UNIVERSITAT JAUME•I

WORKING PAPERS

The agglomeration effect of the Athens 2004 Olympic Games

Economics Department

José M. Albert
Nikolaos Georgantzis
Jorge Mateu
José I. Silva

2012 / 02

Castellón (Spain)

The agglomeration effect of the Athens 2004 Olympic Games

José M. Albert
Universitat Jaume I
Department of Economics
albert@eco.uji.es

Nikolaos Georgantzis
Universidad de Granada
Department of Economics
ngeorgantzis@ugr.es

Jorge Mateu
Universitat Jaume I
Department of Mathematics
mateu@mat.uji.es

José I. Silva
Universitat de Girona
Department of Economics
jose.silva@udg.edu

2012 / 02

Abstract

In this paper, we analyze the spatial distribution of economic activity and labor market variables in Greece from 1980 to 2006. Using a distance-based method within a stochastic point process, we identify two periods with opposite trends regarding the concentration of economic activity in the Greek territory. First, twenty years (1980- 1999) of a moderately decreasing trend of agglomeration due to systematic efforts by the Greek governments to decentralize the economic activity away from the capital. Second, a short period (2000-2006) of sharp increases in agglomeration, coinciding –in space and time- with the public and private investments for the 2004 Olympic Games in Athens. In the same period, a similar effect of a smaller size is observed on the concentration of the labor force, employment and unemployment.

Keywords: Concentration, Olympic Games, D-function, L-function, K-function, point process, spatial economics.
JEL Classification: C15, C16, C21, L16, R10, R50.

The agglomeration effect of the Athens 2004 Olympic Games*

José M. Albert
Universitat Jaume I
Department of Economics
albert@eco.uji.es

Nikolaos Georgantzis
Universidad de Granada
Department of Economics
ngeorgantzis@ugr.es

Jorge Mateu
Universitat Jaume I
Department of Mathematics
mateu@mat.uji.es

José I. Silva
Universitat de Girona
Department of Economics
jose.silva@udg.edu

October 25, 2011

Abstract

In this paper, we analyze the spatial distribution of economic activity and labor market variables in Greece from 1980 to 2006. Using a distance-based method within a stochastic point process, we identify two periods with opposite trends regarding the concentration of economic activity in the Greek territory. First, twenty years (1980-1999) of a moderately decreasing trend of agglomeration due to systematic efforts by the Greek governments to decentralize the economic activity away from the capital. Second, a short period (2000-2006) of sharp increases in agglomeration, coinciding -in space and time- with the public and private investments for the 2004 Olympic Games in Athens. In the same period, a similar effect of a smaller size is observed on the concentration of the labor force, employment and unemployment.

Keywords: Concentration, Olympic Games, D-function, L-function, K-function, point process, spatial economics.

JEL Classification: C15, C16, C21, L16, R10, R50.

1 Introduction

Greece is the birthplace of the Olympic idea. The city of Olympia hosted all the games during the ancient times. This inspired Baron De Coubertin's dream of a revival of the games in Greece, which was fulfilled in 1896, when the first Modern Olympics were hosted by the city of Athens. Since then, it is commonly believed[1] that cities and countries hosting the games enjoy short and long run benefits which are experienced in the form of an accelerated GDP growth. On the 100th anniversary of the modern revival of the Games, Atlanta hosted the 1996 Games against a frustrated Athenian candidature, which was resubmitted and finally crowned with success eight years later. Most Athenians, together with their national and municipal authorities, celebrated euphorically the occasion, convinced that these Games would mean an unprecedented turning point in their way to modernization. The present financial and political crisis in Greece shows that some of

*N. Georgantzis acknowledges financial support by the Spanish Ministry of Education and Science (ECO2008-04636) and the Junta de Andalucía (P07-SEJ-03155). José M. Albert acknowledges financial support by the Spanish Ministry of Science and Innovation (project ECO2008-06057/ECON) and Bancaixa (project P1-1B2010-17.)

[1] And often rigorously predicted, as in Humphreys and Plummer (1995)[10].

these hopes never came true. In fact, despite the initial euphoria on the expected gains from hosting the games, many researchers have expressed their doubts concerning the impact of the 2004 Games on the Greek Economy. Related to the issue studied in this paper, several studies have informally mentioned possible negative environmental and congestion effects. For example, during his speech at a symposium *before* the Athens 2004 Olympics, 2002, Professor Ioannides (2002)[11] of Tufts University asked the question whether Attica (the area around the capital city of Athens) would become a more livable place after all the Olympic projects were completed than it had been before. He could have hardly been more prophetic when he expressed the fear that the broad area around Athens would actually become less livable. His guess was based on the observation that spending by the Greek Government on complementary projects was concentrated almost entirely in the Athens Basin. Furthermore, these projects were intended to deal with problems of peak demand rather than with the overall development of the country in the long run.

The total cost of the 2004 Athens Olympic Games was approximately 11.2 billion euros. Only 20.1% of this expenditure was privately funded. Olympic activities absorbed 2.2 billion euros in capital and 2.3 billion euros as operational expenditures. It had been initially hoped that investments in infrastructure which is not directly related to the Games would have some non-transitory effects on the Greek economy. Employment was a top priority target. However, fulltime employment at a national level remained invariant, although, on the contrary, full-time employment in the sectors related to the games (construction, tourism, etc.) increased by over 6%.

