

# Polycentricity in a developing world: A micro-regional analysis for morphological polycentricity in Turkey

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## Abstract

Following the publication of 'European Spatial Development Perspective' in 1999, a large number of theoretical and empirical studies have been carried out on polycentric spatial development especially in European settlements. The relationship between polycentricity and economic competitiveness, environmental sustainability and social cohesion are some of the main concerns of these studies. This study aims to clarify 'the meaning of polycentricity' in the case of Turkey, as a developing country and analyse the relationship between polycentric spatial development and economic competitiveness, environmental sustainability and social cohesion. After calculation of morphological polycentricity of the regions at NUTS-5 level, the propositions on the positive effects of polycentric spatial development on economic competitiveness, environmental sustainability and social cohesion is tested by using Pearson correlation and OLS regression models. The results of the empirical study are mixed for these three subjects. Polycentric spatial development has not positive effects on economic competitiveness and social cohesion in Turkey case. Conversely, a positive effect exists in terms of environmental sustainability. It can be said, that to reach those policy aims highlighted by European Spatial Development Perspective, could not be realised by only taken into account polycentric spatial development in Turkey case.

## Keywords

Polycentric spatial development, Economic competitiveness, Environmental sustainability, Social cohesion, Turkey

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## Highlights for public administration, management and planning:

- There is a very limited number of studies directly focused on the measurement of the degree of polycentricity at a micro-regional scale and on the relationship of polycentricity and economy, environment and social life.
- There is no positive effect of polycentric spatial development on economic competitiveness and social cohesion in Turkey.
- There is a need for more detailed empirical studies on polycentric spatial development pattern in developing world.

## 1 Introduction

The concept of polycentric spatial development has become popular in both academic and professional debates last four decades. The concept is not new, and different studies for clarifying the concept have been carried out since the mid-twentieth century. Especially, the studies of the Chicago School in urban sociology are very critical in the conceptualization of urban spatial structure (Davoudi 2003). The concept of polycentricity was first conceived by Harris & Ullman as 'multiple nuclei cities' (Harris and Ullman 1945), and after that study some other important studies

were realized on the concept. European spatial planning literature and policy documents became the pioneer of these studies (EU Commission 1999). Polycentricity can be seen in an urban territory that has several activity centres' clusters (Anas et al. 1998). This spatial form is a repercussion of decentralised economic activities, which resulted in complex cross-commuting flows among fragmented spatial formations (Davoudi 2003). Polycentricity can also be defined at different spatial scales (international, national, regional, metropolitan area or mega, macro and meso) (Kloosterman & Musterd 2001; Davoudi 2003; Unit E.C. 2004; Waterhout et al. 2005). 'Meso' level has been traditionally been applied to the intra-urban agglomerations,

while ‘macro’ level is more recently used, focusing on inter-urban scale (multiple centres in a region). The third level is ‘mega’ level, which refers to inter-regional scale and it has also been added currently with the effects of to the spatial development strategies of EU (Davoudi 2003).

Polycentric spatial development has many different dimensions. Two of them i.e. analytical and normative dimensions, are very critical that has to be explained briefly. The analytical dimension should be mentioned first; it aims to describe, measure and characterise the current state of a spatial entity by pinpointing how far a country or a metropolitan area can, for instance, be said to be ‘polycentric’ (Nordrigio 2004:14). Analytical dimension of the polycentricity as describing a specific spatial structure at a certain point in time can be divided into a morphological and a functional dimension.

Secondly, the concept can be understood in a normative sense which could help for instance in reorganising the spatial configuration of such an entity (i.e. either to promote/create polycentricity or to maintain/utilise the current polycentric setting) (Nordrigio 2004:14).

Especially, European Spatial Development Perspective (ESDP) has always promoted a normative approach to polycentricity as a preferred spatial structure due to its ability to encourage a regionally balanced development across the EU. With this argument, polycentricity is accepted as a key tool for economic competitiveness, social cohesion and environmental sustainability.

According to Davoudi (2003:996), prior to the emergence of the ESDP, polycentricity had been used as a descriptive and analytical tool in spatial planning; after the ESDP, polycentricity became a prescriptive and normative model for spatial development. These propositions of ESDP, which are also main concerns of this study, “often lack a theoretical rationale and, even more importantly, they have not been sufficiently corroborated through appropriate empirical investigations” (Veneri & Burgalassi 2012:1018).

Therefore, the consolidated wisdom about the supposed advantages of polycentric regions appears to be at least questionable and unclear (Burgalassi 2010:39). On the other hand, the concept has nevertheless retained its ‘buzzword’ status in spatial planning at the EU level and in many of the EU Member States (Meijers 2008).

From this point of view, this study aims to clarify ‘the meaning of polycentricity’ in the case of Turkey, as a developing country and analyse the relationship between polycentric spatial development and economic competitiveness, environmental sustainabil-

ity and social cohesion. For this aim, degree of polycentricity is measured at a NUTS-5 regional level in Turkish case and then Pearson correlation and OLS regression analyses are realized to investigate these relationships.

This study is based on the both dimensions of the polycentricity (analytical and normative). The clarification of the existing spatial structure of Turkey is based on the analytical dimension of the concept. On the other hand, testing the propositions of ESDP on the positive effects of polycentric spatial development on economic competitiveness, environmental sustainability and social cohesion refers to the normative dimension of the concept.

The paper is organised as follows: after introduction, second section gives introductory information about the different spatial scales and methodological approaches of the polycentricity concept. Third section explains different measurement techniques of polycentricity. Fourth section clarifies the relationship between regional polycentricity and economic, social and environmental conditions by using correlation and regression analyses in Turkey case. The results of the empirical study and possible planning and policy implications for Turkey, are discussed in Section five, which concludes.

