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Local Added Value of the Geothermal Resources: Evidence from Poland

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ABSTRACT

Among the renewable energy resources geothermal is specific to a local production and consumption. Next to the heat and energy production, geothermal energy presents opportunities for rural and suburban areas linking sustainable development goals with expansion of new local economy sectors. Therefore, we assume that the local utilization of geothermal resources delivers a local added value other than energy generation. Moreover, a change in a municipality economic structure is established when geothermal activities are introduced. The aim of this research is to fill in gaps in the literature and to find an empirical link between the local use of geothermal and changes in the economy of the municipalities using this resource. We conduct an added value analysis for the five cases of the geothermal development in Poland, comparing their economic structure with the reference of poviat and voivodeships as a control group in 2005 and 2018. We chose municipalities with a cross-sector use of the geothermal resources in their economies and with different maturity of utilization. A shift share analysis of the local employment economic categories reveals a significant shift in e.g. service sector employment in these geothermal localities. The hypothesis that the geothermal municipalities perform economically better than the poviat results corroborated**.**

1. INTRODCUTION AND RESEARCH PROBLEM

The main factors determining the development of Renewable Energy Sources (RES) in Polish Municipalities, includes, the Local Government Act of 2010 was implemented, as a result, municipalities are tasked with determining energy supply of individual and collective consumers. Local governments become responsible for planning and organizing the supply of heat, electricity and gas fuels bearing in mind the requirements of sustainable development and replacement of conventional fuels with the available RES. Indirect tasks for the municipality, which are determined by the amendment of the energy law, include recognizing the possibility of engaging available renewable energy sources in its strategic development plans. Therefore, the local energy management is to be based on the development of available renewable resources in accordance with the interests and needs of the local community.

In addition, the requirements of the low-emission economy and the limitations of coal-fired heating plants constitute another argument for the development of locally available renewable energy, including the geothermal one. The new Renewable Energy Directive, called the RED II (EU 2018/2001), adopted in 2018, exceeds the obligation to generate energy using renewables, production, heating and cooling and transportation in the European Union up to 30% by the year 2030 (Council, 2018). It prioritizes the use of locally available renewable resources. Special attention in the document is given to highlighting the concept of *renewable community energy*. The articles no. 46, 63 and 65 of the directives in particular discusses geothermal energy as a potential for the benefits of a local economy and population, if geological conditions allow.

Heinbach et al. (2014) argue that a diffuse energy model, i.e. the generation of energy from locally available renewables sources by small generating units delivers locally added value and it is can therefore be an economic driver for weaker or rural regions. The concept of added value refers to an increase in the value of goods as a result of the production process. Therefore, a geothermal municipality is defined as a locality where it is possible to obtain added value from the use of geothermal resources. The added value does not solely occur from the existence of the resource. It is also in the public interest to compensate for the expenditures incurred to start geothermal operations in the form of taxes or fees originating from socio-economic activities caused by the use of geothermal resources.

Due to the endogenous nature of the geothermal resource (Chakravorty et.al., 1997) it is best utilized in the place of development. Moreover, the sustainable character of the resource encourages into further than local energy provision (Fridleifsson, 1998; Konak & Pamukcu, 2006; Kunkel et.al, 2012; Tomaszewska & Szczepański, 2014).

This research aims to answer the question if the use of geothermal resources contributes to a change in the local economic structure. The local economic structure is here defined as the development of the geothermal municipalities in terms of an increased local employment and market specialization. We follow the approach of Almeida (2007) and Glaeser et al. (1992) that determine the local economic structure by the changes in employment. A developing region or a locality attracts more employment and opening of new markets. It leads to new specializations and by so restructures the sectors of local economy long term. In our assumption local

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economic structure measured in the categorized employment change allows to observe a shift from the core economy sectors into the services sector. This assumed change is referred to the local added value concept and references of renewable resources impact on the local economy development are found in work of for instance Del Rio & Burguillo (2009), Heinbach et al. (2014), P. D. Lund, (2009). Forms of geothermal water application in the recreational and health facilities are particularly found to contribute to the alleviation of the local budgets, augmented employment and new local market specialization e.g. in tourism (Dej et al., 2013).

Nevertheless, the concept of the geothermal local added value is underrepresented in the existing literature. Hence, our study is to analyze a selection of the geothermal municipalities in Poland and attempt to determine if the geothermal added value can be found in there. We define the geothermal added value as a change causing phenomenon in the structure of the local economy. With a relatively long time of development of the renewable, we expect to observe a growth in the selected sectors of local employment. The versality of our proposed approach allows conducting such analysis for any geothermal resources exploiting localities in the world.

2. RESEARCH FRAMEWORK AND DATA COLLECTION

We base our concept on the endogenous nature of the geothermal resource and the large potential of its direct development according to the *Lindal diagram* (Gudmundsson, 1988). Various scholars underline the impact of the geothermal resources development for a local economy (Barbier, 2002; Canan, 1986; Dickson & Fanelli, 2013; Fridleifsson, 2001; J. W. Lund & Boyd, 2016; J. W. Lund, Freeston, & Boyd, 2011) and for the environment (Fridleifsson et al., 2008; Kristmannsdóttir & Ármannsson, 2003).

