Regional Prosperity and Public Investment Distribution in Greece

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Abstract
The government aiming at reducing inequalities uses different types of public investment, while regional prosperity is associated with inequalities. Therefore an affective allocation of a Public Investment Program is of great importance and has aroused the interest within the years. Public spending on investment derives from the Public Investment Program (PIP) presented in the annual Budget of the Greek government. Throughout the past years the Greek government spent large amounts of money on investment projects in the Greek prefectures using political criteria. The question to be solved is whether there is a mathematical way of solving this regional allocation problem. In this context, the paper investigates the allocation of public investment using the corresponding rate of distribution found in literature. One of the various applications of regional multipliers is in regional policy depicting the regional inequalities. The rate of distribution that is examined is first described. Then a study is performed using this rate of distribution and data from Greece and the results are compared to the investment allocation in Greece. Finally a sensitivity analysis is performed and the derived conclusions are cited.

Keywords: Public investment, regional allocation, regional prosperity, regional multipliers.

JEL classification: R11, R12, R58

Introduction

One of the critical factors contributing to regional economic development is public capital. Therefore the government's decisions on public investment regional allocation are of great political concern among policymakers. The main industries in Greece are tourism, shipping, industrial products, food and tobacco processing, chemicals, metal products and mining. The main problems that the Greek economy faces are the high rate of unemployment, bureaucracy, corruption and tax evasion. The global competitiveness is low compared to the other European Union countries whereas economic growth has been diminishing since 2009. The ratio of loans to savings was over 100% during the first months of 2010, showing an existing trend of over-lending. The

problem of regional allocation of investment among a number of regions or among all regions in a country has been of increased interest to researchers in recent years. The key research question is how to allocate a budget among regions.

This paper analyses a method, among a significant number of different ones, used to solve the problem of public investment distribution. In contrary to the one analysed here, other methods use single- and multi-criteria maximization problems taking into consideration a number of constraints. In this paper the allocation depends on the calculation of the rate of distribution and the variables defining it. The data used for this application derive from the Hellenic Statistical Service (EL. STAT.) and from EPILOGI 2010. Before calculating the rate of distribution, an investigation is performed regarding the Public Investment Program in Greece for the years 2000-2010, presenting graphs and maps that depict the amount of public investments in the first decade of the 21st century in Greece. Then a case study is performed, calculating the amount of public investment allocated in each Nuts III - region (prefecture) using different five variables. The results are compared to the Public Investment Program implemented in 2010 and conclusions derive whether the regions were favoured or not.

Describing briefly the context of this article, the next section refers to a short review of the corresponding literature. In the following section a research is performed and the inequalities of the PIP allocation are presented in graphs and maps. Then the performed case study and its results are described. Finally a sensitivity analysis is performed and the conclusions are listed.

Methodologies for Public Investment Allocation

Over time, several methodologies were developed and the corresponding models were defined in order to address the problem of regional allocation of investment. A variety of methodologies regarding this problem can be found in literature. These methodologies deal either with private or with public investment. This paper's focus is on public investment. A number of researchers investigate the allocation only of one type of infrastructure but others contribute to the solution of allocating a number of infrastructures or the allocation of the total Public investment program in some regions or in the whole country. The usual allocated facilities found in literature can be airports, factories, schools, hospitals etc (Current et al., 2001).

The investment allocation problem has aroused the researchers' interest since the decade of 1950. In the early 1960' the problem investigated regards the allocation of the total public investment budget in two regions, which can be generalized for the application on the total number of the nation's regions (Rahman, 1963; Dorfman, 1963; Intriligator, 1964). These models proposed the use of one objective function (single-objective optimization models). Over time, it has increasingly being realized that the application of single-objective optimization models does not necessarily provide an adequate solution. The evolution of applied mathematics contributed to the introduction of new models using more than one objective functions to find the optimal solution. Multi-factor decision situations could be handled by optimization techniques that did not function or exist before. Multi-objective programming, therefore, has evolved to be an important tool in modern decision making and designing (Nijkamp and Rietveld, 1976).