This study adds on to the national and international polycentricity debate, where the the number of studies directly focused on the measurement of the degree of polycentricity at micro-regional scale is rather limited (Sýkora & Mulíček 2009; Malý 2016; Vasanen 2013). Additionally, there is not an empirical analysis on the relationship polycentricity and economy, environment and social life in Turkey case. For these reasons, the contributions of this study are very critical.

## 2 Literature review

### 2.1 Defining polycentricity

Despite increasing popularity of the polycentricity in last decades, the concept is not new. According to Davoudi (2003) polycentricity is one of the spatial repercussions of today’s more dynamic, more complex and more decentralised urban structure. The polycentric settlement form, which is commonly accepted as an opposite spatial form of monocentricity, is mostly connected to the Central Place Theory. The theory describes hierarchy of cities according to their main marketing, transportation and administrative service areas (Christaller 1933).

The last four decades witnessed a creation of different types of worldwide web linkages among economic actors. Consumers, producers, investors and workers are connected each other not only by physical ways but also by virtual ways (Kloosterman & Lambregts 2001). This process, i.e. globalization, has transformed the spatial organization of settlements. In other words, with the rise of the informational economy, a spatial transformation has been seen in both region and urban space. The processes of spatial reconfiguration that take place on a global scale redefine cities' position in networks according to their role in the world economy (Taylor 2003). On the other hand, an important transformation has taken place in economic activities' geographies at different spatial scales (i.e. global, national, intra-regional, regional, intra-metropolitan scales and etc.). Advanced service activities traditionally located at central business districts (CBDs) are now relocated in peripheral areas (Van Criekingen et al. 2007), that means they are leaving their 'natural environments'.

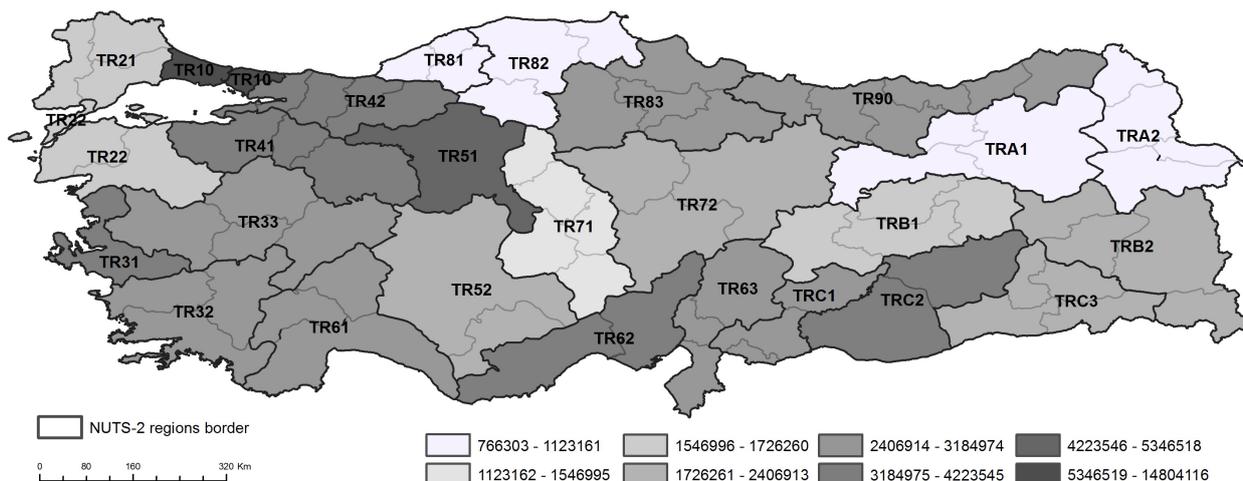
This spatial reconfiguration process can be interpreted there is a transformation from monocentric spatial structure to polycentric ones. The monocentric city, which was first conceptualized by Alonso in 1964, is mainly based on the principles of Burgess' and Park's 'concentric zone theory'. According to the concentric zone theory (Burgess 1925), the morphology of a city is characterized by several functionally distinct zones, together forming several concentric rings: the CBD, the zone of transition, the working class zone, the residential zone, and the commuter zone. The CBD is occupied by department stores, main offices, local government headquarters, banks, theatres and cinemas, and expensive shops (Tian et al. 2010:249). During these years, concentration of economic facilities in CBD and residential areas in suburb resulted in high commuting flows on radial routes from suburb to CBD (Lin et al. 2013). In the mid of 20th century, with the effects of increase in the information and communication technologies, the ratio of employment opportunities in the CBDs of mega cities began to decrease over time and disperse to the newest growth areas located outside of the CBD (Borsdorf et al. 2016). Over the years, it became obvious that the spatial configuration of many metropolitan areas transformed from the monocentric spatial structure to the polycentric ones in which daily trips realised to new economic agglomerations taken place outside the main CBD (Bertaud 2003; Zhao et al. 2017).