Several studies have reported transitory effects of hosting the Olympic Games at the aggregate level. For example, Veraros and Kasimati (2004)[20] reported a significant positive impact on the Athens Stock Exchange of the announcement that Athens was chosen to be the host of the 2004 Games. Recently, Kasimati and Dawson (2009)[12] presented a macroeconomic study reporting modest, if any, financial gains to the Greek economy. This rather pessimistic ex post evaluation of the economic impact of the 2004 Games contrasted with previous ex ante studies by Papanikos (1999)[17] and Balfousia-Savva et al. (2001)[2] who had predicted an increment in annual GDP growth of 0.50% for a period of 6 years. To be fair with the 2004 Games in Athens, a number of studies on previous Games cast doubts on the economic gains obtained by the hosts countries in general. To mention some examples of such studies, Baade and Matheson (2002)[1] report that the 1984 Los Angeles Olympics and the 1996 Atlanta Games had only a transitory impact on unemployment. Also, Madden (2006)[13] found that studies which were aimed at ex ante evaluating the economic consequences of the 2000 Sydney Olympics had been systematically optimistic.

It is reasonable to suspect that the the 2004 Olympic Games affected the geographic distribution of economic activities. For a country like Greece, where almost 50% of the population lives in the congested and polluted Capital city of Athens, this question is anything but trivial. One needs little statistical information to guess how difficult life had been already in Athens over the second half of the twentieth century, less than a century after the 20.000 inhabitants' town of the end of the 1800's had become a four million citizens' capital, and among the largest cities in Europe. Apart from a strong negative effect on the development of other areas in Greece, this agglomeration of people, public authorities and firms in the area of Athens became the cause of severe traffic congestion and a real environmental disaster. Following the re-establishment of Democracy, Greek governments tried a plethora of policy measures aiming at and partly achieving a solution to the problems of inefficient agglomeration, air pollution and congestion.

Strangely, none of the studies on the economic consequences of the 2004 games has addressed the issue of possible effects on the geographical agglomeration of economic activities. In this paper, we use a distance-based method to analyze the evolution of economic activity agglomeration in Greece around the period in which the 2004 Athens Olympic Games took place. We show that the slow decentralization process induced by the Greek governments over the last 20 years was severely reversed by the 2004 Olympic Games and that the resulting agglomeration process has continued over the two subsequent years, 2005 and 2006 for which data are available on the geography of economic activities in Greece. An agglomeration effect of a smaller size is observed on the the labor force and employment.

The rest of the paper is organized as follows. Section 2 shows the statistical framework and the methodology used for the estimation of the proposed spatial statistical functions; in section 3 we develop the empirical application and finally, in the section 4, some closing considerations are made. Technical details on the statistical methodology used are placed in the appendix. In this paper, the distance unit in all Figures is 1000 kilometers.

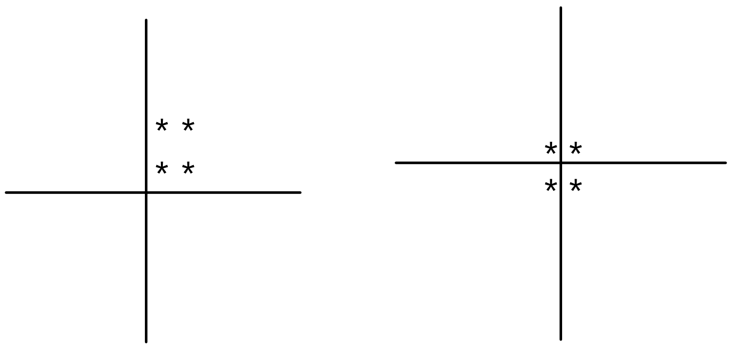

Figure 1: The cluster level of a certain points set can depend on the regional borders

2 Statistical framework and methodology

Work on the characterization of the spatial distribution of economic activity has focused mainly on the calculation of traditional indices such as those defined by Herfindahl, Gini, or Ellison and Glaeser (1997)[9]. These methods evaluate the heterogeneity of the spatial structure at a single geographical level. That is to say, concentration is generally evaluated at an administrative scale. In this paper, we applied tools which use distance-based methods, thus avoiding (see Figure 1) one of the most annoying problems of traditional indices, that is, the modifiable areal unit problem, which refers to their dependence on the particular administrative scale chosen. So, we use spatial statistical techniques based on point processes, as Ripley's K function, Besag's L function and the Diggle and Chetwind D function, together with Monte Carlo simulation envelopes.

A point process is a stochastic model governing the locations of events[2] $\{s_i\}$ in some set A, a bounded region in R^2 (Cressie, 1993[5]). A spatial point pattern is a collection of data $\{s_i = (x_i, y_i) \quad i = 1, ..., t\}$ consisting of t locations in an essentially planar region. A fundamental assumption in the analysis of such data is that they can usefully be regarded as a partial realization of a stochastic point process (Cox & Isham, 1980[4]).

A point pattern with intensity λ for which all the points are independent and randomly located within the region is called a homogeneous Poisson point pattern, which is a realization of a homogeneous Poisson point process. The homogeneous Poisson point pattern is considered the benchmark of *complete spatial randomness* (CSR).

[2]We often call these points events to distinguish them from arbitrary points.

The inhomogeneous Poisson process is a class of processes where the intensity λ_s is a function of the location s. If for an inhomogeneous point process we allow the intensity function itself to be stochastic, then we obtain a *doubly stochastic* process called a Cox process.

A detailed presentation of both, Ripley's K function and Cox processes can be found in Appendix I. Here, according to Marcon and Puech (2003)[14], we will make a brief presentation of Ripley's K. The K function was proposed by Ripley (1976[18], 1977[19]), this function describes the spatial distribution of a set of points. The intensity is considered to be constant, and we use λ to denote the average intensity of points. For each point i of the subplot under consideration, supposing a completely random distribution, the expected number of points in a circle of radious r is $\lambda\pi r^2$. Points located inside the circle around point i are its neighbors. $K(r)$ is defined as the average number of neighbors divided by λ. Accordingly, CSR leads to $K(r) = \pi r^2$, and this value is used as a benchmark. Besag (1977)[3] normalized the K function to obtain as a benchmark the value of zero:

$$L(r) = \sqrt{\frac{K(r)}{\pi}} - r. \tag{1}$$

Hence, if a point pattern exhibits randomness, $L(r) = 0$. If it exhibits concentration, $L(r) > 0$. Finally, if inhibition (regularity) is present, then $L(r) < 0$.

