45th European Congress of the European Regional Science Association
Land Use and Water Management in a Sustainable Network Society
23-27 August 2005, Amsterdam, The Netherlands

Change in the Gravitational Centre of the Turkish Population

Cihan Ahmet Tutluoğlu*
Vedia Dökmeci**

**Bilgi University, Istanbul, Turkey*
***Istanbul Technical University,Istanbul,Turkey*
catutluoglu@bilgi.edu.tr

Abstract

The centre of gravity and tendency of the mass to concentrate around it, is an important element in Physics as well as in Statistics. When it comes to population studies, they may be used to allocate governmental posts as well as to have a good grasp of the dynamics in the country. When it is a country of high changes in population, these statistics may be exploited to see the impact of these changes and enable due alignment to meet the shifting demand. Large shifts in population have marked the history of Turkey as that of many other parts of the developping world. In this paper, the change in the weighted average and the variance of population centres has been calculated for Turkey for each census at city-level and for settlements of above 10,000 inhabitants. The same was done for the GNP. The changes in the mentioned centre of gravity were then regressed on suitable trend functions and meaningful yet different dependencies have been shown. It is worthwhile to note the tendencies to converge and to draw cycles on the data set. Since all of these calculations were accompanied by huge variance terms regarding the relatively high area and population of Turkey, clusters clusters based on variance caps have also been proposed.

Introduction

Turkey has experienced rapid urban population growth and urbanisation since 1950's. A massive trend to flock to the cities, combined with an average population growth rate of 2.1 % per year between 1985 and 1990, has lead to overcrowding in major Turkish cities. Although urbanisation is a natural by-product of industrialisation and has been observed in all presently developed countries, the Third World Urbanisation is yet more marked with unparallel rates of industrialisation and urbanisation.

In Turkey, rural-urban migration has been stipulated by many factors, such as the great socio-economic differentials between the Eastern and the Western parts of the country, a high population growth rate, a shortage of land in rural areas, mechanisation trend in agriculture, attire of the cities and infrastructure requirements. Urban population growth has substantially overpassed natural growth rates, indicating the impact of migratory movements. Rapid urbanisation in its turn has lead into infrastructure shortages and increased pollution as well as urban distress and slam formations around the larger cities, as is typical of the developing world. Slam-dwellers had mounted up to 27% in Istanbul, 29.7% in Ankara and 45% in Izmir by 1990. The immense pressure that this over-population exerts on potential new-comers is still highly off-set by its variety of cultural and urban recreational facilities, employment alternatives and attractive waterfront.

Migration, on the other hand, has always been seen as an important allocative mechanism for integrating the supply and the demand for labour over time and space

Established from almost scratch, with huge displacements in demographic, ethnic and topological layout, the urban and in general settlement scheme and patterns in the new republic were almost artificially generated. As time passed by and as the country moved towards being a more integral part of the global society, a normalisation trend has arguably taken place also. This has been accompanied by the planning decisions and initiatives undertaken by the growing nation-state authority.

Centre of Gravity

Webster's Dictionary defines the centre of gravity as "a point equally distant from the extremities of a line, figure, or body, or from all parts of the circumference of a circle; the middle point or place." or "nucleus; an object of attention, action, or force; around which things are gathered or to which they tend as, a centre of attraction."

The concept of centre of gravity was first introduced by the ancient Greek mathematician, physicist, and engineer Archimedes of Syracuse, showing that torque exerted on a lever by weights resting at various points along the lever is the same as what it would be if all of the weights were moved to a single point -- their centre of gravity. In work on floating bodies he demonstrated that the orientation of a floating object is the one that makes its centre of gravity as low as possible. He developed mathematical techniques for finding the centres of gravity of objects of uniform density of various well-defined shapes, in particular a triangle, a hemisphere, and a frustum of a circular paraboloid.

Following up on its initial use, the centre of gravity is widely used in positive sciences as a technical and a theoretical tool.

Car manufacturers use the centre of gravity in tilt tests to test the stability of their cars.

In aeronautics, defining the amount of mass forward or behind the centre of gravity that needs to be moved in order to pitch the plane up or down without applying any external force, the centre of gravity is of crucial importance.

Social Disciplines have made use of the concept through various analogies just as well.

For example, the concept of centre of gravity has proven one of the most valuable concepts a commander can use to effectively accomplish his objectives.

Calculated from the price and volume of a given security, centre of gravity, due to being easy to understand and requiring less technical information is a useful tool for new traders until their chart reading abilities increase.

The concept of the centre of gravity can be applied to land-economics as well. For example, if we want to select the site for a shopping centre, we would like it to be near the centre of gravity of customers. If we want to select a site for an airport, we probably would like to locate it at the centre of gravity of the region that the airport will serve. In these two cases, the selected sites may have total minimum distance to all their customers.

Liu and Coleman have shown that the centre of gravity of the population in Madison Country and the major Commercial installations actually overlapped. Moreover, the centre of gravity of the black population and the white population coincided with the poor and the affluent neighbourhoods.

Li Y. On the other hand, has shown that the locus of the Chinese population has moved back and forth between 1912 and 1978, leading into possible inferences to be drawn from the history of China.

The studies carried out by the American Census Authorities on the other hand, have shown that the centre of population in the USA has followed a trail that reflects the sweep of the nation's brush stroke across America's population canvas. The sweep is said to be reflecting the settling of the frontier, waves of immigration and the migration west and south. Since 1790, the centre of gravity has moved in a westerly, then a more southerly pattern to more than 1,000 miles away from the first centre in Kent County on Fairlee Neck which is northwest of Chestertown, Maryland to the area near Edgar Springs.