As mentioned above, there are different studies on polycentric spatial development, but it is still

a fuzzy concept. Polycentricity is generally described as an even distribution of human activities in more than one centre in an area (Kloosterman & Musterd, 2001). It is an urban system with containing interdependent several nodes that are independent from each other and interacting in different types of flows (Limtanakool et al. 2009; Parr 2004). In sum, polycentricity is opposed to monocentricity. Monocentric spatial structure has a single centre and main economic activities, service facilities and management activities are realised from the centre. Polycentricity is also opposed to uncontrolled urban spatial expansion and urban sprawl (Varol et al. 2017). Actually, the argument of the Nordregio, in European Spatial Planning Observatory Network (ESPON) report (2004:3): “.. polycentricity is about promoting the balanced and multiscale types of urban networks that are most beneficial from a social and economic point of view, both for the core areas and for the peripheries”. The popularity of polycentricity has been increasing in recent years. European spatial planning literature and policy documents that emphasize the positive effects of polycentricity can be one of the reason increase in the popularity of the concept. According to the ESDP, in order to create synergies and cooperation among cities, polycentricity is a key concept in spatial planning policies (Nordregio 2004). ESPON program also emphasizes the polycentricity as a core topic. In Nordregio's ESPON final report (2004), polycentricity is very crucial spatial planning policy that should be preferred to overcome uneven regional development, economic competitiveness and sustainability.

## 2.2 Measurement of polycentricity

Polycentricity is generally analysed from two different dimensions: the morphological (Lambooy 1998; Parr 2004; Meijers 2008) and functional (Lin et al. 2015) dimensions (Parr 2004; Green 2007; Meijers 2008; Burger & Meijers 2012; Veneri & Burgalassi 2012). Some researchers consider polycentricity as a completely physical phenomenon and use morphological analyses in their studies. These analyses are based on the specific characteristics of the region, i.e. size and territorial distribution. Functional dimension of polycentricity, on the other hand, focuses on flows among different centres, which give information about their interdependencies and interrelations. The functional analyses usually emphasize flows of goods, people, information, services, economic interactions and etc. To learn about the organizations, interactions and supply-



**Fig. 1** Populations of NUTS-2 regions in Turkey (2016)

demand relations among these centres (Brezzi & Veneri 2015). In other words, these analyses usually clarify how these centres organize the rest of the region. It should be pointed out that, there are diverging methodologies in measurement of polycentricity. While some of the researchers select either one of the two dimensions, the others prefer using both dimensions and create a new multidimensional approach (Sinclair-Smith 2015). In this study, because there is no committing flow data in municipality level in Turkey, morphological polycentricity is selected as methodology for measurement of polycentricity. There are several techniques in measurement of the degree of morphological polycentricity, but the most popular techniques are ‘Primacy Index’ and the ‘Rank-Size Rule Method/Rank-Size Distribution’. Primacy index (Adolphson 2009; Burger et al. 2011) is calculated as the ratio of people living in the main/principal city and total population of the region. Primacy index, which is presented in equation (1), is focused on the balanced distribution in the nodality scores. The higher the primacy index, the more monocentric the region.

$$Primacy = \frac{pop(1)}{\sum_{n=1}^N pop(n)} \quad (1)$$

A more complicated measurement model is rank-size rule. This model has been used since the 1960s in urban geography. The focus of this model is to rank cities according to their size in the region. Population and economic production is generally used in the measurement of settlement (Sinclair-Smith 2015). The equation (2) of the rank-size rule is:

$$\ln pop = \alpha + \beta \ln rank \quad (2)$$

The slope of regression line—given in the equation (2), the estimated  $\beta$ , is derived by using ordinary-least-squares log-log rank-size regression method like in the studies of Meijers (2008) and Burger & Meijers (2012). Hierarchical level and polycentricity level within a region can be indicated: the lower the estimated  $\beta$ , the lower the level of polycentricity. In other words, a flatter downward slope of the regression line indicates a more polycentric region (Burger et al. 2014:826)

### 3 Methods and Data

The methodology of the study consists of four steps. The first step is determination of spatial scale of the empirical analysis. The second one is the measurement of degree of polycentricity of each regions. The third step involves selecting the independent variables for economic performance, social cohesion and environmental sustainability and the last step is to calculate the degree of the relationship between polycentricity and selected variables by using Pearson correlation and OLS regression analyses. Determination of spatial scale/territorial units is very important in polycentricity studies. In each spatial scales, polycentricity has different meaning and different analytical framework (Unit E.C. 2005). In this study, ‘city’, which refers to municipality in Turkish institutional definition, is used as a territorial unit. The municipality (NUTS-5 level) that has more than 20.000 inhabitants is taken as a basic unit of analysis for the measurement of regional polycentricity.

**Table 1** Descriptions and sources of selected variables used in correlation and regression analyses

Variable	Description	Sources, Year
<b>Polycentricity/monocentricity</b>		
Rank-size	Rank-size estimation coefficient	Turkstat, 2015
Primacy index	Weight of prime city population over total regional population	Turkstat, 2015
Polycentricity index	the average value of standardized rank-size coefficient and standardized Primacy index	
<b>Economic competitiveness</b>		
GDP	Per capita GDP	Eurostat, 2011
GDP growth	Growth rate of Per capita GDP (2009-2011)	Eurostat, 2009-2011
Unemployment	Unemployment rate (%)	Turkstat, 2015
Productivity	Per capita labour productivity	Ministry of Science, Industry & Technology, 2014
Productivity growth	Growth rate of Per capita labour productivity (2009-2014)	Ministry of Science, Industry & Technology, 2009-2014
<b>Social cohesion</b>		
Education	Share of labour force at least secondary education	OECD stats, 2014
Gini	Gini coefficient on distribution of per capita income	Turkstat, 2014
<b>Environmental sustainability</b>		
CO2	CO2 emissions per capita	OECD, 2014
Airpollution	Air pollution micrograms per cubic metre	OECD, 2014
Building	New & additional building (square m)	Turkstat, 2015

