadająca na 1 osobę wyjeżdżającą do pracy – 2006 rok*	min. = 0.05 max. = 13.7
Agriculture structure/ *Struktura rolnictwa*	share of small farms/ *udział małych gospodarstw rolnych*	share of farms with an area less than 5 ha in the overall number of farms (average for 1996, 2002 and 2010)/ *udział gospodarstw o powierzchni poniżej 5 ha w ogólnej liczbie gospodarstw (średnia z lat 1996, 2002 oraz 2010) [%]*	min. = 15.7 max. = 98.8
	share of economically strong farms/*udział gospodarstw silnych ekonomicznie*	share of farms with an economic size above 15,000 EUR SO – 2010/*odsetek gospodarstw rolnych o wielkości ekonomicznej powyżej 15 tys. euro SO – 2010 rok [%]*	min. = 0.0 max. = 59.5

* distance according to google maps assuming that the shortest route by car is set/o*dległość według map google przy ustawieniach najkrótszej trasy przejazdu samochodem*
Source: own elaboration
Źródło: opracowanie własne

agricultural land. In communes where over 71.3% of farms had an area less than 5 ha, as much as 29.1% of agricultural land was abandoned on average (node ID = 3). For comparison, in the second group of communes (ID = 2), i.e. in which small farms accounted for over 71.3%, only around 9.4% of agricultural land was not used agriculturally.

Observing further splits, starting from the left-side of the tree, we can see that the percentage of the abandoned land was differentiated by the Agricultural Production Space Valuation Ratio (APSVR – Agricultural Production Space Valuation Ratio). In the first group of communes, i.e. in communes where the share of small farms was less than 71.3% and APSVR > 62.1 point (ID = 5), the abandoned land accounted for only 6.5%. With the same assumptions regarding the

share of small farms, but in communes with worse natural conditions of agricultural production (ID = 4), over twice as much land was set aside (15.4% of agricultural land).

Further splits of the tree show that socio-economic (urbanisation) variables also differentiated the percentage of the abandoned land. In communes where the share of farms with an area less than 5 ha was below 71.3%, the Agricultural Production Space Valuation Ratio was lower than 62 points, and the net migration was above 11.4 person/1000 residents, 20.4% of agricultural land was abandoned on average (ID = 9). With the same structure of farms and APSVR, but the net migration below 11.4 person/1000 residents, only 13.8% of abandoned farmland was recorded (ID = 8). When analysing a group of communes with a relatively low land fragmentation but better environmental conditions for agricultural production (ID = 5), we see that the percentage of abandoned farmland was differentiated by population density. In communes where the number of people per 1 km^2 is higher than 206, on average around 13.1% of agricultural land was not used for agricultural purposes (ID = 11). In turn, in communes where population density was lower, the percentage of abandoned farmland was 5.6% (ID = 10).

Proceeding to analysis of communes with the majority of small farms (the share of which in the entire examined group of individual farms was over 71.3%), we see that the percentage of the abandoned farmland was mainly determined by entrepreneurship indicator. In communes where two conditions were met at the same time, i.e. the share of small farms was over 71.3% and the number of enterprises registered with the National Business Register (Polish REGON) was lower than 1342 entities per 1000 working age people, 22.5% of farmland was abandoned (ID = 6). In turn, in the group of communes which were also characterised by significant agricultural fragmentation but where the number of enterprises per 1000 working age