Another study on the Spanish population trails the change in the centre of gravity: from the process of territorial integration where the centre of gravity was in northern Castile through the movement from the interior to the coast due to the changes in Spanish Economy.

A Study on the population in Britain, carried out by the Census Office, on the other hand has found out a 16 mile drift towards the Southeast of the centre of gravity of the British population and attributed it to the Conservative policies and EU membership, whereas a similar study was carried out for Australia to quote about the changes in the sector based orientation of the Australian population.

Therefore the studying of the gravitational centre of the Turkish population may prove to have many repercussions on various fronts.

Through the course of our study, we will first observe the changes in the centre of gravity for the population in Turkey at city-level and try to explain it as a function of time. This way we may see how the general layout of the population has changed as well as provide for some room of application for location theory.

Our next step will be to conduct the same study at the level of urban centres – that is, localities with a population of 10000 or above. This way, we will be able to see whether the trends for the centre of the urban population actually overlap with the centre of gravity of the Turkish population at large.

As a next step, the values for the centre of gravity for the GNP values will be compared with the findings from the previous chapters and some implications as well as a possible partition (clustering) will be debated on.

The Change of the Centre of Gravity in Turkey

Based on City Centres

Although it may be pretentious to be talking about a centre of gravity in such a large, populated and mountainous country as Turkey, the evaluation of the trends in the centre of gravity may bring about implications on Turkish politics on unitary state and the overall effects of the shift of population observed.

In order to calculate the centre of gravity of the Turkish population, a weighted average of all the city centres in Turkey has been taken. The corresponding weights for each of the cities have been taken as the percent of the population of the country living within.

The major shift in population has been observed from mid- 1950's onwards, the trend analysis before that date seems not to yield any significant change. Indeed the policies of the Turkish state on general population scheme and the overall liberalisation in Turkey has started from that date on. Therefore the study below will include an evaluation from that year on. Moreover since 1997 census is considered to be misleading due to erroneous methods used, this year will be exempt from the scope of our study as well.

The centre of gravity for the years 1955 to 2000, calculated for each census may be found in Table 1 below.

Table 1 the Change in the centre of gravity for the urban localities

	1955	1960	1965	1970	1975	1980	1985	1990	2000
Longitude	33,863	33,859	33,877	33,859	33,818	33,716	33,643	33,491	33,366
Latitude	39,380	39,372	39,361	39,350	39,320	39,327	39,304	39,278	39,246
Change in longitude		-0,005	0,018	-0,018	-0,041	-0,102	-0,073	-0,152	-0,124
Change in latitude		-0,008	-0,011	-0,011	-0,030	0,007	-0,023	-0,027	-0,031
Change in x (km)		0,396	1,564	1,529	3,568	8,745	6,292	13,096	10,700
Change in y (km)		0,911	1,192	1,257	3,324	0,805	2,547	2,978	3,486
Total Change(km)		0,994	1,967	1,979	4,876	8,782	6,789	13,432	11,256
Change in x/ Change in y		0,435	1,312	1,217	1,073	10,86	2,47	4,398	3,069

The visual depiction of this change on the other hand is presented on figure 1.:

Figure 1 the Change in the Centre of Gravity for the City Centres

The change in the centre of gravity takes place near to the South of Ankara in the direction of Eskişehir. The definitive trend line with a bias towards the West can be observed to attain a high impetus from 1970's onwards. From this time onwards, minor fluctuations at the level of 1-2 km per 5 years seem to have shifted to a level of 5 km. The largest shift, on the other hand has taken place between 1985 and 1990 (with some 13.5 km overall).

The tendency to increase is apparent on the North-South axis as well as on the East-West axis. With the exception of 1980, the change on the North-South axis fluctuates at a pace of around 2 to 4 times higher than the previous term. The change on the East-West axis on the other hand is observed at 2.5 to 38 times more than the previous years.

What should as well be noted at this point is the shift in disparity between the shifts on the y-axis and on the x-axis respectively. The change in the horizontal direction divided through the change in the vertical direction, seems to have increased from almost a half up to 11 in 1980.

When it comes to expressing these shifts as functions, since the centre of gravity was evaluated on a two dimensional plane, the longitude and the latitudes had be evaluated separate. For each, the regression was carried for all powers of $x^{1/2}$, where x is the base year in question.

Longitude-wise the equation yielding the highest reliability was...

$-98561{,}2512369 + 165{,}41827408\ x - 0{,}124870071016\ x^2 + 0{,}0014939077606\ x^{5/2}$

Table 2 the Regression Statistics for the longitudes and the latitudes of City Centres

Regression Statistics for the latitudes		*Regression Statistics for the longitudes*	
Multiple R	0,989997505	Multiple R	0,993158
R Square	0,980095061	R Square	0,986364
Adjusted R Square	0,973460081	Adjusted R Square	0,978182
Standard Error	0,007300313	Standard Error	0,027483
Observations	9	Observations	9

Latitude-wise the equation, on the other hand is:

$$-48{,}89269763+0{,}092254876\ x - 0{,}000024093\ x^2$$

Therefore the expectation for the year 2005, if the trends keep on, will be 33,29474 for the longitude and 39,22369 for the lattitude, which would imply the following values for the changes in the centre of gravity with respect to the year 2000.

Table 3 the variability information for the study on the urban localities

	2005	**2010**	**2015**
longitude	33,29	33,27	33,27
latitude	39,22	39,2	39,18
Change in longitude	-0,071	-0,028	0,004
Change in latitude	-0,023	-0,022	-0,024
Change in y (km)	6,154	2,418	0,354
Change in x (km)	2,506	2,47	2,624
Total Change(km)	6,645	3,457	2,648

Table 3 suggests that by 2005, a return to the 1985 values may occur, implying a relative decline in the change on both axis. The trend seems to follow up, based on the model, through 2010 and 2015, returning well back to the trends before 1980's.