**Table 2** The results rank-size distribution (estimated beta) and primacy index

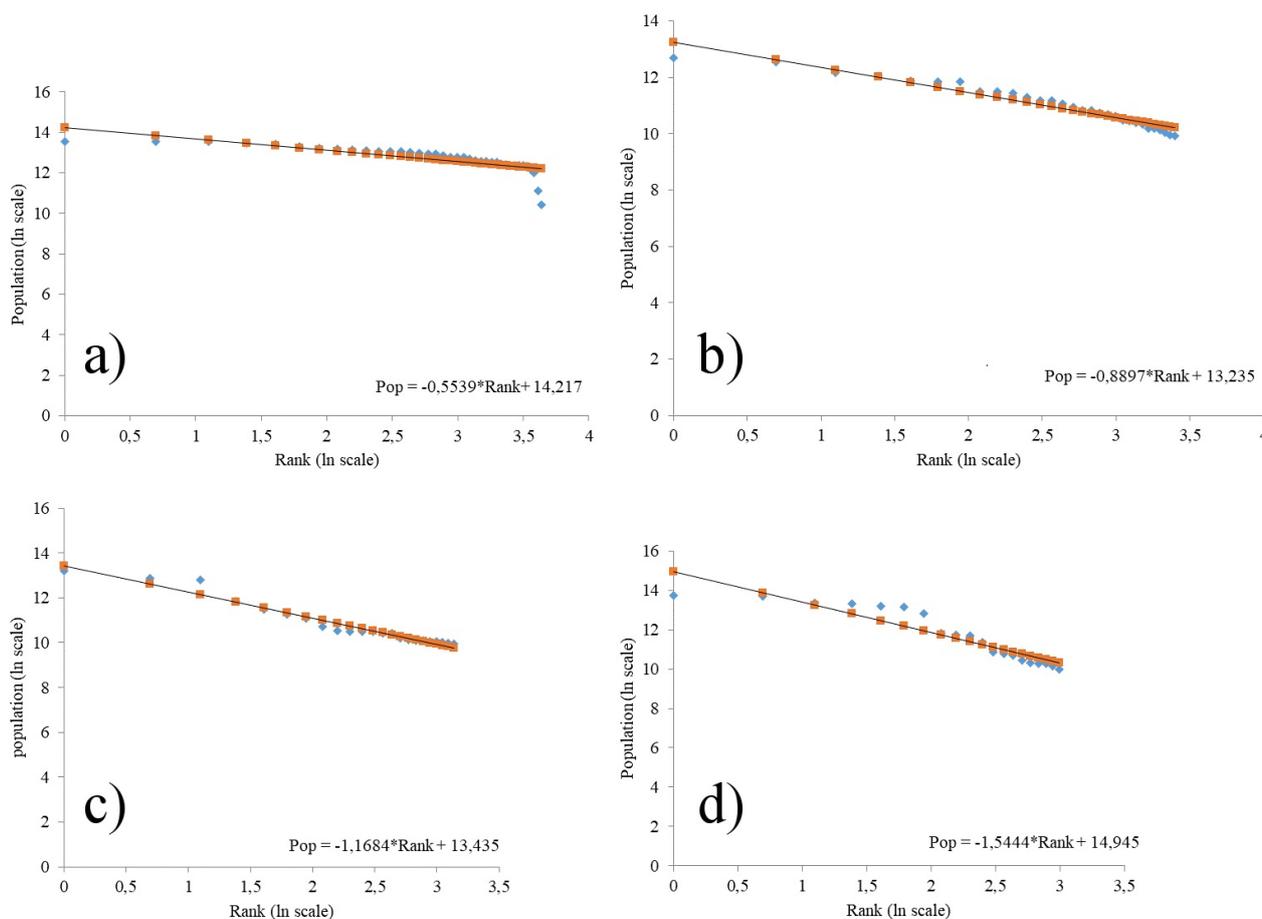
# NUTS-5 regions	Beta		Primacy index	
TR10	38 -0,55		TR10	0,052
TR22	25 -0,78		TR33	0,102
TR90	39 -0,79		TR42	0,102
TRB2	28 -0,8		TR22	0,107
TRA2	17 -0,85		TRC2	0,107
TR82	10 -0,86		TR31	0,115
TR21	19 -0,88		TR32	0,119
TR33	33 -0,89		TR63	0,125
TR83	30 -0,89		TR83	0,128
TR63	27 -0,91		TRB2	0,136
TR32	34 -0,91		TRA2	0,145
TR81	13 -0,92		TR90	0,149
TRC2	27 -0,93		TR21	0,154
TR42	35 -0,94		TR51	0,177
TRA1	13 -0,97		TR61	0,178
TRC3	23 -0,98		TR81	0,178
TR31	28 -1,04		TRC3	0,201
TR61	23 -1,08		TR62	0,207
TR71	15 -1,08		TRA1	0,222
TR72	23 -1,17		TR41	0,222
TR52	18 -1,18		TR71	0,236
TR62	20 -1,21		TR72	0,256
TRB1	13 -1,29		TR52	0,273
TR41	20 -1,29		TR82	0,28
TRC1	13 -1,52		TRB1	0,289
TR51	20 -1,54		TRC1	0,34

source: data collected from Turkstat (2015), author's processing

As mentioned in the study of [Veneri & Burgalassi \(2012\)](#) when considering polycentricity in terms of NUTS-2 regions, using municipalities as a territorial unit, makes the estimations very reliable than other spatial units and enables the regional polycentric development to be more thoroughly characterized. There are 26 NUTS-2 regions in Turkey and 604 municipalities (in level NUTS-5) more than 20.000 inhabitants ([Figure 1](#)).