In case of Poland, the geothermal resource is under 80% of the country's earth crust, one of the highest capacity in Europe and 40% of this potential is technically ready to deliver and economically attractive geothermal argue Kepinska (2003) and Górecki et al. (2012). Moreover, Poland is capable of producing 625.000 PJ of geothermal energy, whereas, annual energy consumption is circa 5500 PJ (Ney, 1997 and Huculak, Jarczewski, & Dej, 2015). According to Skjærseth (2014) and Szulecki et al. (2016) increased geothermal production creates a degree of energy independence from the conventional resources and imports. Jarczewski et al. (2015) discuss that in case of Poland, the optimal conditions for the geothermal development are found in locations that are at the source of the renewable geothermal energy or in close vicinity, in relatively small-mid size municipalities with a dense housing and infrastructure network. It provides them with geothermal related opportunities such as a local energy source, jobs creation, economic savings, and increased entrepreneurship. Yet, despite the resource potential in Poland, currently geothermal use is limited to local district heating and recreational/ bathing centers (Halaj, 2015; Sowizdzal, 2018). The associated added value from geothermal investment and operations in Poland are mostly felt in the same area as the municipality. Hence, we formulate the hypothesis that the availability of geothermal resources provides economic savings development in the municipalities in comparison to the area of poviat. Poviat is the second degree of local government and administrative area of Poland, equal to the NUTS 4 geographical nomenclature. We assume a shift in the employment structure towards the service sector in geothermal municipalities' economies in comparison to poviats. To validate this assumption two approaches are taken, the comparative analysis of the geothermal municipalities and poviats and the comparative analysis of these poviats and the superior administrative units i.e. the voivodeships. Such structured comparison determines if the geothermal resources utilization is the sought element of changes in the local employment composition.

Following Figure 1 displays the geothermal resources activities in Poland. Although, there are 54 economically viable geothermal boreholes, the actual geothermal development is much lower that the country potential (Felter et al., 2015). The resource is used in the municipalities that have decided to invest in geothermal installations, which represents less than a quarter of geothermal capacity.

Figure 1: Geothermal resources development map in Poland (Sowizdzal, 2018).

Since our study aims to answer the question about the impact of geothermal resources on the local economy we focus on a selected group of five municipalities with geothermal developed. We run a case study comparative analysis based on the observation of the local economy employment sectors that capture the added value. The following municipalities in the Table 1 are examined according to the assumption of our study. They use the geothermal resources in various forms and in a different time frame. Two municipalities i.e. Szaflary and Bukowina Tatrzańska established two geothermal recreational centers. However, in Bukowina Tatrzańska geothermal waters supply to only the recreational and health centers without yet developing a geothermal heating plant. Opposite to Stargard, where the resource is used mainly for heating and communal purposes without applications in other services. These municipalities selected due to the inclusions of the geothermal resource development in strategic plans of development.

Table 1: Geothermal activities in the selected municipalities in Poland (source: own elaboration based on http://pgi.gov.pl).

	Municipality	*Geothermal enterprise*	*Installation year*	*Recreational center*	*Additional use*
1	Mszczonów	Geotermia Mazowiecka SA	2000	2008	a,b
2	Uniejów	Geotermia Uniejów LLC	2001	2008	a,b,c,d
3	Szaflary	Geotermia Podhalańska S.A.	1993	2007 (1^{st}) and 2015 (2^{nd})	a,c,d
4	Bukowina Tatrzańska	Bukowina Geothermal Society LLC	2008	2008 (1^{st}) and 2011(2^{nd})	c
5	Stargard	G-TERM Energy LLC	2005	*n.a.*	c

a- Application in public utilities, communal use
b- Commercial activities (e.g. food production)
c- Heat pumps
d- Balneotherapy

Studies by Kurek (2016) about the development of geothermal municipalities in Poland, shows that resource utilization is correlated with the categories of a local development including local economy, public finance and tourism. In this study, we aim to find out if the selected municipalities observe changes in the local economy while they develop the geothermal resources. For this purpose, we examine the local employment in years 2005 and 2018. It results in a comparative analysis of the two time periods and allows for conclusions of an assumed change of local economy measured in employment within the tested 13 years. The analysis is conducted from the year 2005 regardless of the fact that geothermal energy was used prior to. The choice of this time frame is justified by the data coherency needed for this comparative research. Due to methodological changes in 2004 regarding the collection of the economic sectors employed in Poland we are limited to the coherent data availability from the year 2005 onwards.

As discussed, the geothermal development and associated added value can be categorized as a positive change in the local economy structure. Therefore, we seek for a significant change in the structure of local employment, mostly for the shift from the traditional economic sectors to the ones representing trade and services. Based in the presented literature, we assume that the change in employed is enhanced by the geothermal development opportunities that arose. Forms of local utilization the geothermal resources can induce the new employment opportunities. Therefore, the analysis of the local economy structure bases in the indicator of the *NACE sections of economic activities*. Comparison of this data reflects on a change in the population employed in the NACE sections. NACE classification corresponds with the *Statistical Classification of Economic Activities in the European Community*[2] and it is the set of types of socio-economic activities, systemized in sections A-U that are carried out by economic entities. In Poland, the NACE refers to the Polish Classification of Activities (PKD). The NACE classification illustrates the specialization and the dynamics of economy. The expected change in the employed population by the NACE section indicates a structural change in the local economy, which we relate with the expansion of the geothermal resources use. Moreover, the shift in the NACE sections employment is related to the possibilities of local use of the geothermal resources according to the beforementioned geothermal Lindal diagram. It is as well a non-monetary indicator therefore inflation weights are not required and observations base in the unprocessed data.

As a comparative analysis the *shift-share* method is to be used. It is a comparative method dedicated to the regional analysis. In essence, the shift-share analysis explains why regional economic conditions may differ from national level trends. We adopt this approach to our research problem to the level of the administrative areas of the geothermal municipalities, poviats and voivodeships. The data for the comparative analysis is sourced from the Local Data Bank[3] of the Central Statistical Office at the level of NUTS 2, 4 and 5[4] in the years 2005 and 2018.