If we are to observe the trends in the changes in the axis, we should therefore take the derivatives in both directions. The functions for the latitude and the longitude in order in this case will be...

Longitude : $165{,}418274079 - 0{,}249740142032\ x + 0{,}0037347694015\ x^{3/2}$

Latitude : $0{,}092254876 - 0{,}000048186\ x$

These values suggest that the change in the longitude values will drop down to 0 by 2012 (the previous "turning point" having been observed through 1962). From that point onwards, a reversal to the East is forecast. The equation attitudinise seems to offer a shift towards the North.

However, it should be noted that each of these values include the following variance terms in themselves. These variances are calculated based on the whole set of latitude-longitude values for all of the cities in Turkey.

Table 4 The variability information for the study on city centres

	1955	**1960**	**1965**	**1970**	**1975**	**1980**	**1985**	**1990**	**2000**
Std longitude	4,777	4,762	4,763	4,763	4,733	4,752	4,744	4,727	4,717
Std latitude	1,473	1,476	1,479	1,485	1,501	1,505	1,515	1,531	1,548
Appr.Std in x(km)	162,294	162,594	162,983	163,588	165,363	165,809	166,847	168,630	170,528
Appr.Std in y(km)	410,565	409,297	409,397	409,518	407,119	408,705	408,122	406,854	406,180
Overall std	441,478	440,410	440,646	440,984	439,421	441,058	440,910	440,416	440,525
Std Error long	0,059	0,059	0,059	0,059	0,058	0,0587	0,05857	0,0584	0,0582
Std Error lat	0,018	0,018	0,018	0,018	0,019	0,0186	0,0187	0,0189	0,0191
Overall std error x	18,033	18,066	18,109	18,176	18,374	18,423	18,5386	18,737	18,948
Overall std error y	45,618	45,477	45,489	45,502	45,235	45,412	45,3469	45,206	45,131
Overall std error	49,053	48,934	48,961	48,998	48,825	49,006	48,99	48,935	48,947

The standard deviation values for the individual locations of the city centres are quite high (pointing at a 440 km-radius variance). However, since we are basically dealing

with the average value of the cities, it is more plausible to use the standard error term, which is achieved by dividing the standard deviation values through the square root of the number of city centres, which means the square root of 81, being 9. The resulting standard error terms nevertheless do not go any below 50km. This indeed puts the very expectations for the centroids under question.

If we follow with a hypothesis on normality and calculate the standardised values for the change from the previous years and see the p-values for the hypothesis that the mentioned differences in both axis are greater than 0 (having it as the alternative hypothesis), we may see that the following numbers emerge:

Table 5 p-values for the significance of the change for city centres

	1960	**1965**	**1970**	**1975**	**1980**	**1985**	**1990**	**2000**
p-value for the change in x(km)	0,48942	0,4583	0,4593	0,4063	0,2809	0,3386	0,19445	0,2419
p-value for the change in y(km)	0,48256	0,4772	0,476	0,4365	0,4846	0,4513	0,44306	0,4334
p-value for the total change(km)	0,48448	0,4693	0,4691	0,4244	0,3659	0,3956	0,30031	0,3307

Table 5 does suggest that none of the changes in between the 5-year intervals can be found significant enough to rely on the mentioned claim at 10% alpha.

However, once the change from 1975 until 2005 is to be put under question, the p-values presented on table 6 may be observed:

Table 6 p-values for the significance of the total change between 1975 and 2000 for city centres

p-val. For Δx(km)	**p-val. For Δy(km)**	**p-val. for ΔT(km)**
0,005112688	0,346749242	0,060713959

It may therefore be noted that the change in x and the total tendency to change are remarkable, whereas the change in y is not as apparent (still at 10% alpha).

Based on Urban Centres

An alternative approach to finding the centre of gravity may be to work on the urban localities (defined to be having a population of 10000 or more.)

Again, in order to calculate the centre of gravity of the Turkish population with breakdowns at urban level, a weighted average of all the urban centres in Turkey with a population of 10000 or above has been taken.

Unlike the city- based formulation where the centre of gravity for the population has remained more or less the same until the mid-20th century, the change of the urban localities does follow on a steady trend from the very founding of the republic.

Therefore, the centre of gravity for the years 1927 to 2000, should be calculated for each census as may be found on table 7.

Table 7 the Change in the centre of gravity for the urban localities

	1927	**1930**	**1935**	**1940**	**1945**	**1950**	**1955**	**1960**	**1965**	**1970**	**1975**	**1980**	**1985**	**1990**	**2000**
Longitude	31,46	31,73	32,01	32,02	32,07	32,24	32,4	32,51	32,57	32,73	32,81	32,23	32,29	32,32	32,27
Latitude	39,68	39,64	39,57	39,57	39,56	39,55	39,49	39,45	39,45	39,44	39,41	39,57	39,49	39,49	39,52
Change in longitude		0,270	0,280	0,009	0,043	0,173	0,160	0,108	0,067	0,154	0,079	-0,580	0,063	0,032	-0,049
Change in latitude		-0,042	-0,068	0,000	-0,008	-0,015	-0,052	-0,040	-0,007	-0,010	-0,027	0,164	-0,083	-0,002	0,029
Change in y (km)		23,095	23,994	0,795	3,691	14,825	13,692	9,295	5,720	13,200	6,760	49,844	5,417	2,736	4,200
Change in x (km)		4,646	7,519	0,024	0,863	1,715	5,810	4,438	0,770	1,109	2,998	18,193	9,198	0,214	3,244
Total Change(km)		23,564	25,156	0,795	3,791	14,925	14,879	10,303	5,771	13,248	7,396	53,006	10,676	2,745	5,306
D x/ Dy		4,971	3,191	33,59	4,279	8,646	2,356	2,094	7,425	11,907	2,255	2,740	0,589	12,773	1,295

The visual depiction of this change on the other hand is shown on figure 2.