So as to evaluate the polycentricity of individual regions, primacy index and the rank-size distribution analyses are realized in the second stage of the study. In addition to these two analyses, a mono/polycentricity index is calculated to reach an overall value for each individual region. According to [Meijers & Sandberg \(2006:10\)](#), to construct an overall indicator for these two methods: "...A z-score of 0 was given a value of 100, and 1 standard deviation was given a value of 20. So, a z-score of -1 results in a value of 100-20=80. we calculated such values for both indicators for each country, and the mono/polycentricity index score presents their average value". [Table 3](#) shows the results of mono/polycentricity index, lower values indicate more polycentric and higher values indicate more monocentric urban systems.

After determination of regions' polycentricity degrees, independent variables for economic performance, social cohesion and environmental sustain-



**Fig. 2** Examples for Slope regression line-population threshold of 20.000 (from the most polycentric a) TR10 Istanbul - to the most monocentric one d) TR51 Ankara; b) TR83 Samsun, Tokat, Corum, Amasya; c) TR72 - Kayseri, Sivas, Yozgat)

ability are selected in the third stage of the study. With reference to the previous studies on the subject, per capita GDP, growth rate of per capita GDP between 2009 and 2011, unemployment rate, per capita labour productivity and growth rate of per capita labour productivity between 2009 and 2014 are used as indicators of economic performance of individual regions. For social cohesion, share of labour force at least secondary education and Gini coefficient on distribution of per capita income are selected as indicators. Environmental sustainability, on the other hand, is evaluated by using the CO2 emissions per capita, air pollution micrograms per cubic metre and new and additional building (square m) (Table 1).

The fourth and the final stage includes the evaluation the relationship between degree of polycentricity and economic competitiveness, social cohesion and environmental sustainability by using correlation coefficients and OLS regression analyses. These analyses are realized by using SPSS (Statistical

Package for Social Sciences). After calculating correlation coefficients among variables, regression analyses are realized. Three different models are used to specify feature of spatial structure of regions in the analysis. While, Model (1) takes into account the slope of the regression line of rank-size calculations (beta), Model (2) considers primacy index and Model (3) includes both primacy index and rank-size rules results as mono/polycentricity index. Using these different spatial specifications helps to interpret results with more robustness (Brezzi & Veneri 2015). It should be emphasized that these models are not an attempt to distinguish the most explanatory factors or to provide the most exhaustive list of those explaining the persistence of economic performance, social cohesion and environmental sustainability. Rather, it is interested in examining whether the findings from the analysis of correlations are still held when the influence of a number of other explanatory variables are controlled.

**Table 3** Index of mono/polycentricity

NUTS-2 Regions	Standardised score slope regression line rank-size distribution	Standardised score primacy index across territory	Index of mono/polycentricity	
TR10	60,03	64,10	62,07	most polycentric
TR22	79,46	79,49	79,48	
TR33	89,30	77,99	83,65	
TRB2	81,62	87,77	84,70	
TR42	94,20	78,10	86,15	
TR90	81,02	91,32	86,17	
TRC2	93,01	79,59	86,30	
TR32	91,14	82,94	87,04	
TR83	89,45	85,47	87,46	
TR63	91,10	84,71	87,90	
TRA2	85,69	90,15	87,92	most monocentric
TR21	88,22	92,70	90,46	
TR31	102,23	81,80	92,01	
TR81	92,06	99,40	95,73	
TRC3	96,93	105,96	101,44	
TR61	106,01	99,37	102,69	
TRA1	96,92	111,90	104,41	
TR82	86,83	127,92	107,38	
TR71	106,29	115,79	111,04	
TR62	117,63	107,67	112,65	
TR72	113,90	121,19	117,54	
TR41	124,86	111,90	118,38	
TR52	114,69	126,08	120,39	
TR51	146,89	99,02	122,95	
TRB1	124,75	130,60	127,67	
TRC1	144,55	144,86	144,71	

source: source: data collected from Turkstat (2015), author's processing

**Table 4** Pearson Correlations between polycentricity indicators and variables used for economic performance, social cohesion and environmental sustainability

	Rank-size distribution	Primacy index	Poly index
Education	-0,386	-0,027	0,195
Gini	-0,159	-0,087	0,040
Building	0,001	-0,356	-0,194
Air pollution	-0,267	0,204	0,257
CO2	0,141	-0,201	-0,187
Unemployment	-0,066	-0,102	-0,020
GDP	0,004	-0,36	-0,198
GDP growth	-0,052	0,014	0,036
Productivity	-0,147	-0,272	-0,068
Productivity growth	0,019	0,006	-0,007