The problem of public investment distribution can be defined assuming that country with a two region closed economy (Rahman, 1963). The national income of this country is equal to the sum of the income of the two regions:

$$Y = \sum_{i=1}^{n} Y_i = Y_1 + Y_2 \tag{1}$$

$$\begin{aligned} C_i &= c_i Y_i \\ I^t{}_i &= k_i (Y_i^{t+1} - Y_i^t) \\ s_i &= 1 - c_i \\ Y_i &= C_i + I_i \end{aligned} \tag{2}$$

$$(1) \overset{(2)}{\Rightarrow} \qquad k_1(x_{t+1} - x_t) + k_2(y_{t+1} - y_t) = s_1 x_t + s_2 y_t \tag{3}$$

Where:

Y_i	=	national income of this country is equal to the sum of the income of the two regions
C_i	=	consumption of each region
c_i	=	the rates of consumption of each region
I_i^t	=	investment is assumed to have a "gestation lag" of one year for each region
k_i	=	the familiar incremental capital/output ratios for each region
s_i	=	the rates of saving in regions A and B respectively

Investment is assumed to have a "gestation lag" of one year for each region and is equal to I_i^t for each region. Two extra constraints are imposed; the 'non-disinvestment constraint' where total investment is limited to total saving. (Rahman, 1963).

$$Y_i^{t+1} \geq Y_i^t \tag{4}$$

Following, the 'political constraint' is established where the regional income disparity cannot exceed a certain political tolerance limit in either direction (Rahman, 1963)

$$\frac{Y_2^{t+1}}{Y_1^{t+1}} \geq r_2, \quad \frac{Y_1^{t+1}}{Y_2^{t+1}} \geq r_1 \tag{5}$$

The problem is to maximize the equation (1) subject to conditions (3), (4) and (5).

Tian et al.(2007) on the other hand introduced a multi-criteria model using large number of criteria resulting a more efficient outcome. New objective functions are proposed in order to accomplish a relevant result. Time flow is introduced in the objective of final total income. The combination of time flow total income maximization and of total income gives a new objective that explains in a better way total welfare. So the total welfare objective can be written as follows (Tian et al.,2007):

$$MaxW = \eta \cdot \sum_{i=1}^{n}\sum_{j=1}^{m} \omega_i \xi_{ij} Y_{ij}(T) + (1-\eta)\int_{To}^{T} e^{-\mu(t-To)} \left(\sum_{i=1}^{n}\sum_{j=1}^{m} \omega_i \xi_{ij} Y_{ij}(t)\right) dt \quad (6)$$

where ω_i is the weight of region i, ξ_{ij} is the weight of sector j of region i, Y_{ij} is the income of region i of region j, μ is the exponential discounting factor.

Maximization of employment rate is important for the regional development. The employment objective is described as follows (Tian et al.,2007):

$$MaxP = \frac{\sum_{i=1}^{n} L_i(t)}{\sum_{i=1}^{n} N_i(t)} \quad (7)$$

s.t.

$$\frac{L_i(t)}{N_i(t)} \geq B \quad \text{and} \quad 0 < B < 0 \quad (8)$$

where L_i is the labor in region i ,N_i the population of region I and B is a lower limit of regional employment rate in order to achieve moderate employment rate and equity between regions.
The third objective formulating the model is about the cross-region income per capita gap minimization (Tian et al.,2007).

$$MaxE = (-1)\sum_{k,v=1}^{n}\int_{To}^{T} \left| Y_k(t)/N_k(t) - Y_v(t)/N_v(t) \right| dt \quad (9)$$

s.t.

$$I(t) = K'(t) + \gamma \cdot K(t) \quad (10)$$

$$L_{ij}(t) = \lambda_{ij} \cdot I_{ij} + C_{ij} \qquad \lambda_{ij}, C_{ij} > 0 \quad (11)$$

$$\begin{aligned} K'(t) = {} & r(t)\sum_{i=1}^{n}[(1-\sum_{k=1}^{n} b_{ij}) z_i \sum_{j=1}^{m} \varphi_{ij} Y_{ij}(t)] \\ & + (1-r(t)) \cdot \sum_{i=1}^{n}[(1-\sum_{k=1}^{n} a_{ij}) s_i \sum_{j=1}^{m} \phi_{ij} Y_{ij}(t)] - \gamma \sum_{i=1}^{n}\sum_{j=1}^{m} K_{ij}(t) \end{aligned} \quad (12)$$

$$Y(t) = \sum_{i=1}^{n}\sum_{j=1}^{m} A_{ij} K_{ij}(t)^{\alpha_{ij}} L_{ij}(t)^{\beta_{ij}} \quad (13)$$