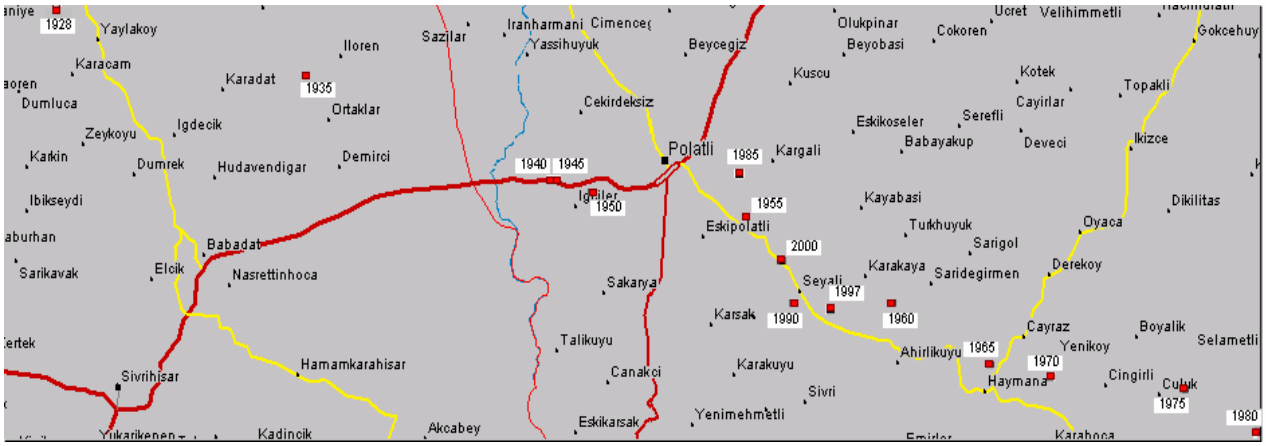

Figure 2 the Change in the Centre of Gravity for the urban Localities

It is striking to see that the centre of gravity for the urban centres follows a bias towards the East until 1980's, from when onwards, a cyclic pattern may be observed. The change in the centre of gravity on the other hand, has been much more significant than the change in the centre of gravity for the overall population, although subject to more deviation in magnitude rather than a steady increase observed for the former. The highest shift seems to have taken place from 1980 until 1985, of a magnitude almost as high as the past 30 years combined, albeit in the opposite direction. The movement takes place in the border of Ankara and Eskişehir.

Until the last decade, it seems that the movement had a stronger effect on the horizontal (East-West) axis than on the vertical (North-South) with ratios ranging from 2 to 12 times.

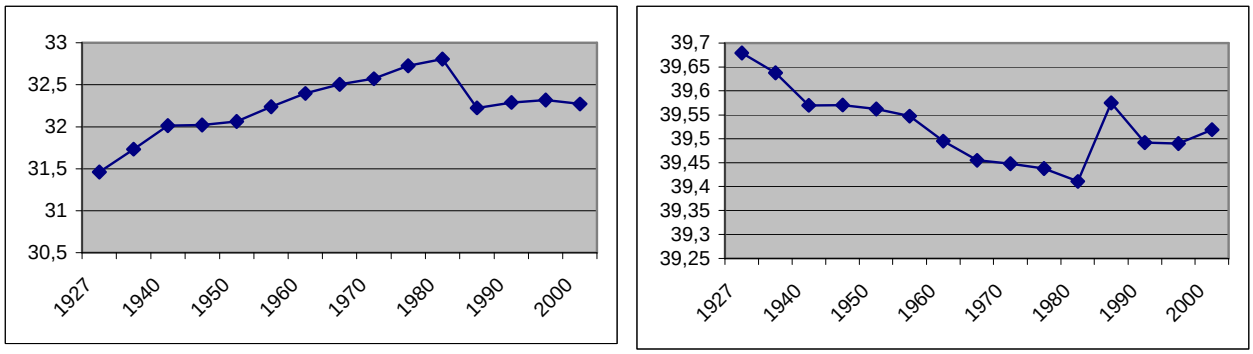

Figure 3 The time series data for the change of the centre of gravity for the longitudes(Left) and the latitudes(Right)

It can be seen from the graphs on figure 3, that the trends for both directions are more oscillatory. Indeed this allows us to use sinusoidal functions in guessing about the best fit. Therefore, various combinations of sinusoidal functions and quadratic forms were used to come up with the explanatory functions.

Another interesting result was that both functions resembled each other in the broad sense. Indeed, when they are regressed onto each other, a correlation of 94.5% can be attained. This may help us in understanding that the trends that made the centre of gravity for the town centres move had definitive attraction centres located towards alternating axis, based on the policies, overall aiming towards the Northwest or the Southeast in turn.

The equation for the longitudes has turned out to be:

$$795{,}1 - 42*10^{-15}\, x^5 + 6.4 * 10^{-5}\, x \sin x - 0.035\, e^{\cos x} - 197379 \tan(1 / x)$$

Table 8 the Regression Statistics for the longitudes and the latitudes of Urban Localities

Regression Stats for longitudes		*Regression Stats for latitudes*	
Multiple R	0,956681	Multiple R	0,915703
R Square	0,915239	R Square	0,838512
Adjusted R Square	0,881335	Adjusted R Square	0,794470
Standard Error	0,122261	Standard Error	0,034189
Observations	15	Observations	15

The equation for the latitudes, on the other hand has turned out to be:

$$-110{,}4 + 8.3*10^{-16}\, x^5 - 1.55 * 10^{-5}\, x \sin x + 38800 \tan(1 / x)$$

Therefore the expectation for the year 2005, if the trends keep on, will be 32,232 for the longitude and 39,513 for the latitude, which would imply the values on table 9 for the changes in the centre of gravity with respect to the year 2000.