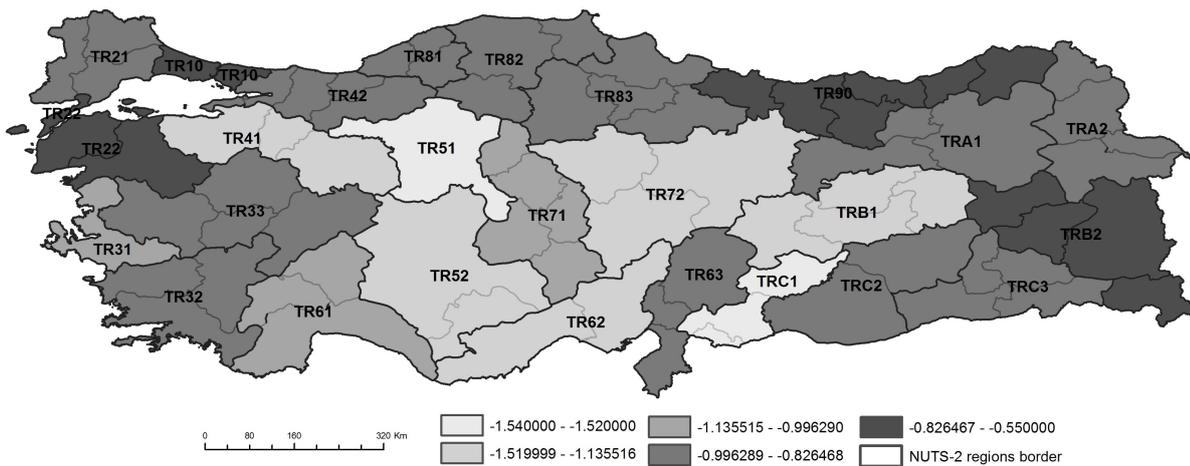
## 4 Results

### 4.1 Morphological polycentricity in Turkish regions

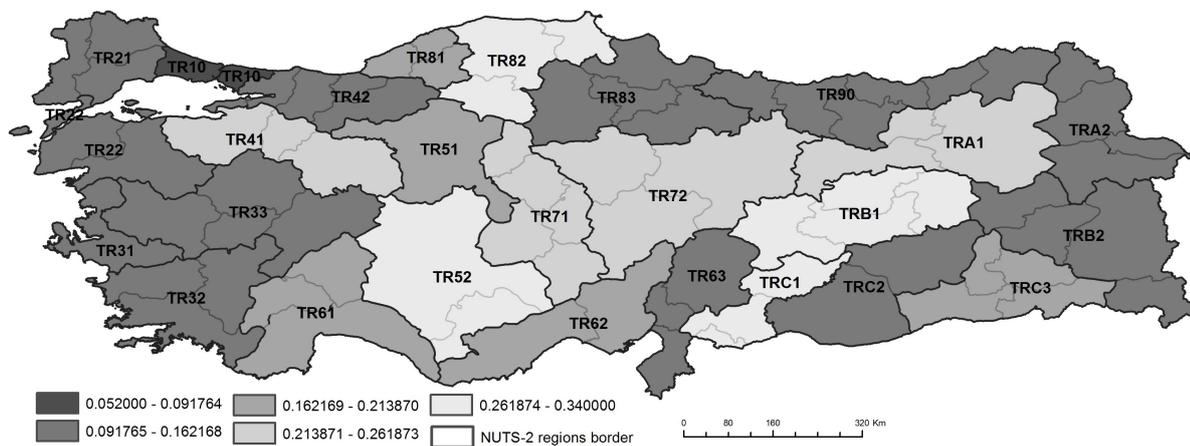
The degree of the polycentricity in Turkish regions are calculated by using primacy index, rank-size rule and mono/polycentricity index in this study. According to the rank-size distributions, the slope of regression line, (estimated beta), which gives information about the degree of polycentricity within a region. The higher the value of estimated beta means a flatter slope of line interpolating data that indicates a higher the level of polycentricity (Figure 2). The results of rank-size distribution analysis show that, TR10 (Istanbul), which is most populated city in Turkey and has 38 NUTS-5 regions (municipalities more than 20.000 inhabitants), is the most polycentric city in Turkey (Table 2). This result means, the gap among municipalities in terms of population distribution in Istanbul is smaller than other cities in the country.

The most monocentric city, on the other hand, is TR51 (Ankara), the capital of Turkey. the slope of regression line in the rank-size distribution is steeper than other cities, the population gap is higher, and hierarchical population structure exists in the city.

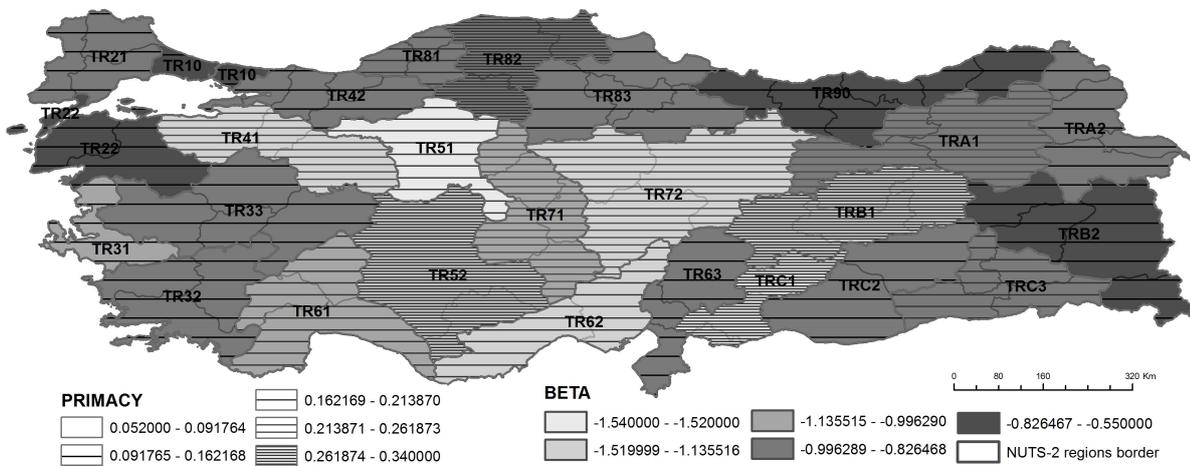
Primacy index describes the dominance of the prime city in relation to the region: the higher the primacy, the more monocentric the region. Primacy index shows the ratio of people living in the main city (i.e., the principal city) and the total population the city. Table 2 shows the results of primacy index. TR10 (İstanbul) is the most polycentric city in Turkey, as similar the results of in rank-size distribution. Population distribution is more balanced in TR10 relative to other regions. TRC1 (Gaziantep, Adıyaman, Kilis) on the other hand, the most monocentric region, that means the nodality score is very high. In addition to these two analyses, a mono/polycentricity index is calculated to reach an overall value for each individual region with reference to the studies of Meijers & Sandberg (2006). The most monocentric region, according to the results of this overall mono/polycentricity index, is TRC1, similar to primacy model. Ankara, capital city is the second monocentric region according to this index. The degree of polycentricity of TR10 (Istanbul), which is the most polycentric region in both primacy index and rank-size distribution models is not change in this analysis. TR10 is the most polycentric region according to the index of mono/polycentricity (Table 3).