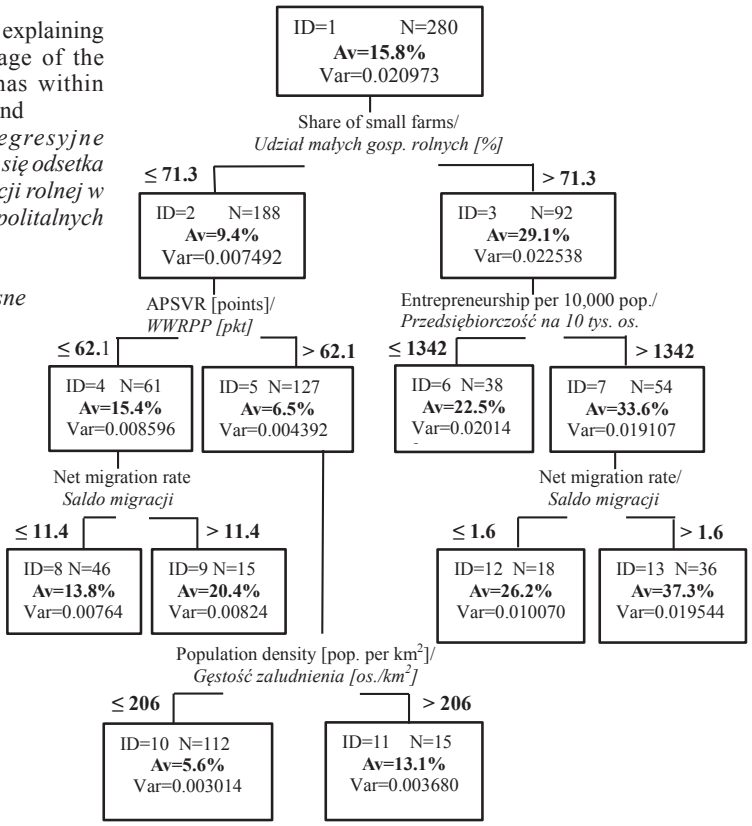

Figure 1. Regression tree explaining the level of the percentage of the abandoned land in gminas within metropolitan areas in Poland
Rysunek 1. Drzewo regresyjne objaśniające kształtowanie się odsetka ziemi wyłączonej z produkcji rolnej w gminach obszarów metropolitalnych w Polsce
Source: own elaboration
Źródło: opracowanie własne

people exceeded 1342, 33.6% of agricultural land was abandoned on average (ID = 7). Further, it should be noted that apart from the entrepreneurship indicator, the high percentage of the abandoned land was also impacted by the net migration. In communes where the net migration was above 1.6 person/1000 residents (following the previous assumptions), as much as 37% of farmland was abandoned (ID = 13), whereas in the second group of communes (net migration ≥ 1.6 person/1000 residents), the figure was 26.2% (ID = 12).

The regression trees method also enables the assessment of the significance of the different predictors of the dependent variable. It can be used to identify and rank several most important variables (fig. 2). The results show that the variable that best explains the differentiation of the share of the abandoned farmland was the share of small farms. Of relatively significant importance in explaining the phenomenon under investigation was also the share of economically strong farms, entrepreneurship indicator, population density, agricultural production space valuation ratio and net migration.

The other variables, including in particular those referring to the location of commune relative to the urban centre (metropolis), turned out to be of little significance for explaining the percentage of the abandoned farmland.

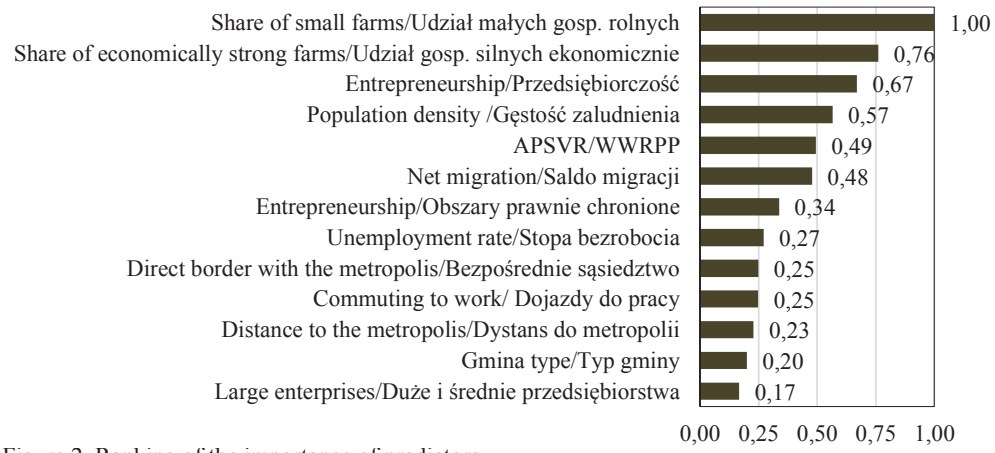

Figure 2. Ranking of the importance of predictors
Rysunek 2. Ranking ważności zmiennych
Źródło: opracowanie własne
Source: own elaboration