Table 9 The forecasts for the centre of gravity for the urban localities

	2005	2010	2015
Longitude	32,232	32,14	31,93
Latitude	39,5133	39,54	39,58
Change in longitude	-0,039	-0,091	-0,210
Change in latitude	-0,006	0,023	0,046
Change in x (km)	3,378	7,845	18,038
Change in y (km)	0,659	2,547	5,100
Total Change(km)	3,442	8,247	18,739

Table 9 suggests that the trend towards the Northwest will continue and by 2015, large displacements may occur. It is as well assumed that the centre of gravity will by 2015, go well further Northwest than how it used to be in 1950.

Since the oscillatory motion will be kept in the model in the trend functions as well, up's and down's may be expected to follow one another. However, the functions do suggest that the amplitude of the oscillation may be expected to drop over time, which indeed seems to be the case.

The Standard deviation associated with each point on the other hand is given on table 10.

Table 10 The variability information for the study on the urban localities

	1927	1935	1940	1945	1950	1955	1960	1965	1970	1975	1980	1985	1990	2000
Std longitude	4,706	4,722	4,766	4,780	4,739	4,709	4,679	4,707	4,637	4,620	4,854	4,859	4,699	4,675
Std latitude	1,489	1,519	1,536	1,532	1,539	1,555	1,556	1,548	1,548	1,553	1,536	1,650	1,552	1,606
Appr.Std in x(km)	164	167,3	169,1	168,7	169,5	171,2	171,4	170,5	170,5	171,1	169,1	181,6	171	176,8
Appr.Std in y(km)	402,7	404,3	408,4	409,7	406,3	403,7	401,4	404,1	398,1	396,7	416,9	416,4	403,2	401,2
Overall std	434,8	437,6	442,1	443,1	440,2	438,5	436,4	438,6	433,1	432	449,9	454,3	438	438,4
Std Error long	0,336	0,279	0,237	0,243	0,222	0,188	0,156	0,132	0,107	0,088	0,091	0,081	0,075	0,075
Std Error lat	0,034	0,029	0,025	0,025	0,023	0,02	0,017	0,014	0,012	0,01	0,009	0,009	0,008	0,009
Overall std error x	20,18	18,71	17,26	17,4	16,86	15,76	14,48	13,16	12,03	11	10,49	10,63	9,989	10,33
Overall std error y	49,57	45,21	41,69	42,26	40,42	37,16	33,92	31,18	28,08	25,5	25,86	24,37	23,56	23,44
Overall std error	53,52	48,93	45,12	45,7	43,8	40,37	36,89	33,84	30,55	27,77	27,9	26,58	25,59	25,61

The standard deviation values for the individual locations of the urban centres are even higher (at over 400 km-radius variance). However, as done for the city centres, a

normalisation using the number of town centres is done. 25km bench for the standard error, despite an accompanying steady decline, basically due to the increasing number of towns, cannot be crossed below.

As done with the city centres, if we follow with a hypothesis on normality and calculate the standardised values for the change from the previous years and see the p-values for the hypothesis that the mentioned differences in both axis are greater than 0 (having it as the alternative hypothesis), we may see that, except for the year 1985, none of the changes in the intervals can attain a p-value lower than 13%. However, the clear bias of a trend to move and the implications of the move make it obvious that there indeed is a move towards the southeast well before 1980, followed by a clear reversal.

Based on the GNP

As a final benchmark, the centre of gravity based on the GNP's at city-level has been calculated. The results obtained from this, together with the others are tabulated on Table 11.

Table 11 A comparison of the centroids based on GNP, urban localities and the population

	City Centres	Urban Localities	GNP
Longitude	33,366	32,27	32,12
Latitude	39,246	39,52	39,42
Std longitude	4,717	4,675	4,533
Std latitude	1,548	1,606	1,590
Appr.Std in x(km)	170,528	176,8	173,726
Appr.Std in y(km)	406,180	401,2	395,287
Overall std	440,525	438,4	431,778

This table clearly shows us that there is a strong correlation between the centre of gravity for the urban population and the centre of gravity for the GNP, and they happen to be located at quite a sizable distance. This partially is explained by the fact that GNP in Turkey is mainly centred around the urban localities.(Urban Localities in Turkey constitute 68% of the total population and more than 76% of all income)

It may as well be seen that these centroids are further to the West than is the centroid for the population of the city centres. This again is a consequence of the wide disparity between the East and the West of Turkey.

However, it may as well be noted that all of the results exhibit high variability. This may be assumed to be hampering their validity. One possible explanation for this could be that large growth poles in Turkey such as Adana, Izmir, Ankara and Istanbul are located quite apart from another. This also may be used to follow up on the argument that the variability is an inherent characteristic of the population, partially caused by the regional topology and settlement characteristics.

In a place where a sizable difference between the rural and the urban persist, one may predictably argue that a movement from the rural to the urban is due, given that

boundaries set against the free movement are not so strong (may they be the pecuniary or non pecuniary costs faced by individuals or those imposed through regulations).

Therefore, it may be assumed that the current disparity between the centre of gravity for the GNP, the urban and the city centres cannot be sustainable for a long time. One may see, watching the trends for the centre of gravity for the urban localities and the city centres that they have followed up on a diverging pattern except for the year 1985, where the urban localities indeed portrayed an exceptional pattern.

The changes in the centre of gravity are put together on figure 4. It is well clear on this map that the urban centres and the locus of population, although converging are still quite far one from another.