Where:

γ	=	the current capital stock depreciating constant rate
λ_{ij}	=	the labor investment ratio of sector j of region i
I_{ij}	=	the investment on sector j of region i
C_{ij}	=	the necessary simple labor of sector j of region i
K(t)	=	the capital stock
r	=	the income tax rate
a_{ij}, b_{ij}	=	the proportions of capital transfer loss between regions

z_i, s_i = the rates of savings of public and private sectors respectively of region i

= the weight of public sector investment to sector j of region i

= the weight of private sector investment to sector j of region i

A_{ij} = the contribution of technological innovation to output of sector j of region i

α_{ij}, β_{ij} = the increase of output that will happen when the capital and simple labor respectively will increase 1%

The described investment allocation model is maximizing all three equations (6), (7) and (9) subject to the constraints (8), (10), (11), (12) and (13).

Trying to solve the problem of investment allocation researchers used indexes of regional inequalities. The aim of this paper is to distribute a national program of public investments taking into account the following two assumptions,

- The public investments constitute reduction of regional inequalities and therefore means of regional development.
- The distribution of the budget for the construction of public works usually in Greece use mainly political criteria and is not based on a concrete methodology.

Using the following relation the distribution of a program of public investments is possible with the use of regional disparities indexes; this relation is a modification of another one found in literature (Kavvadias, 1992).

$$E_r = [f_{ir} + (d_i)^e \frac{M_{\min}}{M_r}]P_r \Big/ \sum_{i=1}^{n}\left\{[f_{ir} + (d_i)^e \frac{M_{\min}}{M_r}]P_r\right\} \qquad (14)$$

Where:

E_r = the rate of distribution of economic object of a program of public investments for the prefecture r.

$M_{\min}$, M_r = the smaller inequality index and the inequality index of prefecture r respectively.

f_{ir} = a "corrective" factor, which depicts the interventionist faculty of government for change of general policy depending on the political or economic conditions (i=1,2,3,..n) with structural or interventionist expediency.

$(d_r)^e$ = a variable, that regulates the intensity of regional policy of public investments, while exhibitor e oscillates between 0 and 1 ($0<e<1$). In the case where $e=0$ will be $(d_r)^e = 1$, therefore it is eliminated.

P_r = the population of prefecture r.

The prices the two variables $(d_r)^e$ and f_{ir} take, depict alternative policies of allocating a public investment budget, characterizing the different intensity in the policy reducing regional inequalities. According to literature it is possible to study four different

policies, which are the (i) retaining, (ii) proportional, (iii)powerful and (iv)the combined regional policies (Kavvadias, 1992; Polyzos, 2004).

Table 1: Values of $(d_r)^e$ and f_{ir} for the different type of policies

Type of Policy	Variables		
	e	$(d_r)^e$	f_{ir}
Retaining	**0**	**1**	**>0**
Proportional	**0**	**1**	**0**
Powerful	**>0**	**>1**	**0**
Combined	$0<e<1$	**>1**	**Various values**

Public Investment Allocation in Greece

Public spending on investment derives from the Public Investment Program (PIP) presented in the annual Budget of the Greek government. The PIP covers investment in infrastructure in the economy's primary and secondary sectors, as well as payments for infrastructure in roads, bridges, ports, airports and tourist facilities (e.g., marines), urban infrastructure (primarily water and sewage facilities and public housing), social infrastructure (education and health) as well as administrative expenses related to the above categories of public investment (Lambrinidis et al., 2005). Public Spending has fluctuations over the last decade. Some regions during the first years of the decade 2000-2010 accept small budgets and during the last years of this decade large budgets, whereas other regions take constantly large amounts of subsidy. Moreover there are Nuts III regions that endorse throughout the research period constantly small amounts of subsidies. The previous are graphically depicted in its figures 1 and 2. Following figure 3 depicts the average budget allocated in Greece during 2000-2010.