Discussion

The analyses showed that the metropolitan areas examined varied very significantly in terms of farmland abandonment. The clearly most important factor differentiating the scale of this phenomenon was the share of small entities in the overall number of farms. In communes where over 70% of farms had an area less than 5 ha, the percentage of the abandoned farmland reached almost 30%. These results are in line with the analyses conducted by Tomasz Wojewodzic [2017] and Pointereau [2008], who stress that a small area of an farm does not allow satisfactory incomes to be achieved, which is the reason why farmland is not used. The transfer of land to other agricultural units, as pointed out by Łukasz Satoła and others [2017], is limited due to relatively high costs of exiting agriculture and speculations of landowners, who expect large increase in land prices. A landowner is also not interested in leasing out the land to another farmer, as a small area of land means low income, and signing a lease agreement entails some limitations to the land use, including its sale should an unexpected and attractive offer appear. Analysing deagrarianisation processes, Tomasz Wojewodzic [2017] also highlights huge importance of the factor that illustrates the quality of agricultural space. This was also reflected in the studies conducted, as APSVR played an important role in farmland abandonment,

second only to the enterpreneurship indicator and population density. The studies found out that in metropolitan areas, especially in communes with large fragmentation, even high quality of environmental conditions and the resulting benefit of differential rent I were less important than social-economic (urban) factors. In communes with a large number of enterprises, which provided more opportunites to find an attractive job other than in agriculture, farmers more often decided to abandon farmland. The impact of an attractive (urban) labour market on the processes of disappearing of farms was noticed by Andres Wästfelt and Qian Zhang [2012], and Bernd Pölling [2016], among others, who stress that part-time farmers and owners of small farms are particularly eager to resign from agricultural production.

The research also showed that processes of farmland abandonment were more significant in areas with a relatively high net migration and communes with higher population density. These were predominantly communes undergoing sub-urbanisation processes, usually located relatively close to the core of the metropolitan area as well as local or regional government units where the relation of people coming to work to those going away to work was in favour of the latter. With such communes, of huge importance was also an attractive big-city labour market. In this context, it is a little surprising that such variables as the distance from the centre of the metropolis and sharing the border with the metropolis were not very significant in explaining the percentage of the abandoned farmland. However, this is connected with the different size of individual metropolises and the strength of their attraction. In the case of Warsaw metropolitan area, even in communes located 40 km away from the city centre (i.e. not bordering the metropolis), sub-urbanisation processes were very significant, whereas communes located 40 km away from the centre of Lublin were much less impacted by the city. That's why these variables turned out to be of little significance.

Conclusions

The research encompassed the six chosen metropolitan areas in Poland. Analyses were concerned with factors of diversity of land abandonment scale in the areas with ongoing urbanization processes. The research found out that nearly 16% of farmland in Polish metropolitan areas had been abandoned. The described process was more intense than on average in Poland. In the researched areas there was a strong diversification, which was mainly the result of the influence of social-economic factors and agricultural structure. The factor that most affected set-aside was the share of small farms with an area of less than 5 ha of agricultural land. In communes with the majority of small farms, almost 30% of agricultural land was set aside. Entrepreneurship indicator, population density and net migration were also significant in explaining the process of land abandonment. High values of those measures correlated with more advanced processes of farmland abandonment. The studies found out that in metropolitan areas, especially in communes with large fragmentation, even the high quality of the soil and the resulting benefit of differential rent were less important than social-economic (urban) factors.

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Streszczenie

Głównym celem opracowania była ocena czynników wyłączania gruntów z produkcji rolnej w wybranych obszarach metropolitalnych w Polsce. W badaniach wykorzystano wtórny materiał badawczy, w tym dane GUS oraz literaturę przedmiotu. Analizy prowadzono z wykorzystaniem metody drzew regresyjnych. Badania wykazały, że w polskich obszarach metropolitalnych prawie 16% gruntów rolnych nie było wykorzystywanych produkcyjnie. Czynnikiem, który w największym stopniu różnicował odłogowanie gruntów był udział gospodarstw rolnych o powierzchni poniżej 5 ha UR. W gminach, w których dominowały małe gospodarstwa rolne odłogowano prawie 30% gruntów. Duże znacznie w wyjaśnianiu opisywanego zjawiska odegrały również wskaźnik przedsiębiorczości, gęstość zaludnienia oraz saldo migracji. Wysokie wartości wymienionych mierników przedkładały się na wyższe zaawansowanie procesów wyłączania gruntów z produkcji rolnej.

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