Figure 4 The centres of gravity found by the mentioned studies. The brown dots represent the centres of gravity based on urban centres and the green ones refer to the result obtained from city centres. The star represents the centre of gravity for the GNP

Clustering

Having laid out the centre of gravity for Turkey on various fronts, we may want to go on investigating for a possible nested hierarchy of such centres and define centres of gravity at various levels.

On doing this, our basic point of reference may be assumed to be Christaller's model on central places, since each increment in the number of clusters actually corresponds to a refinement in the explanatory power of that cluster and hence may be exploited so as to offer corresponding services. The basic difference though is that we are trying to see how much the relatively high variability may be dropped down at different levels, without necessarily seeking to define a perfect layout of superimposing circles at different levels having to totally include one another.

As table 12 suggests, for the population based calculation, the maximum variability for the latitudes can be dropped down to 1.72, 1.24and 0.99 as the number of clusters are increased to 5, 8 and 15 respectively. The same values for the longitudes follow as 1.12, 1.03 and 0.81.

Table 12 The Cluster centres at 8, 5 and 15 nodes together with the standard deviation involved within each cluster and the centroid information.(Based on the population on the Left and the GNP on the Right)

Pop

	LONG		LAT		
	Mean	Std	Mean	Std	% of Total
1	28,54	0,96	40,20	1,10	34,39
2	32,78	0,62	39,57	1,24	14,36
3	30,03	0,86	37,85	0,95	8,56
4	35,77	0,98	37,37	0,96	15,06
5	36,73	1,03	40,74	0,56	8,01
6	40,41	0,81	40,50	0,57	4,42
7	42,78	0,70	38,86	0,99	5,52
8	39,50	0,99	37,85	0,57	9,67
Max		1,03		1,24	
Std		0,15		0,27	

GNP

	LAT		LONG		
	Mean	Std	Mean	Std	% of Total
1	38,97	1,21	39,84	0,91	3,80
2	38,75	1,31	42,63	0,63	1,55
3	40,75	0,55	36,57	1,00	2,70
4	37,26	0,86	35,65	0,94	6,50
5	39,73	1,11	32,74	0,58	7,45
6	40,79	0,46	29,18	0,58	17,45
7	37,48	0,64	30,29	0,65	2,75
8	38,67	0,99	27,46	0,58	7,80
Max		1,31		1,00	
Std		0,32		0,18	

	LONG		LAT		
	Mean	Std	Mean	Std	% of Total
1	28,83	1,12	39,73	1,42	42,96
2	32,78	0,62	39,57	1,24	14,36
3	35,90	0,92	38,29	1,72	20,86
4	39,35	0,99	38,86	1,51	14,64
5	42,46	0,87	39,15	1,05	7,18
Max		1,12		1,72	
Std		0,18		0,26	

	LAT		LONG		
	Mean	Std	Mean	Std	% of Total
1	40,63	0,57	29,91	1,77	24,80
2	38,01	0,60	28,86	1,86	10,35
3	40,66	0,56	37,91	2,31	4,40
4	38,26	0,65	40,63	1,66	3,80
5	37,21	0,74	35,60	1,06	6,65
Max		0,74		2,31	
Std		0,07		0,45	

	LONG		LAT		
	Mean	Std	Mean	Std	% of Total
1	27,60	0,50	38,46	0,68	10,64
2	26,95	0,50	41,03	0,64	2,49
3	29,21	0,52	40,74	0,45	23,34
4	32,74	0,62	40,31	0,64	9,81
5	30,24	0,65	37,68	0,73	6,49
6	34,97	0,34	37,00	0,34	5,80
7	36,79	0,53	36,93	0,54	6,35
8	34,87	0,56	39,28	0,76	4,70
9	37,00	0,81	40,71	0,54	6,91
10	32,59	0,24	37,78	0,26	3,59
11	35,15	0,00	42,02	0,00	0,28
12	40,41	0,81	40,50	0,57	4,42
13	42,78	0,70	38,86	0,99	5,52
14	40,52	0,34	37,85	0,44	4,28
15	38,68	0,37	37,86	0,66	5,39
Max		0,81		0,99	
Std		0,22		0,24	

	LAT		LONG		
	Mean	Std	Mean	Std	% of Total
1	40,67	0,53	40,58	0,80	1,25
2	37,82	0,36	40,51	0,36	1,10
3	38,65	0,59	38,99	0,56	1,60
4	38,00	0,54	42,58	0,59	1,10
5	40,28	0,57	43,19	0,43	0,30
6	40,72	0,53	36,88	0,77	2,25
7	37,57	0,95	34,96	0,44	4,50
8	40,23	0,60	32,72	0,58	5,80
9	36,86	0,53	36,77	0,54	2,30
10	40,77	0,44	29,23	0,51	17,05
11	37,40	0,70	30,62	0,12	2,15
12	37,78	0,25	32,58	0,24	1,35
13	41,19	0,71	26,82	0,41	1,20
14	38,36	0,62	27,68	0,64	7,60
15	40,88	0,64	34,99	0,09	0,45
Max		0,95		0,80	
Std		0,16		0,21	

The standard deviation for the change in the standard deviations on the other hand, varies around 0.1 to 0.3, as the number of clusters is increased.

The same partitioning based on the GNP on the other hand gives the following results: the maximum variability for the longitudes can be dropped down to 2.13, 1.00 and 0.80 as the number of clusters is increased to 5, 8 and 15 respectively. The same values for the latitudes follow as 0.75, 1.31 and 0.95.

The standard deviation for the change in the standard deviations on the other hand, varies, although at a somewhat lower pace than the study on populations.