Agglomeration phenomena are common in economics and should be treated with inhomogeneous point processes (cluster processes), rather than with standard homogeneous processes. Cluster processes constitute an important family of point processes useful to model patterns of two or more points, which are, on average, grouped together more frequently than the homogeneous Poisson hypothesis implies. Usually, cluster processes are built assuming a point process generating the center points of clusters (usually called *parents*) whose numbers and locations are distributed (see left hand side of Figure 2) according to a given *parent process*. Next, each parent produces new points, usually called *offsprings*, whose spatial positions are distributed according to a certain offspring process. Finally, parent points disappear, and only offspring points remain.

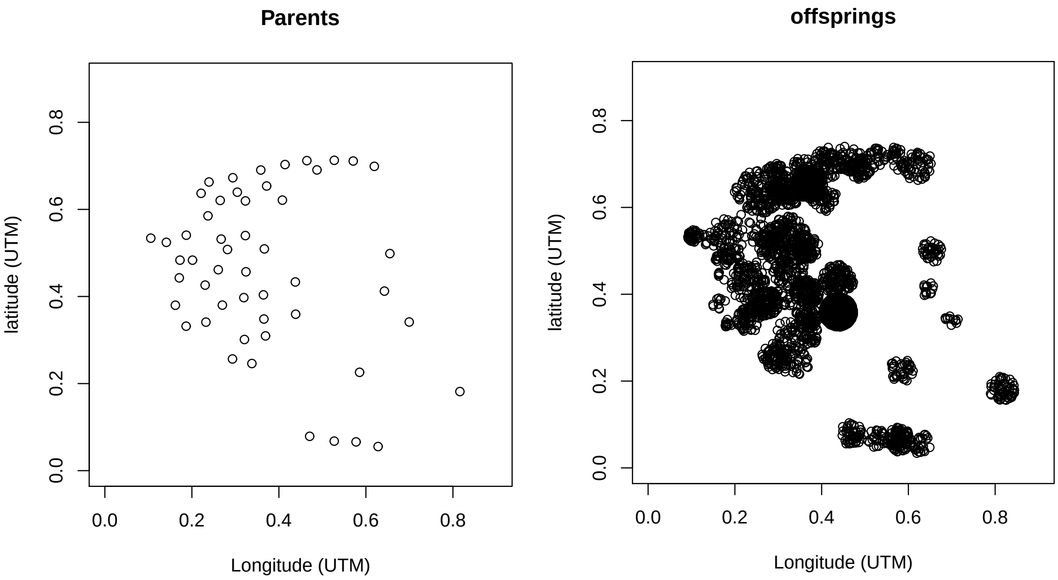

Figure 2: Greek regions location (left). Spatial distribution of economic activity in Greece, 1980 (right)

In this paper, to model the spatial distribution of economic activity in Greece, we assume a Cox parent process, with an offspring process (see the right hand side of Figure 2) generating random point patterns containing independent uniform random points in a circular disc centered in each parent location.

3 Data and empirical application

In this paper we have used six data sets. The first two are the values of the surface and the GDP of the 51 Greek regions, from 1980 to 2006, obtained from Eurostat at the NUT3 regional level. The next three correspond to the Greek labor market data (workforce, employment and unemployment), from 1999 to 2008[3], also obtained from Eurostat at the NUT3 regional level. The sixth data set contains the spatial locations in UTM coordinates of these Greek regions[4]. To model the spatial distribution of economic activity in Greece, we proceeded in two steps. First, we assume a cluster process whose realizations are cluster patterns, with parents set equal to the UTM coordinates previously obtained from the locations set (see the left hand side of Figure 2) of 51 Greek regions. Each parent represents the location of a single Greek region. Second, for each Greek region, we assume an offspring process that generates a random point pattern containing n_i $(i = 1, 2, ..., 51)$ independent uniform random points in a circular disc centered at each parent location, with n_i equal to GDP of the ith Greek region. Each circular disc has a surface $A_i = \pi r_i^2$, where A_i equals the ith Greek region surface. Proceeding like this for each Greek region, and using the 1980 GDP data, we obtain (see the right hand side of Figure 2) a point pattern that represents, the spatial distribution of economic activity in Greece for 1980. We should stress that the right-hand side of Figure 2 is *a* point pattern (not *the* point pattern) that represents, the spatial distribution of Greek GDP for 1980, given that the points inside each circular disc are randomly distributed[5]. Hence, in order to obtain a reliable measure of the concentration or dispersion of Greek GDP for 1980, we need to build a set of point patterns with 1980 data, and calculate the $L(r)$ for each of them, thus constructing Monte Carlo-based confidence intervals. In this paper we choose a confidence interval of 5% and, by fixing the original centroid for each region[6], we generate 200 simulations for each year inside a bounded planar area (see left hand side of Figure 3) containing the 51 Greek regions. The right-hand side of Figure 3 shows the confidence intervals obtained for the year 1980 and for a distance ranging from 0 to 200 km.

3.1 Evolution of the spatial distribution of GDP

Proceeding this way for the period between 1980 and 2006, we obtain that between 1980 and 1985, the concentration of GDP in Greece decreases, whereas between 1985 and 1992 it moderately increases (see Figure 4)[7] but remains lower than in 1980. Then, the concentration remains virtually unchanged until 1999. Interestingly, between 1999 and 2000 (see Figure 5) the concentration rises sharply, exceeding that of 1980. Furthermore, between 2000 and 2006 the concentration continues to increase. Observe that in 1980 the concentration reaches a maximum for a distance of 64 kilometers, while the absolute maximum is obtained for a distance of 144 kilometers. In 2006 there is only an absolute maximum for a distance of 64 kilometers, and this change occurs mainly between 1999

[3] The data available in Eurostat's regional labor market in Greece begin in 1999.