[2] https://ec.europa.eu/eurostat/statistics-explained/index.php/Glossary:Statistical_classification_of_economic_activities_in_the_European_Community_(NACE)
[3] https://bdl.stat.gov.pl/BDLS
[4] NUTS is the Eurostat's Nomenclature of Territorial Units for Statistics. In Poland, NUTS levels 2, 4 and 5 correspond with voivodeship, poviats and municipalities administrative units respectively.

With regards to the NACE sections employed population in the Local Data Banks database the data is merged into five groups:

1. agriculture, forestry, hunting and fishing (section A),
2. industry and construction (sections B,C,D,E,F),
3. trade; repair of motor vehicles, transport and storage, accommodation and gastronomy, information and communication (sections G,H,I,J),
4. financial and insurance activities, real estate market services (sections K,L),
5. other activities (sections M,N,O,P,Q,R,S,T,U).

Moreover, the restrictions of the NACE data collection of the Central Statistical Office limit the information to the enterprises employing more than 9 persons and budgetary units regardless of the number of employees. Therefore, the conclusions for the NACE sections employed will concern the dynamics of a local labor market without individual enterprises. The data on the municipality level NUTS 5 is not fully available in the online database therefore, it was ordered and prepared by the Communication and Education Department of the Central Statistical Office in Warsaw, Poland. The dataset used in this research is presented in the Annex.

3. RESEARCH METHOD

In most of the shift-share analysis, the regional economy is compared to the national economy. However, this technique is used to compare any two regions or areas. In case of our study, as discussed, we compare the municipality to the poviat, in which it is located and consequently these poviats to the voivodeships where located. Hence, we conduct two shift-share analysis, first the NUTS 5 and NUTS 4 areas, second the NUTS 4 and NUTS 2 areas. Such reference allows for examining if the geothermal resources utilization in a municipality is a significant factor of the local economy structure change in the examined NACE categories. This spatial approach allows to assess the impact of the use of geothermal resources in the municipalities on the evolution of the dynamics this economic variable in relation to the neighboring location. Hence, the introduced poviats and voivodeships constitute the control group. Table 2 depicts the subject of the shift-share analysis i.e. the geothermal municipalities, poviats and voivodeships. Nowotarski and Tatrzański poviat are in the same Małopolskie voivodeship. Number of inhabitants is shown for a population size reference.

Table 2: Geothermal municipalities, poviats and voivodeships used in the comparative analysis (number of inhabitants in thousands in year 2018, source: https://bdl.stat.gov.pl)

	voivodeship	poviat	municipality
1	Mazowieckie (5.403.412)	Żyrardowski (75.848)	Mszczonów (11.554)
2	Łódzkie (2.466.322)	Poddębicki (41.205)	Uniejów (7.004)
3	Zachodniopomorskie (1.701.030)	Stargardzki (120.091)	Stargard (68.195)
4	Małopolskie (3.400.577)	Nowotarski (191.508)	Szaflary (11.054)
5		Tatrzański (68.146)	Bukowina Tatrzańska (13.351)

Shift-share analysis is a quantitative method used in the economic analysis of regional studies dedicated to the employment economic factor. It allows for descriptive examination of structural changes that are assumed to occur within a country, region or locality (Dunn, 1960). It helps to answer the question about the growth or decline of employment in the economic sectors. The main objective of the share-shift technique is the quantification of geographical changes by decomposing growth rates in structural and competitive components. The shift-share analysis developed in the 1960s has matured into numerous extensions (Knudsen, 2000). In the case of local approach, this method helps as well to determine if a component contributes to the local economy or impacts local competitiveness. It is done by a retrospective decomposition of variations in the selected local economic indicators. Furthermore, throughout the descriptive analysis the structural change is compared within another referenced geographic (or administrative) area. In this way, we can observe regional differences or assign a structural change to a particular economic sector (or activity). Shift-share analysis is therefore popularized for explaining regional factors of growth (Adao et al. , 2018; Bartholomew & Peck, 1989; Kurre & Weller, 1989; Márquez et al., 2009). Esteban (2000) applies the shift-share analysis to investigate the regional convergence and regional specification of an added value.

We adopt Esteban's (2000) three factor decomposition of the shift-share method i.e. structural, differential and allocative component. Since we look into a local analysis the national effect is omitted and we label the components as *actual shift* (allocative component), *differential shift* (differential component) and *proportional shift* (structural component). Traistaru & Wolff (2002) provide detailed explanation of the shift-share components framework. Actual shift measures a covariance of the differential and proportional shifts, and it indicates where a structural change of the examined components takes place. It explains how much economic growth in a location can be attributed to overall growth rates in the regional economy. The differential shift corresponds with any local specific factors that enabled the structural change in the local economy; a part of a local growth that is attributed to the specific local circumstances. In our assumption the geothermal resources development in the municipalities is responsible for the differential shift in the examined economic indicator. The proportionality shift explains the size of a structural economic change between the compared units. This shift indicates if the growing economy sectors are represented the analyzed data. It derives from the local specialization and usually points to growth share of the competitive sectors of a local economy. Following formulas of the shift-share analysis provide the (1) actual, (2) differential and (3) proportional shift scores.

$$S_a = \sum_{i=1}^{n} W_{ijt} - \frac{W_t}{W_0} \sum_{i=0}^{n} W_{ij0} \quad (1)$$

$$S_d = \sum_{i=1}^{n} (W_{ijt} - \frac{W_{it}}{W_{i0}} W_{ijo}) \quad (2)$$

$$S_p = S_a - S_d \quad (3), \text{ where}$$

W_{ij0}: the variable *i* in municipality *j* or poviat *j* or voivodeship *j* in year *0* (starting year)

W_{ijt} *:* the variable i in municipality j or poviat j or voivodeship j in year t (final year)