**Fig. 3** The levels of morphological polycentricity in the Turkish NUTS-2 regions - Rank size



**Fig. 4** The levels of morphological polycentricity in the Turkish NUTS-2 regions - Primacy index



**Fig. 5** The levels of morphological polycentricity in the Turkish NUTS-2 regions - Primacy/Beta

**Table 5** OLS estimation results for economic performance

Variables	Economic performance					
	Labour Productivity			GDP		
Dependent						
Independent	(1)	(2)	(3)	(1)	(2)	(3)
Constant	-1.47 (-0.052)	12.493 (0.442)	0.309 (0.009)	3507.4 (1.416)	3705.067 (1.550)	4943.811 (1.631)
GDP	0.753 (5.687)	0.760 (5.236)	0.769 (5.622)			
GDP growth	0.213 (1.334)	0.215 (1.319)	0.213 (1.400)			
Labour productivity				0.944 (8.548)	0.880 (7.853)	0.914 (8.438)
Labour productivity growth				-0.483 (-4.556)	-0.463 (-4.411)	-0.474 (-4.525)
Unemployment	0.179 (1.132)	0.188 (1.157)	0.190 (1.184)	-0.337 (-3.190)	-0.343 (-3.286)	-0.340 (-3.254)
Rank-size distribution	<b>-0.127 (-0.97)</b>			<b>0.130 (1.272)</b>		
Primacy index		<b>0.018 (0.126)</b>			<b>-0.154 (-1.480)</b>	
Polyindex			<b>0.081 (0.596)</b>			<b>-0.146 (-1.467)</b>
R <sup>2</sup>	0.573	0.554	0.561	0.747	0.753	0.752

note: t-stats in parentheses, author's calculations

**Table 6** OLS estimation results for environmental sustainability

Variables	Environmental sustainability					
	Building			Air pollution		
Dependent						
Independent	(1)	(2)	(3)	(1)	(2)	(3)
Constant	-1.073E7 (-1.880)	-9.434E6 (-1.585)	-8.788E6 (-1.364)	17.530 (6.050)	20.559 (7.744)	17.759 (4.772)
GDP	0.901 (5.583)	0.833 (5.066)	0.871 (5.509)	-0.824 (-3.534)	-0.809 (-0.248)	-0.803 (-3.330)
Air pollution	0.332 (1.936)	0.289 (1.844)	0.312 (1.952)			
Building CO2	-0.151 (-1.086)	-0.160 (-1.158)	-0.158 (-1.138)	0.448 (1.921)	0.465 (1.870)	0.469 (1.947)
Rank-size distribution	<b>0.104 (0.720)</b>			<b>-0.264 (-1.627)</b>		
Primacy index		<b>-0.147 (-1.001)</b>			<b>0.078 (0.422)</b>	
Polyindex			<b>-0.131 (-0.916)</b>			<b>0.188 (1.102)</b>
R <sup>2</sup>	0.533	0.543	0.54	0.342	0.269	0.301

note: t-stats in parentheses, author's calculations

## 4.2 Correlation and regression analyses

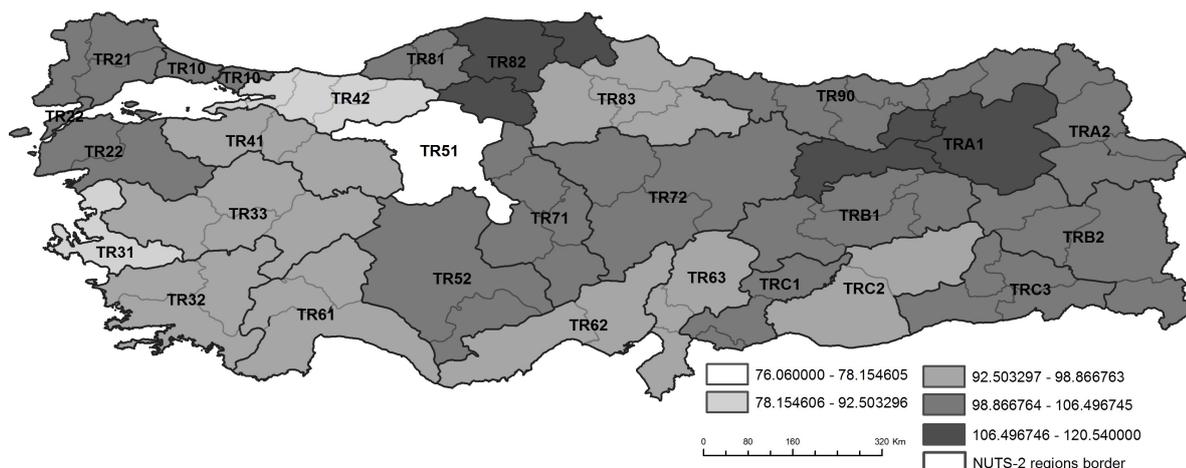
After determining degree of polycentricity in Turkey, correlation and regression analyses are realised in this stage. The results of analyses on relationship between polycentricity indicators and economic performance, environmental sustainability and social cohesion will be given below.