[4] To obtain these coordinates, for each region, we have searched the geographical coordinates of the area with most of the population within each region, using the software Encarta 98[15]. Next we transformed these geographic coordinates in UTM coordinates using the procedure of Morton (2003)[16]

[5] We don't know the spatial distribution of GDP within each region of Greece, so we have to simulate it.

[6] We are working with the inherent variability of the simulation method.

[7] In all figures showing confidence intervals, the order from top to bottom of the graphical representation of confidence intervals is the same as the legend labels.

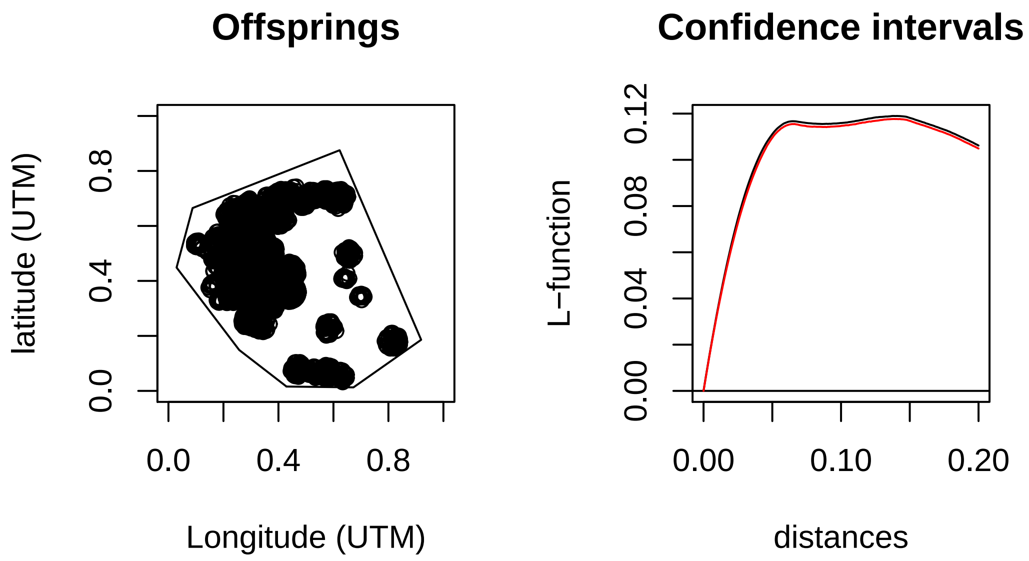

Figure 3: Greece, data of 1980: offsprings bounded area (left), confidence interval values (rigth)

and 2000, which is the time of announcement and initial investments for the 2004 Olympic Games.

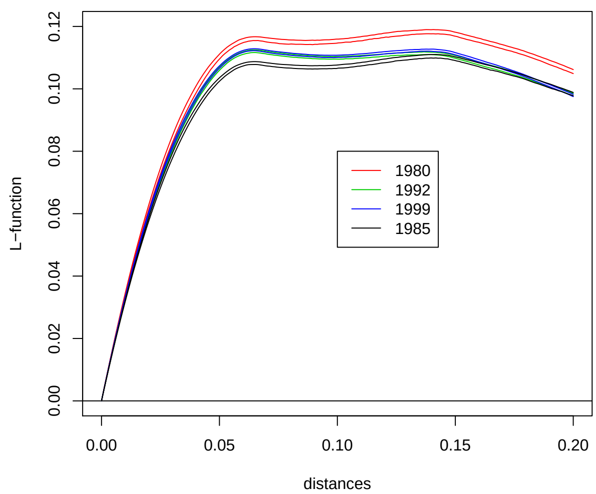

Figure 4: Confidence intervals for the L function for 1980, 1992, 1999 and 1985

It should be noted that, by using the K and L functions, we implicitly assume that the point pattern is homogeneous, i.e, it exhibits constant intensity of points. In our case it seems reasonable and realistic to consider heterogeneity in the spatial distribution of the economic activity in Greece (see right hand side of figure 2). In this context, Diggle and Chetwind (1991)[8] introduced the D function[8], defined as the difference between the K function for studied points (called *cases*) and the K function for the others (called

[8]Diggle and Chetwynd made its proposal based on the work of Cuzick and Edwards (1990)[6], and both works assumed unknown total population. In our paper the total populations are known, therefore we use a very simple approach to the D function.

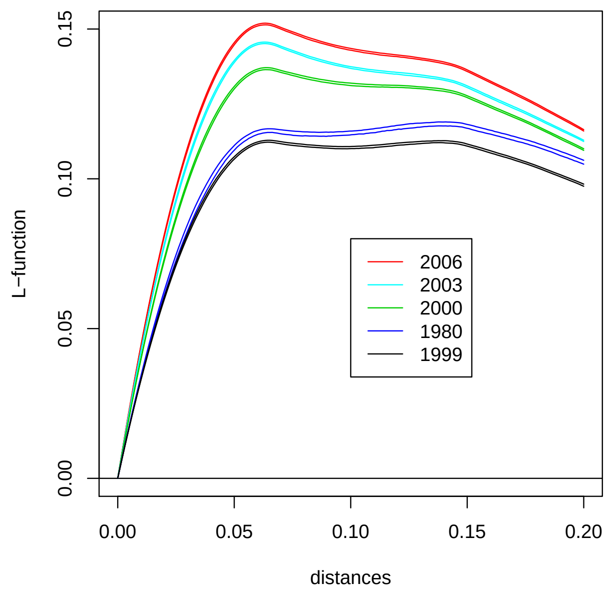

Figure 5: Confidence intervals for the L function for 2006, 2003, 2000, 1980 and 1999

controls)

$$D_r = K_r(cases) - K_r(controls) \tag{2}$$

The value of D depends on whether the cases are more dispersed or aggregated than controls. The D function shows dispersion or concentration relative to the controls. The controls constitute a benchmark capturing spatial heterogeneity. We compute the value of D function using as control population the K function values obtained for the spatial concentration of Greek economic activity in 1980, and using the others as the population of cases. We have then obtained the values of the D function for all the years ranging from 1981 to 2006. Figure 6 shows the main results. In this Figure, negative values of D function show that the spatial concentration is lower than for 1980, and positive values of D function show that the spatial concentration is higher than in 1980. Therefore, as we can see, the results reported above are robust to this alternative treatment.