$W_t : \Sigma W_{it}$, $W_0 = \Sigma W_{i0}$

Heijman & Schipper (2010) suggest using the relative shifts for a better comparison of the examined regions or areas. They are obtained by dividing each shift (actual, differential and proportional) score by the total value of observed in year 0. In our case, a sum of each economic indicators. The relative shifts are addressed as follow:

Relative actual shift: $RS_a = \frac{S_a}{\sum W_{ij0}}$ (4)

Relative differential shift: $RS_d = \frac{S_d}{\sum W_{ij0}}$ (5)

Relative proportional shift: $RS_p = \frac{S_p}{\sum W_{ij0}}$ (6)

Hence, we adjust our primary hypothesis to the shift-share analysis concept that the differential shift results positive in the examined geothermal municipalities, but it is negative in compared poviats. The shift-share method requires time reference, and, in our case, we compare the five NACE sections of employment between the year 2005 and 2018. This relatively long-time frame allows to validate the observations and the geothermal energy developments are assumed to mature and generate impact locally. Computations of the presented relative shifts formulas 4, 5 and 6 result in a single shift score for each of the examined geothermal municipality in reference to the poviat. The same procedure is conducted for the poviat and voivodeship. If the value of the relative actual shift (Sa) is positive, the employment in the geothermal municipality NACE sectors is assumed to grow faster than in the poviat. A positive score of the relative differential shift (Sd) indicates a specific local condition that causes the increase in the employment, in our case it is the assumed geothermal resources use in the municipality. Whereas, a positive relative proportional shift (Sp) shows a relative dynamic of the examined indicator, here the employment. Similar approach refers to the analysis between poviats and voivodeships. Since this is the control group we aim to test if the analysis results repeat in the cases of poviats and voivodeships allowing to accept or reject the hypothesis.

4. RESEARCH RESULTS AND ANALYSIS

Table 4 presents the pairs in which the shift-share analysis of the NACE sectoral employment is conducted according to the formulas 4, 5 and 6.

Table 3: Subject of shift-share analysis in the comparative pairs (source: own elaboration).

municipality	poviat
Mszczonów	Żyrardowski
Uniejów	Poddębicki
Stargard	Stargardzki
Szaflary	Nowotarski
Bukowina Tatrzańska	Tatrzański

poviat	voivodeship
Żyrardowski	Mazowieckie
Poddębicki	Łódzkie
Stargardzki	Zachodniopomorskie
Nowotarski	Małopolskie
Tatrzański	Małopolskie

The scores enclosed in the Table 5 and Table 6 indicate the results of the shift-share analysis conducted for the municipalities, poviats and voivodeships from the Table 4. The relative actual (Sa), differential (Sd) and proportional (Sp) shifts represent the dynamic of the NACE sectors employed population indicator.

Table 4: Results of shift-share analysis for the examined geothermal municipality in relation to poviat between 2005 and 2018 (source: own elaboration).

NACE sections employed, municipality and poviat	relative Sa	relative Sd	relative Sp
Mszczonów	0,121661	0,114030	0,007632
Uniejów	0,959415	0,811944	0,147471
Stargard	0,096298	0,040019	0,056279
Szaflary	0,149237	0,582804	-0,433570
Bukowina Tatrzańska	0,978451	1,208524	-0,230070

Table 5: Results of shift-share analysis for the examined poviat in relation to voivodeship between 2005 and 2018 (source: own elaboration).

NACE sections employed, poviat and voivodeship	relative Sa	relative Sd	relative Sp
Żyrardowski poviat	-0,156580	-0,140305	-0,016274
Poddębicki poviat	-0,148336	-0,039180	-0,109156
Stargardzki poviat	0,059804	0,056850	0,002954
Nowotarski poviat	-0,094082	-0,125637	0,031554
Tatrzański poviat	-0,094082	-0,125637	0,031554

Results of the shift-share analysis indicate that the geothermal municipalities outperform the poviats in the appointed economic indicator in the examined years. Therefore, the employment grows faster in the geothermal municipalities than in poviats. The results of the relative differential shift point to the scale of the shift in the NACE employment sectors between the municipality and poviat related to the geothermal resources development. Interpretation of the poviats and voivodeships analysis points to the opposite trend. Voivodeships outperform poviats in the tempo of the employment growth between years 2005 and 2018. The following Figures 2 and 3 illustrate the scores of the relative shifts summarized in the Tables 5 and 6.