It may therefore be claimed that the variability within the classes for the longitudes are higher for the GNP-based calculations, whereas the same holds for the latitudes and the population based one. However, the variability values converge to each other as the number of clusters is increased.

The Clusters on the other hand turned out to be as on figure 5.

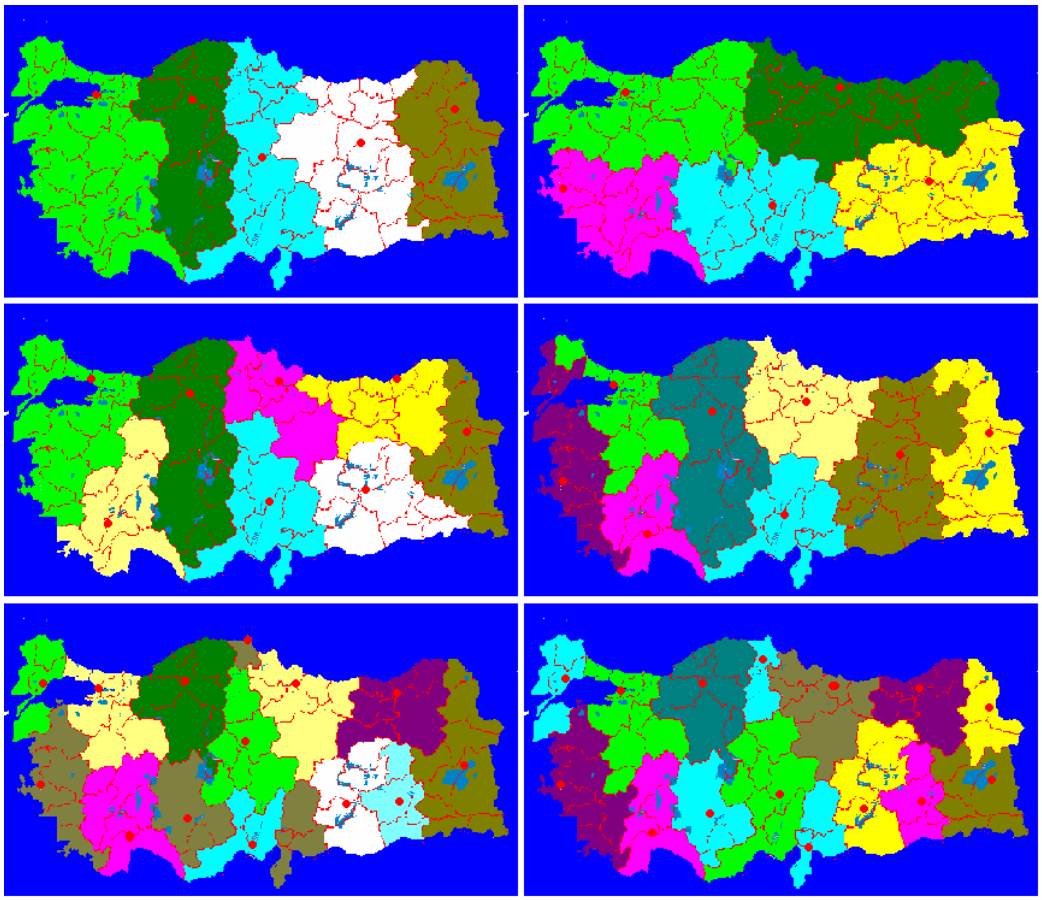

Figure 5 The Cluster Analysis carried out for the population (to the left) and the GNP (to the right) at 5, 8 and 15 nodes

As can be seen from the graphs, the GNP distribution in Turkey follows more centripetal tendencies-agglomeration axis- on a balanced scheme justified through an East-West axis and a North-South axis at the same time. Following on the assumption

that GNP is more in tune with the centre of gravity for the urban population, one may argue that this scheme indeed causes the Northwest-Northeast direction for the movement of the centre of gravity over time. Southern port Adana and its agricultural hinterland; Izmir on the Aegean and its historical hinterland; the industrial agglomeration elongated through Istanbul-Ankara axis are all quite clear in this setting when the map is to be divided into 5 regions.

The population distribution on the other hand follows more vertical axis. One reason for such an elongation may be due to the fact that population is mainly concentrated on two opposing seas, the effects of which cancel out each other to yield population foci around the Anatolian peninsula. Mountain elevation that keeps up through the West-East axis may also be causing empty islets between population concentrated areas, thereby alienating them into different agglomerations.

However, it is striking to see that as the number of clusters are increased to 8, although in the population clustering map, the general scheme is preserved with three clusters splitting up into smaller ones, as though to justify our claim on offsetting forces; the map for the GNP distribution is almost totally distorted, resembling somewhat more to the population scheme than before. This may be given as the reason why the variance for the longitudes increases following the shift. However, that the whole Aegean Coast should be unified and that, as the industrial agglomeration area around Istanbul is preserved, excluding Ankara, there have been triggered agglomerations between the Konya plain and the Ankara region. The concentration around the central Black Sea Region, the pattern left back at this area of less developed economic activity, is more reminiscent of the 5- cluster pattern for the population groups.

The 15-cluster maps on the other hand are almost the same, with the exception that Kayseri Region which developed in line with the Adana strip is included in that cluster for the GNP clustering and the Eastern provinces that differ in their involvement patterns with the border-trade are grouped into different clusters. This indeed signals that at a suitable level, clusters that concur may be proclaimed.
It is also interesting to note that these schemes vary in some parts from the various clusters proposed for Turkey, and keeping in mind that none of these clusters were

sustainable, although partially due to political decisions, one may tube lead into thinking that these patterns should be better investigated.

It may as well be observed that the centres of gravity for GNP are slightly closer to the industrial towns, than in the other setting, even when the clusters are the same.