Undoubtedly, between 1999 and 2006, the increase in the spatial concentration of economic activity in Greece was swift and strong. The question remaining to be answered is why this happens. To answer this question we refer to Table 1 and Figure 7. Table 1 shows, for three time periods, at current market prices, the average annual growth rates of GDP both in Greece and its two main regions (Athens and Thessaloniki). As we can see in this Table, between 1980 and 1985 the annual growth in the Athens region (7.22 %) was lower than that of Greece (8.96 %), and also lower than the region of Thessaloniki (9.51 %), and as we know, during this period the dispersion of economic activity in Greece increased. Between 1985 and 1999, the annual growth in the Athens region (11.22 %) was lower than that of Thessaloniki (15.62 %), but slightly higher than in Greece (10.89 %), and as we know, during this period the concentration of economic activity in Greece increased but remained lower than in 1980. Finally, between 1999 and 2006, the annual growth in the Athens region (15.16 %) was higher than in Greece (7.8 %), and much higher than in Thessaloniki (3.29 %). In fact, during this period, we see a negative growth in four Greek regions, for the first time in the period under study. As we know, during this period the concentration of economic activity in Greece rises sharply. Let us imagine now what would have happened if between 1999 and 2006 the GDP growth in Thessaloniki were that of Athens and vice versa. Figure 7 shows the response. The benchmark (the horizontal axis) is the 2006 spatial concentration of economic activity. This is used as the "control" of the D-function, and as a "case" we use the spatial concentration obtained assuming that the 2006 GDP growth in Thessaloniki were that of Athens in the same period, and vice versa. The D-funtion values of Figure 7 are negative for the entire range of distances, indicating that the dispersion is increased for any distance. From the above it follows that the swift and strong increase of Greek GDP spatial concentration is due to the large increase in economic activity in the Athens area, which in turn is because the region had to host the 2004 Olympic Games.

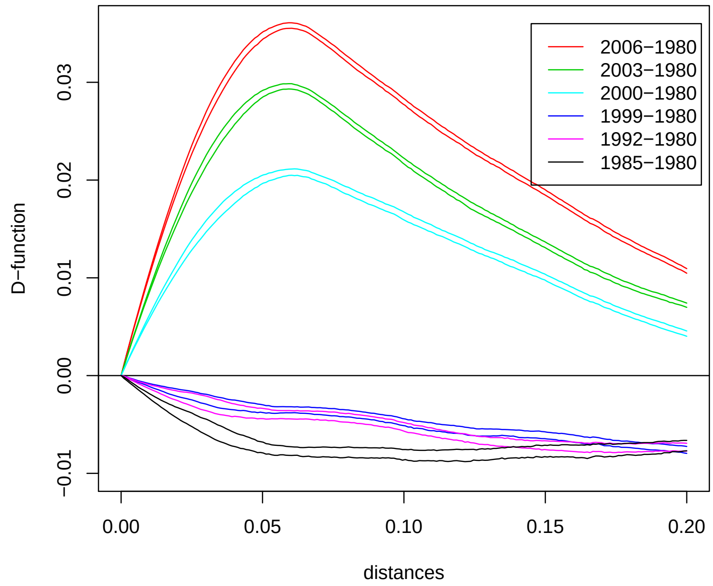

Figure 6: D function: Confidence intervals for 2006, 2003, 2000, 1999, 1992 and 1985

Table 1: Average annuals growth rates of GDP (current prices)

Region	1980-85	1985-1999	1999-2006
Greece	8.96 %	10.89 %	7.8 %
Thessaloniki	9.51 %	15.62 %	3.29 %
Athens	7.22 %	11.22 %	15.16 %

3.2 The agglomeration effect on the labor market

From the economic point of view, employment was a top priority target of the investments for the Olympic Games. To analyze the labor market effects of the increase in the spatial concentration of economic activity in Greece, we compute the value of the D function using as control population the K function values obtained for the spatial concentration in Greece in 1999. Unfortunately, there are no labor market data available for the years before 1999. In this case, negative values of the D function show that the spatial concentration is lower than for 1999, and positive values of D function show that the spatial concentration

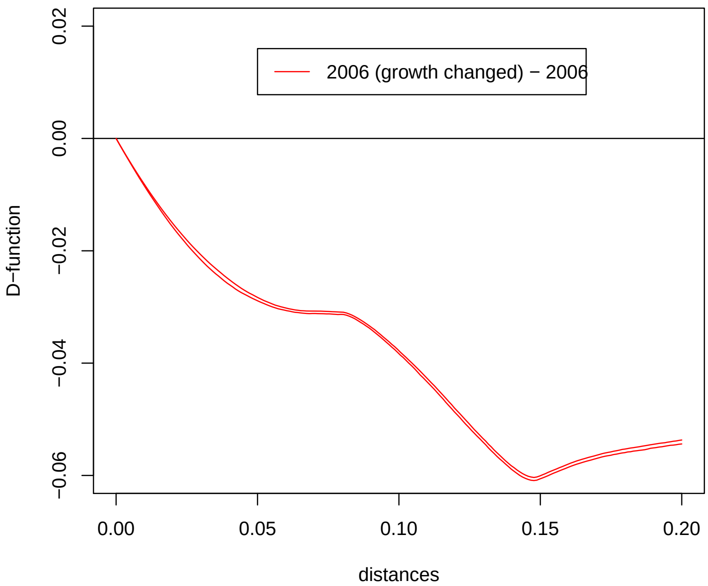

Figure 7: Changing the growth of Athens Thessaloniki (1999-06)

is higher than in 1999. For the economic activity, the results are identical to those we had obtained using 1980 as the control year. Between 1999 and 2006, there is an increase in the spatial concentration of economic activity in Greece (see the left hand side panel in Figure 8). For the labor market, we observe an increase in the spatial concentration of both the labor force and employment. More in detail, the D function values of the right hand side panel in Figure 8 and the left hand side panel in Figure 9 are positive for the all range of distances, indicating that the dispersion in the labor force and employment is reduced for any distance, although in a much lower magnitude to that observed on the economic activity.