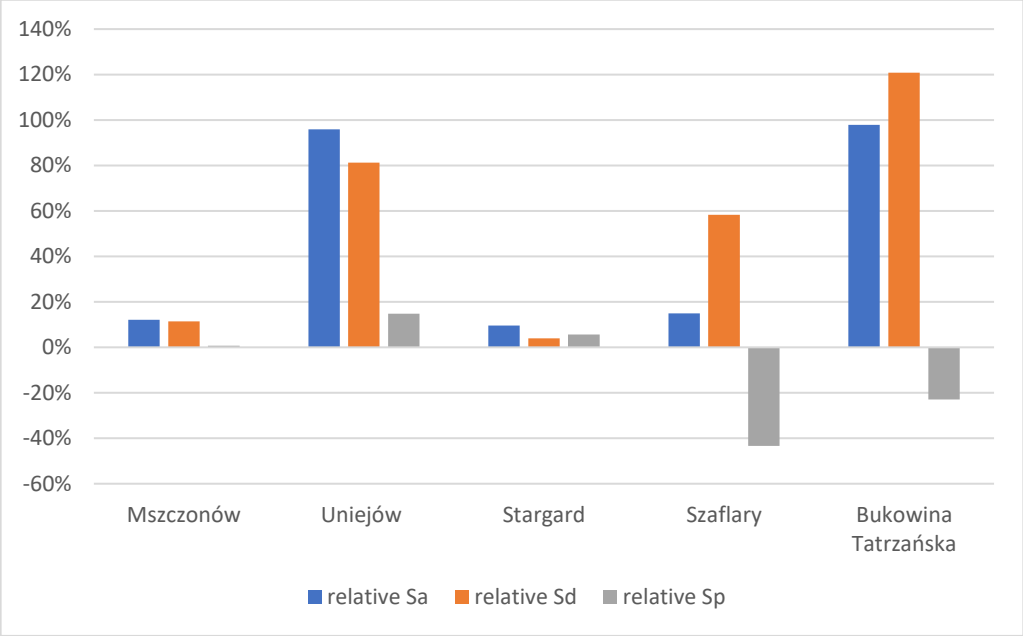

Figure 2: Illustration of the relative shifts in the geothermal municipalities in years 2005-2018 (source: own elaboration).

The relative actual shifts are a sum of the relative differential and proportional shift. Therefore, the economic structure is a sum of economic factors that are generated to stimulate the economy and the ability of a place to adopt to economic challenges. In all of the examined municipalities the relative actual and differential shift results are positive. It indicates that the growth of the employment according to the NACE sections is faster than in the referenced poviat and moreover, there is an internal factor that stimulates the employment growth. Both scores are very high in case of Uniejów and Bukowina Tarzańska. These municipalities doubled the employment within the observed 2005 and 2018. The size of the relative differential shift indicates that there is a very strong force that stimulates the local economy. In case of Szaflary, the same trend is observed but with a lower relative actual shift. Therefore, in this municipality the general growth is less attributed to the regional economy still, this growth is related to positive circumstances that appeared between 2005 and 2018. The growth of Mszczonów is moderate, but positive. The significant results of the relative differential shifts in each of the cases indicate a strong role of a factor or a positive circumstance that took place in the municipality and stimulated the increase in employment sectors. In Uniejów, Szaflary, Bukowina Tatrzańska and Mszczonów we can relate this phenomenon to the geothermal resource utilization mostly in form of the establishment of geothermal recreational parks and health centers. These establishments enable related economic sectors of tourism, real estate and services of all kind. The relative proportional shift has a positive value in case of Mszczonów, Uniejów and Stargard. It is interpreted as the growing employment sectors are represented in these local economies. Municipalities of Szaflary and Bukowina Tatrzańska score a negative relative proportional shift therefore, fast growing economic sectors of the region are underrepresented in these municipalities. However, these municipalities have their own employment trend (which is indicated by the relative differential shift). In case of Stargard, although the relative shifts result positive the local economic structure hasn't intensified as much as in the other examined municipalities. Moreover, the relative differential shift was minimal, thus, we cannot attribute the expansion of employment solely to the geothermal development in this municipality. It is a contributing factor to the local economy, but not one of its determinants resulted in the rest of the municipalities.

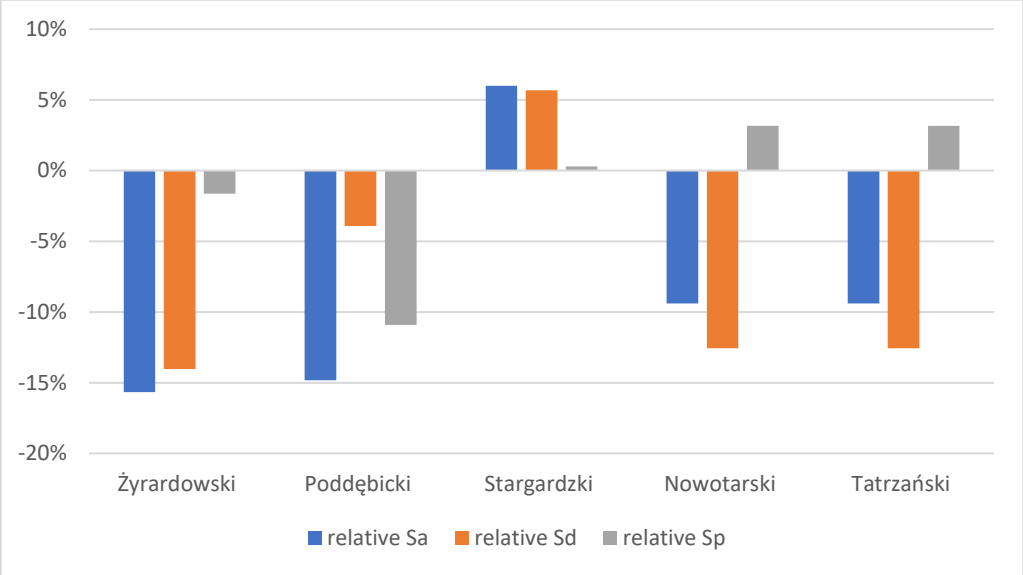

Figure 3: Illustration of the relative shifts in the poviats in years 2005-2018 (source: own elaboration).

The analysis of shift-share application to the control group of poviats and voivodeships resulted in opposite scores in geothermal municipalities and poviats. In four examined cases the relative actual shift and differential shift are negative. Therefore, poviats Żyrardowski, Poddębicki, Nowotarski and Tatrzański are strongly outperformed by the referenced voivodeships. These poviat economies do not follow the economic changes in the regions and no significant employment stimulus took place there. Poviats Nowotarski and Tatrzański observe a positive relative proportional shift which means that the structure of employment is changed there between years 2005 and 2018. The only poviat that experiences positive shifts in the measured employment categories over 13 years is Stargardzki. Nevertheless, the growth is moderate and corresponds with the growth trend of the Stargard municipality.