Conclusions

It may be seen from the analysis that GNP distribution in Turkey is still quite different from the topology for the population itself.

This may be useful in trying to gauge administrative or economic decisions.

From an administrative point of view, or when it comes to offering services, it may be proposed that laying out the coordination centres in horizontal forms assumed by the cluster analysis and that designing incentive programs and development projects based on the GNP scheme may prove to be more efficient, since, following the fact that relatively lower variances may be achieved, locused around certain centres hence allowing for enhanced spread effects. To this end, based on the policy, certain variance caps may be proposed so as to specify which level of tolerance may be accepted while implying the projects. That the variance measures should be lower for more developed regions than poorer ones may be an obstacle nevertheless. Notwithstanding that, significant reductions may be reached.

Moreover, the relatively high descriptive nature of the functions proposed, which actually may be enhanced by adding on differential equations, may allow us to see how the population and economic patterns will change for the population at large. Policies based on the intuitive stabilisation nodes that the functions imply may be entertained to design for future allocation of funds. The theoretical framework that would suggest that all these centres will converge over the time, has also been tested through this research. It is seen that uniformity at a certain cluster level is already partially achieved and most probably either of the factors will align themselves to adjust to the other. In this research, it has been found that both the urbanisation (and

duly the GNP dispersion) and the population topology converge each other. Until 1980, it seems that the tendency for the urbanisation trend to dissipate throughout the rural part of the country has been prevalent. However, from that point onwards, the urbanisation has been more directed towards larger economic centres of the West. This may be partially due to the policies pursued by different policies undertaken under different governments. The high liberalisation movement in the 80's, the regime of insecurity and the constant ignorance cast on agriculture has partially caused the shift towards the West. However, we should also consider that, as a study carried out by Icduygu and Sirkeci implies, it is not always the least developed regions that provide the labour influx into the larger regions. Indeed, a region requires to have attained a level of development before giving out further immigrants to cities of higher orders, since the risk involved and the perception index which may be yet ripe may bring about reluctance to venture long distances for rural parts. Therefore it may also be suggested that the previous trends to dissipate urbanisation towards the East have made it easier for, and indeed caused people to move towards the West.
One should nevertheless take it in account that all of the assumptions involve high variance terms which weaken their validity.

Moreover, the number of nodes used for the study was relatively confined. The claims should therefore be tested against various other parameters implying welfare and more data shall be collected to go into further investigation at least to be more confident on the functions that have been observed. This may also require going back into historical data which, for Turkey, is often either inexistent or not reliable.

Another future research may include an evaluation of the existing layout of the shopping malls and or administrative scheme under the light of these findings, hence have an empirical point of reference.

Notes on the Methods used:

On calculating the clusters, two-stage least-squares regression method was used, through SPSS Statistics Software. This technique uses instrumental variables to produce regressors that are not contemporaneously correlated with the disturbance. Parameters of a single equation or a set of simultaneous equations can be estimated. This way, a common analogy so as to minimise the distance between the centroids is found. For more detailed information on the method, please refer to SPSS 11.5 Syntax Reference Guide Base System Advanced Models through www.spss.com. One addition done though was to normalise the values before entering them on the SPSS Menu and converting them back to normal values. The position of Turkey causes different distances to emerge between consecutive the Longitudes and the Latitudes (by a factor of 1.33). Since the distances are calculated on Euclidean norms, a normalisation so as to be able to reach actual distances by done, simply by taking out the minimum value from each latitude, multiplying them with the difference coefficient and adding up the minimum value back again and doing the reverse when the results are found. It is worthwhile to note that this causes the standard deviation to require a back-normalisation procedure.

The general method by which the approximate values for actual distances were given was first to express each coordinate in radians (by dividing through pi and multiplying through 360- the total number of longitudes that span the earth) and then using

ACOS(SIN(lattitude1) x SIN(lattitude2)+COS(lattitude1) x COS(lattitude2)
x COS(longitude1-longitude2)) x 6371

to make use of the spherical coordinates of the earth using the 6371 value which has been found to be more or less standard for Turkey.

As a final notice, the weighted averages are found by multiplying each of the coordinates by the weights of the centres and taking their average. For a more detailed explanation of the method used, you may refer to the Geography Division U.S. Census Bureau U.S. Department of Commerce Washington, DC 20233.

References:

Icduygu, Sirkeci, The Change in the centre of gravity for the urban localities, 2001, International Migration Vol.39

Centers of Population Computation, 2001, U.S. Census Bureau

David K. Undeland; Center of Gravity - Use and Misuse, 2001 NAVAL WAR COLL NEWPORT RI JOINT MILITARY OPERATIONS DEPT

Guchuan Liu, Gravity Center Analysis Using ArcView and Avenue, 2000

Gürsel,S.,Levent H.,Selim,R., Poverty and Income Distribution based on individuals for Turkey,2000,TUSIAD, Istanbul

Dinler, Zeynel, Regional Economics, 2001, Ekin Kitabevi Yayinlari, Ankara

Loxanne 2001 mapping and GIS software / www.loxane.com – the geographical coordinates based on urban localities and city centres and the maps

www.websters.com- definition and the use in aeronautics for the centre of gravity

DIE-State Statistical Institute of Turkey – the GNP Values for 2001, based on the cities; - the changes in the population at city and urban localities level; - the income distribution based on the residence, 2001

Graeme Hugo ,Regional Development Through Immigration? The Reality behind the Rhetoric, Australian Social Policy Group, 1999

Tutluoglu, C., Altınel, K.,"Optimal Dealer Network for Private Cars for the Mercedes Benz Turk Co.", 2003 –not published

Boratav, Korkut, The History of Turkish Economy, 2003, Imge, Istanbul