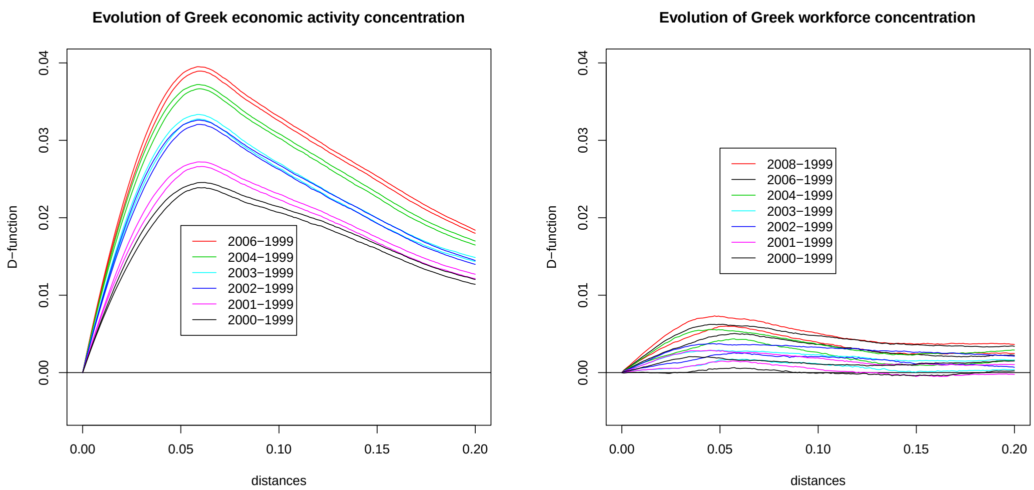

Figure 8: Comparison between economic activity and workforce.

Regarding the labor force, it is reasonable to expect such increase in the agglomeration

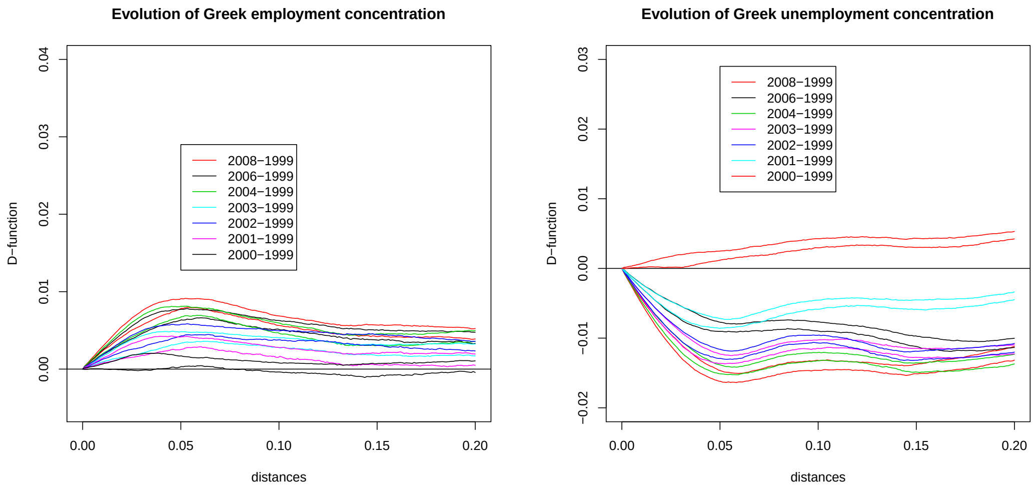

Figure 9: Comparison between employment and unemployment.

due to the migratory flow of workers from other regions (and even other countries) to Athens. Table 2 shows that between 1999 and 2006 the annual growth rate of the labor force in the Athens region (1.69 %) was higher than that of Greece (0.94 %), and also higher than that in the region of Thessaloniki (1.25 %).

With respect to the level of employment, its increase in the spatial concentration is also reasonable, as this variable is directly connected to what happened with resepcet to the economic activity. Table 2 shows that between 1999 and 2006, the annual growth of employment in the Athens region (2.51 %) was also higher than in Greece (1.49 %) and Thessaloniki (1.94 %).

Table 2: Average annuals growth rates of labor market variables between 1999 and 2006

Region	Labor	Employment	Unemployment
Greece	0.94 %	1.49 %	-3.10 %
Thessaloniki	1.25 %	1.94 %	-3.40 %
Athens	1.69 %	2.51 %	-3.90 %

Finally, what was observed with respect to unemployment depends on which effect dominates. On the one hand, if the increase in the flow of workers to the region of the Olympic Games is higher than the increment in employment, then we would observe an increase in the spatial concentration of unemployment, which would also be concentrated in the region of the Olympic Games. On the other hand, if the increase in the labor force results to be less important than that of employment, we expect a reduction in the spatial concentration of unemployment. In the case of Greece, the increase of employment in Athens was relatively higher to the flow of workers from other regions to Athens. As a result, the spatial concentration of unemployment was reduced (see the right hand side panel in Figure 9). In table 2, we observe a yearly reduction of 3.90 % in the number of unemployed workers in Athens, which is higher than the decrease of 3.10 % observed at the national level.