Summary of the shift-share analysis can be concluded as following:

The comparative analysis of the two groups of municipalities, poviats and voivodeships shows a strong local economic structure in the geothermal municipalities that is not influenced by the regional economic trend. A visible cause of the increase in the NACE sections employment is explained by the strong results of the differential shift. For the purpose of this research we assume it to be the local utilization of geothermal resources. The municipalities with the highest relative differential shift take advantage of the geothermal resources establishing geothermal recreational and health centers (next to using the resource for heating and communal purposes). We may assume that this optimization of geothermal resources created an induced effect for the localities. With the popularization of the geothermal water centers there the tourism, services and trade sectors of economy expand.

The lowest score of the relative actual and differential shift is observed in Stargard. It is a marginal result in comparison to the other tested municipalities. This municipality observes positive changes in employment and the poviat where this municipality is located follows this trend. Nevertheless, that change should not be attributed to the local development of the geothermal energy solely. Other economic impulses stronger than the geothermal resources use cause the positive results of the shift-share analysis. Moreover, this municipality uses the resource only for heat and water provision. No commercial activities that base in the geothermal are yet established.

Examined municipalities of Mszczonów, Uniejów, Szaflary and Bukowina Tatrzańska regardless their population size and economic profile present comparable results. The relative differential shift is a strong result and is related with the positive economic circumstances. The poviats analysis results negative therefore, the changing circumstances arose there with the economic opportunities of geothermal bathing and health centers. The poviats analysis in general reveal no specific circumstances of the economic structure change. By observing the control group, the significant shift in the examined municipalities is to be related with the use of the geothermal resources mostly in the form of recreation and health services. Hence, having analyzed the shift-share results in the selected cases we accept the hypothesis that the differential shift results positive in the examined geothermal municipalities, but it is negative in compared poviats. It justifies the research assumption of the stimulating role of geothermal resource utilization in the local economies.

Furthermore, the local economy shifts from the traditional sectors of agriculture and manufacturing into the trade and services strikes out as a significant effect of the geothermal resources utilization in the majority of the examined municipalities in this study. The creation of the geothermal resources-based tourism generates local jobs in direct and indirect forms. Following Figure 4 depicts the compilation of the population employed by the grouped NACE sections of economy between the two observed years 2005 and 2018. The exact numbers are available in the Annex.

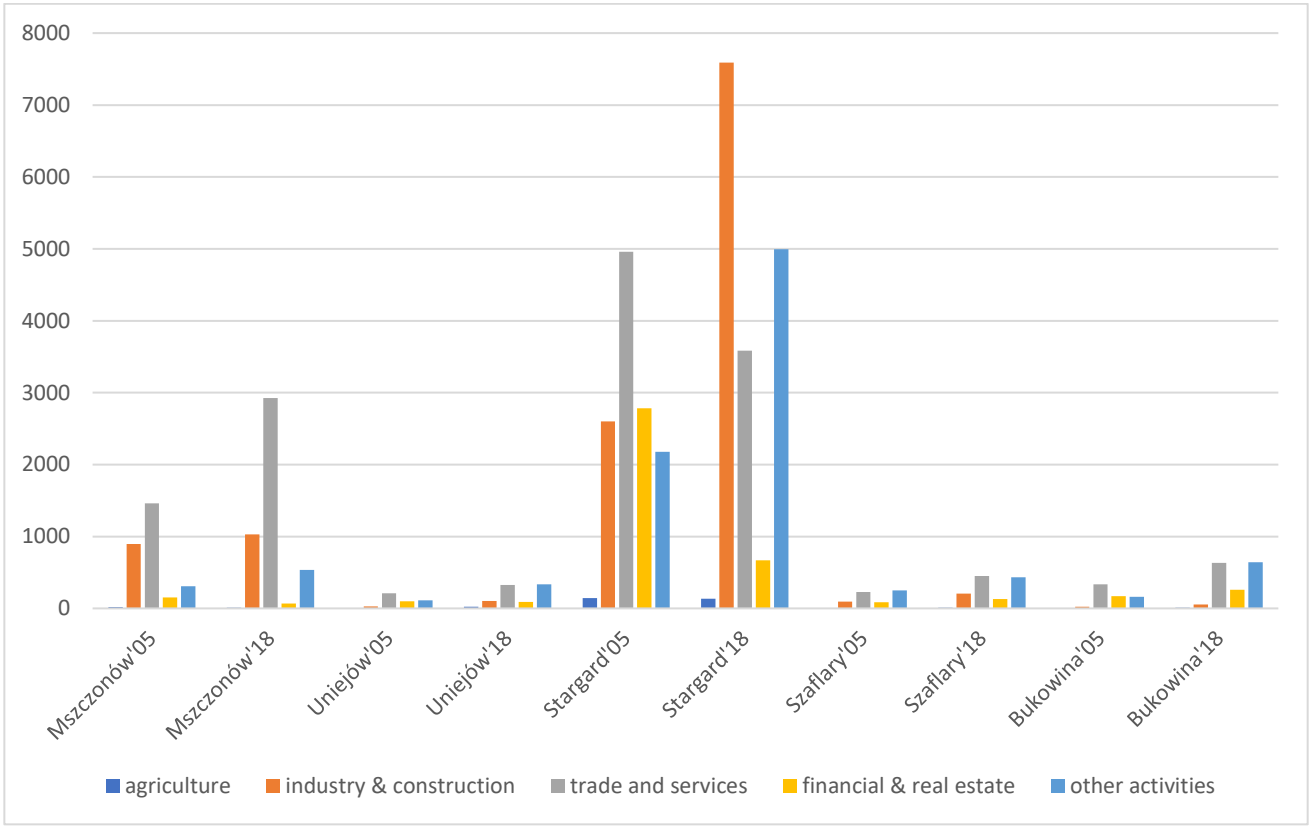

Figure 4: The number of population employed in the NACE sections of economy in years 2005 and 2018 in the selected geothermal municipalities (source: https://bdl.stat.gov.pl)