### 4.2.1 Economic performance

Table 4 gives the outcomes of correlation analysis and Table 5 illustrates OLS estimation results for different model specifications. as mentioned above, according to the ESDP polycentric spatial development is a key factor to determine economic development (Unit E.C. 2004). In order to test this proposition in Turkey case GDP and labour productivity are selected as dependent variables. The correlation among polycentricity indicators and economic performance variables is determined before

the regression analysis (Table 4). First off all, it has to be mentioned that, the correlation among dependent variables and polycentricity indicators are very weak. On the other hand, labour productivity and GDP correlate negatively with primacy and mono/polycentricity index and the degree of these correlations are the highest ones compare to all other variables.

There is also a slight positive correlation between GDP and rank-size distribution. The results of regression analysis confirm this association between GDP and all indicators of polycentricity (Table 5). The negative correlation between labour productivity and rank-size distribution is also seen in the regression analysis results. All in all, the results of correlation and regression analyses are mixed and all these analyses' results would suggest that the polycentricity have poor and negative influences on regional economic performance in Turkey case.



**Fig. 6** The levels of morphological polycentricity in the Turkish NUTS-2 regions - Polycentricity index

**Table 7** OLS estimation results for social cohesion

Variables	Social Cohesion		
	Gini		
Dependent	(1)	(2)	(3)
Independent			
Constant	0.352 (10.377)	0.378 (12.859)	0.385 (9.090)
GDP	-0.574 (-1.328)	-0.991 (-2.491)	-0.848 (-1.946)
Education	0.428 (0.914)	0.754 (2.030)	0.701 (1.608)
Rank-size distribution	0.009 (0.032)		
Primacy index		-0.423 (-1.834)	
Polyindex			-0.266 (-1.030)
R <sup>2</sup>	-0.012	0.122	0.035

note: t-stats in parentheses, author's calculations

#### 4.2.2 Environmental sustainability

In order to verify to what extent environmental sustainability and polycentricity are associated in terms of land use configurations, different environmental sustainability variables were chosen (Table 4, Table 6). Polycentricity means more land in need for urban fabric. for this reason, the number of new building licences is selected as dependent variable. There is a slight positive correlation in particularly evident when accounting the rank-size distribution, but on the other hand, highly negative correlation exists in terms of primacy index and mono/polycentricity index. These results (both signs and degree of relationships) are confirmed in regression analysis and this would sug-

gest that the land demand does not highlight a role for polycentricity.

Air pollution is another dependent variable and it negatively correlates rank-size distribution, on the contrary, positively correlates primacy index and mono/polycentricity index. Similar trend can be seen in regression analysis. But the association between air pollution and rank-size distribution is relatively high. That would suggest the more polycentric the region the less air pollution exists.

#### 4.2.3 Social Cohesion

According to ESDP the polycentric spatial development supports equal distribution of income. To test this idea, the Gini index, which measures the extent of distribution of income within an economy. The results of correlation analysis show that income distribution correlates negatively rank-size distribution and primacy index, but positively mono/polycentricity index (Table 4). The result of correlation is also consistent with primacy index from regression analysis. The association between income distribution and primacy index is significantly high and negative, similar results can be seen for mono/polycentricity index (Table 7). These findings show that the more polycentric the region the more unequal the income distribution in Turkey case. Although these results are different from ESDP conclusions, similar results are supported in the studies of Meijer and Sandberg (2008) and Veneri and Bulgarassi (2012).

## 5 Concluding remarks

Polycentric spatial development, which is highly supported by ESDP and is becoming more popular, is the main concern of this study. Although not as clear and planned as in European countries, it is observed that, some of the metropolitan cities in Turkey are also evolving from monocentric spatial structure to polycentric ones (Sat 2018). Nevertheless, there is very limited empirical evidence on the measurement of this spatial evolution at micro-regional scale in Turkey. From this point of view, this study aims to clarify the degree of polycentricity in Turkey, and to find out the relationship between polycentric spatial development and economic competitiveness, environmental sustainability and social cohesion in Turkish case. The results of the empirical study are mixed for these three subjects.

There is no strong relationship between polycentricity and economic competitiveness; the results would suggest that the polycentricity have poor and negative influences on regional economic performance in Turkey case. This should also mean that linkages among cities/regions in Turkey are not strong enough to enhance economic integration. As emphasized in the Nordregio (2004:20) “an urban region can improve its economic performance through better co-operation and improved links within the region”. Thus, the common planning strategies, which clarify the roles of each settlement in economic and social cooperation and service provision, should be determined in a more comprehensive way. Polycentricity means more land in need for urban fabric. The land demand, as one of the indicators of the environmental sustainability, does not highlight the role for polycentricity according to the results of the empirical analysis. However, the association between air pollution and rank-size distribution is relatively high, suggesting the more polycentric the region is the less air pollution it displays. With this suggestion, the promotion of ESDP is supported in environmental sustainability subject. One of the interesting findings of the empirical study is that the more polycentric the region the more unequal the income distribution in Turkey case. Although these results are different from ESDP conclusions, similar results are supported within the studies of Meijer and Sandberg (2008) and Veneri and Bulgarassi (2012).

All in all, empirical analyses of this study show that reaching the policy aims highlighted by ESDP could not be realised by only taken into account polycentric spatial development in Turkey case. Whilst,

this study provides new insight for both the national and international polycentricity debate, because of its spatial scale and case study area. Actually, there is a very limited number of study directly focused on the measurement of the degree of polycentricity at micro-regional scale and on the relationship polycentricity and economy, environment and social life. On the other hand, studies on polycentricity are generally focused on European regions and cities. For this reason, studying spatial development pattern in a developing world, should give different perspectives for both academics and professionals.

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