The regional disparities in the cost of living can be one of the reasons behind the smaller agglomeration observed in the labor market with respect to that of the economic activity. According to *Numbeo*, a free Internet database on the cost of living worldwide, although the median monthly disposable salary in Athens is 13.4 % higher than in Thessaloniki, the housing and restaurant prices are also, respectively, 18.1 % and 9.7 % higher. Thus, if we add the mobility costs and the possibility of an expected short-run employment effect of the Olympic Games, then we can expect a lower spatial concentration in the labor market than in the economic activity after the Olympics games.

4 Conclusions

The ongoing crisis has left few if any doubts that the Athens 2004 Olympic Games were just another missed opportunity for a successful restructuring of the Greek economy in a way guaranteeing sustained economic growth. Our results indicate that the failure has gone further than missing an opportunity for economic development. In this paper, we have analyzed the evolution of economic activity agglomeration in Greece around the period in which the 2004 Athens Olympic Games took place. Our findings are the first to shed light on a serious drawback of hosting the Games in a city which was already excessively polluted and congested. Specifically, while the overall impact of the Games on the Greek economy have been modest, if any, the effect of the Games on the agglomeration of Economic activity in the area of Athens have meant a sever reversal of a mild, but favorable decentralization process triggered by government policies over the last 20-30 years. This finding definitely outweighs any possible gains experienced by the Greek economy as a whole and calls for a more cautious examination of the advantages and disadvantages of hosting the Olympic games in already congested and polluted cities.

For the labor market, we also observe an increase in the spatial concentration of both the labor force and employment but in a much smaller magnitude. We argue that the regional disparities in the cost of living can be one of the reasons behind the smaller agglomeration observed in the labor market with respect to that of the economic activity. Further research related to the agglomeration effect on the labor market should consider the incentives and disincentives to move to the host city of the Olympic Games. Along this line, our future research will be focused on designing a job search model with matching frictions to capture the incentives for moving to the host city and their implications for the spatial distribution of the labor market.

References

[1] R.A. Baade and V. Matheson. *Transatlantic Sport: the Comparative Economics of North America and European Sports.* Edward Elgar, London, 2002.

[2] Athanassiou L. Zaragas L. Balfousia-Savva, S. and A Milonas. The economics effects of the Athens Olimpic Games. Technical report, Centre of Planning and Economic Research, Athens (in Greek), 2001.

[3] J. Besag. Some methods of statistical analysis for spatial data. *Bulletin of the International Statistical Institute*, 47:77–92, 1977.

[4] D.R. Cox and V. Isham. *Point processes.* Chapman & Hall, London, 1980.

[5] N. Cressie. *Statistics for Spatial Data.* John Wiley and Sons, New York, 1993.

[6] J. Cuzick and R. Edwards. Spatial clustering for inhomogeneous populations (with discussion). *Journal of the Royal Statistical Society, Series B*, (52):73–104, 1990.

[7] P.J. Diggle. *Statistical Analysis of Spatial Point Patterns.* Academic Press, London, 1983.

[8] P.J. Diggle and A.G. Chetwynd. Second-order analysis of spatial clustering for inhomogeneous populations. *Biometrics*, 47:1155–1163, 1991.

[9] Glen Ellison and Edward L. Glaeser. Geographic concentration in U.S. manufacturing industries: A dartboard approach. *Journal of Political Economy*, 105(5):889–927, October 1997.

[10] J.M. Humphreys and Plummer M.K. The economic impact on the state of Georgia of hosting the 1996 Olimpic Games. Technical report, Selig Center for Economic Growth, Georgia, 1995.

[11] Y. Ioannides. An economist' thoughts on the economic impact of Athens 2004. Unpublished Speech at the Athens 2004 Symposium, April 17 2002.

[12] E. Kasimati and P. Dawson. Assesing the impact of the 2004 Olympic Games on the Greek economy: A small macroeconometric model. *Economic Policy*, 26:139–146, 2009.

[13] J. Madden. Economic and fiscal impacts of maga sporting events: a general equilibrium assesment. *Public Finance and Management*, 6:346–394, 2006.

[14] Eric Marcon and Florence Puech. Evaluating the geographic concentration of industries using distance-based methods. *Journal of Economic Geography*, 3:409–428, 2003.

[15] Microsoft. Atlas encarta 98. Electronic publication, Microsoft, 1998.

[16] Alan Morton. Tm_ll.xls workbook. Electronic publication, Distribution mapping software (DMAP), www.dmap.co.uk, 2003.

[17] G. Papanikos. Tourism impact of the 2004 Olympic Games. Technical report, Tourism Research Institute, Athens (in Greek), 1999.

[18] B.D. Ripley. The second-order analysis of stationary point process. *Journal of Applied Probability*, 13:255–266, 1976.

[19] B.D. Ripley. Modelling spatial patterns (with discussion). *Journal of the Royal Statistical Society*, B 39:172–212, 1977.

[20] N. Veraros and E. Kasimati. The 2004 Olimpic Games announcement and its effect on the Athens and Milan stock exchanges. *Applied Economics Letters*, 11:749–753, 2004.

5 Appendix I

In this Appendix we show a detailed presentation of both, Ripley's K function and Cox processes. The interested reader is referred to the books of Diggle[7] and Cressie[5]

Definition 1. *A point process is a stochastic model governing the locations of events*[9] $\{s_i\}$ *in some set A, a bounded region in* R^2 *(Cressie, 1993[5]).*

Definition 2. *A spatial point pattern is a collection of data* $\{(x_i, y_i) \quad i = 1, ..., t\}$ *consisting of t locations in an essentially planar region.*

A fundamental assumption in the analysis of spatial point patterns is that they can usefully be regarded as a partial realization of a stochastic point process (Cox & Isham, 1980[4]). A useful way to describe an unknown-law process is through its first and second-order properties. Consider an area A supplying a realization of a point process. The number of points in A, *N(A)*, is a random variable with a first moment:

$$\mu(A) = E(N(A)) \tag{3}$$

The measure μ is also called the mean measure.