In the municipalities that have the geothermal recreational or health centers the employment in trade and services (NACE sections G, H, I, J) is at least double in 2018 comparing with the 2005 figures. This section includes tourism and all the related with it employment. Moreover, in all municipalities we observe dramatic decline of the agriculture sector (NACE section A). The agriculture employed population is very low in comparison with other NACE economic sectors. The selected municipalities are rural or urban-rural communes therefore, agriculture is historically part of their economic profile. The number of employed in the sector of financial and real estate services (NACE sections K,L) has moderately grown within the observation period, except Stargard. On the other hand, all of the examined municipalities observe a significant increase in the other market activities (NACE sections M,N,O,P,Q,R,S,T,U) e.g. administration, recreation, health and outwork economic activities. Those services are usually complementary services to the trade and business of other NACE sections (G,H,I,J). Another employment economic category that augmented is the industry and construction (NACE sections B,C,D,E,F). The growing economy in general enhances new production and construction demand however, part of this growth can be attributed with the developing sector of tourism, trade and services. The emergence of a new market phenomenon such as the geothermal recreational or health center entails new services, utility buildings and creates new market demands. We can argue that the geothermal municipalities notice growing and developing economic trend. This observation is justified in the local economies shift in the services employment market.

The same NACE sectors employed data visualization in the Figure 5 is prepared for the examined poviats.

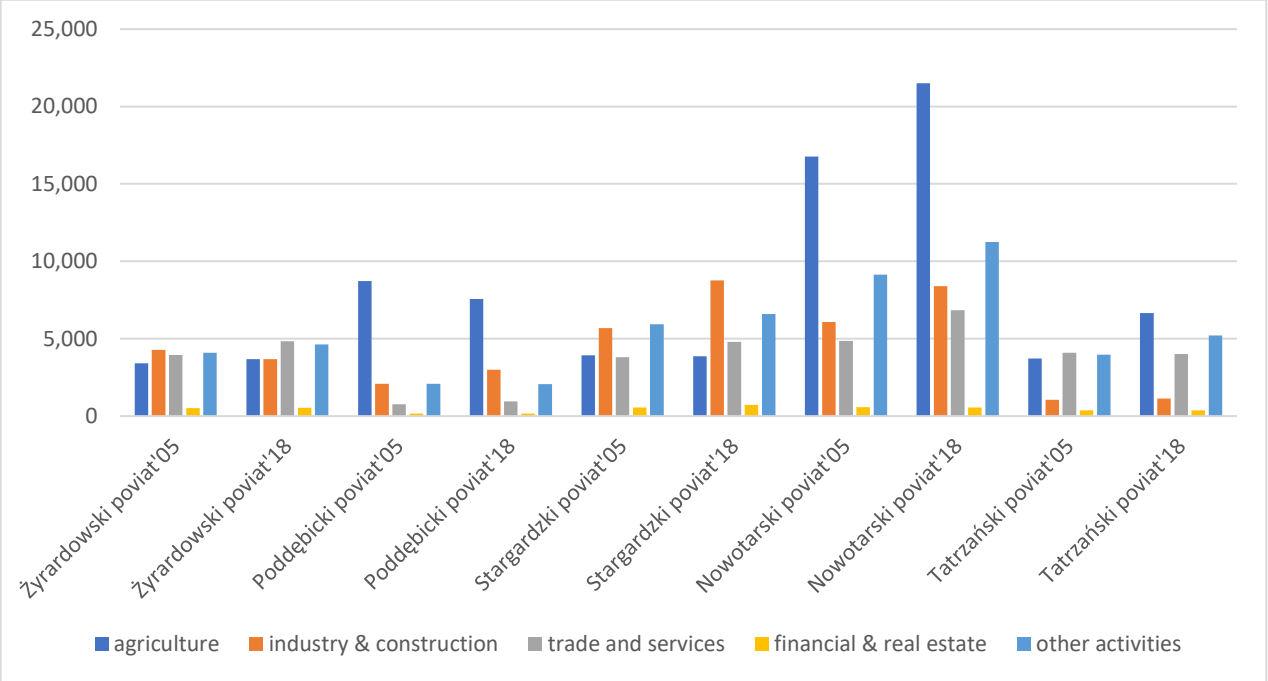

Figure 5: The number of population employed in the NACE sections of economy in years 2005 and 2018 in the selected poviats (source: https://bdl.stat.gov.pl)

In cases of the poviats selection we observe different employment trends. The sector of agriculture remains significantly important in the total composition of the employment categories. It is the fastest growing sector and it employs more inhabitants in 2018 than in 2005, opposite to the situation in municipalities. The decrease of employment is observed in the financial and real estate sectors (K,L). The remaining sectors of industry and construction (sections B,C,D,E,F), trade and services (sections G,H,I,J) and other activities (sections M,N,O,P,Q,R,S,T,U) notice a moderate growth,. From the shift-share analysis we know that these poviats have weaker economic structure than the analyzed voivodeships. Hence, the examined poviats do not represent the development trend of the geothermal municipalities.

5. CONCLUSION AND DISCUSSION

Our research is based in the assumption that the development of the geothermal resources generates a positive outcome in the local economic structure. In order to verify this argument, we zoomed into the five cases of municipalities in Poland that utilize this resource within 13 years. We introduced as well the control group of poviats and voivodeships to be able to identify better the change in economy trends. The NACE categories of employment were used as the variables in the appointed method. The shift- share analysis is a snapshot of the changes in the local economic structure within the years 2005 and 2018. The results show significant changes in the municipalities employment linked with the characteristics of the geothermal development in Poland. These changes were not observed in the analyzed control group. The hypothesis that the availability of the geothermal resources provides a positive economic stimulus to the economic development of the municipalities in comparison to the area of poviat is therefore corroborated. It is as well justified by the strong results of the relative differential shift ascribed to the role of the local geothermal resources harnessing.