The process second-moment measure is:

$$\mu^{(2)}(A_1 \times A_2) = E(N(A_1)N(A_2)) \tag{4}$$

where A_1 and A_2 are sub-areas of A.

The first-order intensity is defined by

$$\lambda(s_i) = \lim_{ds_i \to 0} \frac{\mu(ds_i)}{ds_i} \tag{5}$$

where ds_i is the elementary area around s_i.

The process is homogeneous if $\lambda(s_i)$ is a constant. A process with $\lambda(s_i)$ depending on the location is a non-homogeneous point process.

The second-order intensity is defined by

$$\lambda_2(s_1, s_2) = \lim_{ds_1, ds_2 \to 0} \frac{\mu^{(2)}(ds_1 \times ds_2)}{ds_1 \times ds_2}. \tag{6}$$

Let us define another second-moment measure of the point process

$$\alpha^{(2)}(A_1 \times A_2) = \mu^{(2)}(A_1 \times A_2) - \mu(A_1 \cap A_2). \tag{7}$$

Then, $\alpha^{(2)}(A_1 \times A_2)$ is the measure of point pairs located one in A_1 and the other in A_2.

Usually, under continuity, $\alpha^{(2)}$ has a density function $\ell^{(2)}$ called the second-order product density. The two of them are related by

$$\alpha^{(2)}(A_1 \times A_2) = \int_{A_1} \int_{A_2} \ell^{(2)}(s_1, s_2) ds_1 ds_2. \tag{8}$$

[9] We often call these points events to distinguish them from arbitrary points.

One can interpret $\ell^{(2)}$ as the probability of one event in each elementary area ds_1, ds_2. If the process is isotropic, $\ell^{(2)}$ only depends on the distance r between the events s_1 and s_2 and it is denoted by $\ell^{(2)}(r)$.

The ratio

$$g(r) = \frac{\ell^{(2)}(r)}{\lambda^2} \tag{9}$$

is called point-pair correlation function.

A point pattern for which all the points are independent and randomly located within the region is called a homogeneous Poisson point pattern, which is a realization of a homogeneous Poisson point process, and for this process $g(r) = 1$. Any homogeneous point process is assumed to be a variation of the homogeneous Poisson point process. In addition, any inhomogeneous point process is assumed to be a variation of the inhomogeneous Poisson point process. For a cluster process $g(r) > 1$, and for an inhibitory process $g(r) < 1$. A homogeneous Poisson point process is both, stationary and isotropic.

For a homogeneous Poisson process, Ripley (1977)[19] showed that:

$$\frac{\nu(r)}{\lambda} = \int_{u=0}^{r} g(u)2\pi u du \tag{10}$$

where, if by *neighborhood of an event* we define all the points located at a distance lower than or equal to a given value r, the expected value of the number of neighbors is then $\nu(r)$, and u is any distance vector.

Ripley (1977)[19] defined the K function as:

$$K(r) = \int_{u=0}^{r} g(u)2\pi u du \tag{11}$$

The K function is a good indicator for spatial structures (Besag, 1977[3], Diggle, 1983[7], Cressie, 1993[5]). For a Poisson point process, $g(r) = 1$ holds. Hence, the expected number of points in a circle of radius r is $\lambda\pi r^2$, and therefore $K(r) = \pi r^2$. This value is used as a benchmark, while $K(r) < \pi r^2$ indicates dispersion and $K(r) > \pi r^2$ indicates agglomeration.

Besag (1977)[3] normalized the K function to obtain as a benchmark the value of zero:

$$L(r) = \sqrt{\frac{K(r)}{\pi}} - r. \tag{12}$$

Hence, if a point pattern exhibits randomness, $L(r) = 0$. If it exhibits concentration, $L(r) > 0$. Finally, if inhibition (regularity) is present, then $L(r) < 0$.

Definition 3. *For a positive real number λ , the set of events $s_1, s_2, s_3...$ in X is an homogeneous Poisson process with intensity λ if:*

1. *The number of events $s_1, s_2, ..., s_n$ in any bounded region $A \in X$ follows a Poisson distribution with mean $\lambda|A|$; being $|A| =$ surface of A.*

2. *The n events are uniform and independently distributed in A.*

In accordance with condition (3.1), the intensity λ is constant. The condition (3.2) avoids the existence of interactions among the events. In economics the presence of agglomeration phenomena is usual, and this kind of phenomena cannot be treated with homogeneous processes, so we must work with inhomogeneous point processes. Any inhomogeneous process defines a variation of the inhomogeneous Poisson process in the following way

Definition 4. *Let* $\lambda(s) : X \to \mathbb{R}_+$ *be a non-constant function on* X*. The set of events* $s_1, s_2, ..., s_n$ *in* X *is an inhomogeneous Poisson process if:*

1. *For each bounded region* $A \in X$ *the number of events* $N(A) = n$ *follows a Poisson distribution with mean* $\int_A \lambda(s)ds$*.*
2. *Given* n *events in* A*, the locations* $s_1, s_2, ..., s_n$ *in* X *form a random and independent sample of this distribution on* A *with a density that depends on the intensity function* $\lambda(s)$*,* $s \in A$*, and whose values depend on the different locations*

Definition 5.

1. *Let* $\Lambda\,(s)$*,* $s \in X$ *denote a non-negative stochastic process on* X*.*
2. *A realization of* $\Lambda\,(s)$ *is a Cox process if is an inhomogeneous Poisson process with intensity function* $\lambda(s) = \Lambda\,(s)$

The result of the realization inherits the properties of the process $\Lambda\,(s)$ in a natural way.