The geothermal resources development causes a significant change in the local economic structure. The degree of the change is related with the diversification of the resource use in the municipalities. The more diversified the development the bigger impact is noted. That is why Szaflary and Bukowina Tatrzańska municipalities with two geothermal recreational centers scored high in the shift-share analysis. In case of Stargard, the geothermal energy development is a contributing factor to the local economy but not yet a determinant. This municipality uses the geothermal heat solely in the district heating, whereas the geothermal waters are not yet applied into business activities. Nevertheless, in this study we examine only five municipalities in Poland with the use of the resource. The results are positive and indicate local development of the geothermal resources generate added value services.

This statement is observed on the example of shifts in the NACE employment sectors in the given years. In most of the cases observation of the employment categories data indicate the trade and service sectors (including the hospitality activities) created significant employment opportunities between 2005 and 2018. The geothermal recreational and health establishments induce tourism, trade and accompanying economic sectors, what we observe in significant employment raise in these categories. It results in the shown analysis of the geothermal municipalities. It can be argued that it is a general change in the employment in Poland in the given years however, our analysis points out that specific areas of economy related to the geothermal recreation grow faster than the traditional sectors. The analysis of poviats verifies this statement since the dynamic of employment differs from those observed in the geothermal municipalities.

We can therefore conclude that the commercial application of the geothermal resources, for instance, in recreation and health centers triggers the expansion of services that offer employment. The emergence of tourism and accompanying services followed by the demand of infrastructure and real estate is remarkably related with the geothermal recreational and health centers in Uniejów, Szaflary, Bukowina Tatrzańska and Mszczonów. Moreover, the examined municipalities are rather small to medium small administrative units in Poland (by the number of inhabitants, see Table 2). Yet, the obtained shift-share results point to the bigger

changes in the local economic structure than in the cases of more populated poviats. This is an argument for a role of the geothermal resources in the economic development of the municipalities. Therefore, the geothermal resources developed especially in small localities can play a role as change agent to ignite growth or at least a new specialization opportunity. Specifically, in Uniejów and Szaflary, thanks to the large geothermal spas, are now considered in the public opinion as the new tourist destinations in Poland (Dej et al. 2014; Dryglas & Hadzik, 2016; Halaj, 2015).

The geothermal resources developed is reflected in our shift-share results are as well as in the raw data analysis. The relative differential shift adopted as an indication of the geothermal effect in the municipality economics results significantly strong in our study. It is a corroborated indication of the added value generated from the local use of the geothermal energy. Therefore, according to our findings the local geothermal added value corresponds with the expansion of employment in trade and services sectors. We may also attempt to define a geothermal municipality as a location where the local added value generated by this resource is strongly observed.

Hence, the results of the shift-share analysis point to the significant shift in the profile of the examined municipalities. The traditional sectors of agriculture and manufacturing are dominated by the sectors of services including commerce and tourism facilities in all the five cases. The approach to identify the geothermal resources impact on local economy indicates the important role of the resource in local economic development. Our study establishes an argument for the expansion of the geothermal resource usage locally. Although the commercialization of the geothermal energy still can be broadening in Poland, the investigated cases are already proven beneficial for the local economies. Therefore, we argue that the investment in geothermal energy in municipalities delivers not only a local clean energy source, but a local added value as well.

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Annex: NACE categories employed population in examined municipalities, poviats and voivodeships for the years 2005 and 2018, in number of employed persons (source: https://bdl.stat.gov.pl).

	2005	**2018**	**2005**	**2018**	**2005**	**2018**
NACE sections	*municipality*		*poviat*		*voivodeship*	
	Mszczonów		**Żyrardowski**		**Mazowieckie**	
agriculture	19	10	3405	3683	320115	300846
industry & construction	896	1030	4279	3681	334710	376444
trade & services	1462	2927	3953	4843	365170	506458
financial & real estate services	1154	67	516	538	107017	144775
other activities	307	536	4093	4623	493596	657764
	Uniejów		**Poddębicki**		**Łódzkie**	
agriculture	2	23	8727	7559	191724	178230
industry & construction	30	102	2080	2990	206256	222686
trade & services	208	325	762	948	94510	148975
financial & real estate services	97	92	174	175	22843	26295
other activities	111	333	2088	2072	182317	220562
	Stargard		**Stargardzki**		**Zachodniopomorskie**	
agriculture	144	133	3934	3858	42010	48446
industry & construction	2600	7588	5681	8762	105334	113223
trade & services	4961	3584	3801	4802	67147	97129
financial & real estate services	2784	670	553	719	13893	12131
other activities	2177	4995	5928	6599	114597	135023
	Szaflary		**Nowotarski**		**Małopolskie**	
agriculture	1	10	16771	21492	183561	271742
industry & construction	94	204	6077	8404	213966	256423
trade & services	229	451	4848	6851	136906	228857
financial & real estate services	86	130	581	552	23661	31687
other activities	250	434	9129	11244	239154	320913
	Bukowina Tatrzańska		**Tatrzański**		**Małopolskie**	
agriculture	7	11	3725	6655	183561	271742
industry & construction	24	54	1060	1127	213966	256423
trade & services	334	635	4098	4019	136906	228857
financial & real estate services	171	261	363	381	23661	31687
other activities	163	643	3968	5211	239154	320913