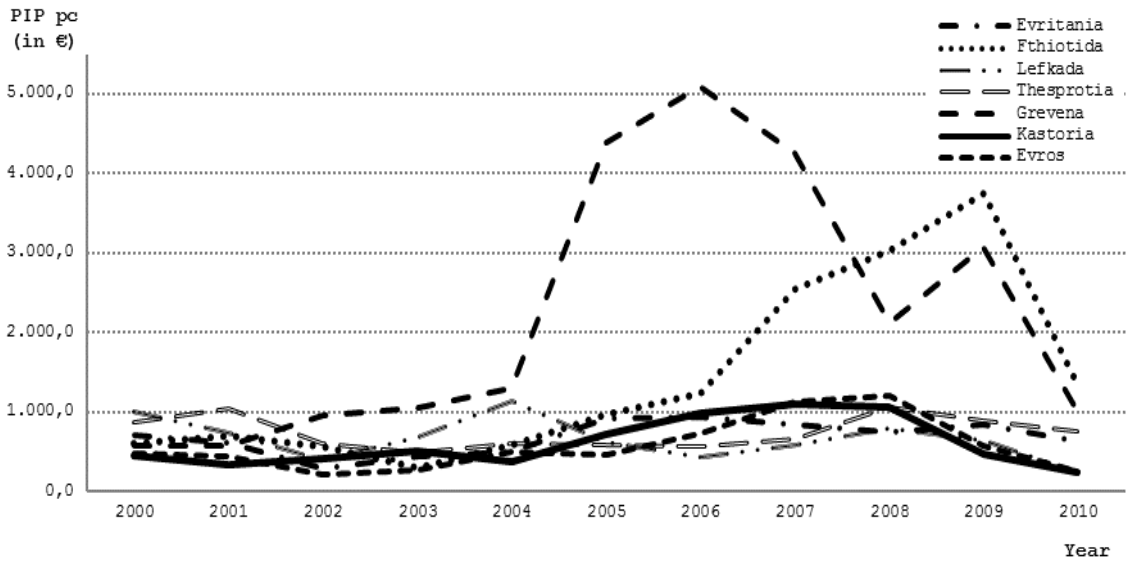


Figure 1: Top 7 Nuts III Regions regarding Public Investment Program Distribution for the years 2000-2010 (Data: EPILOGI 2010)

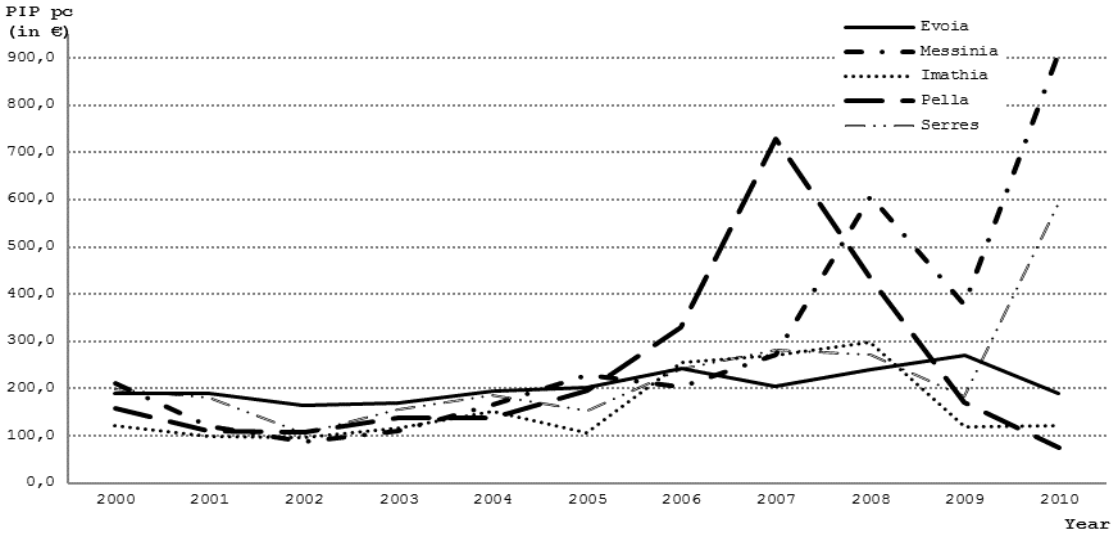


Figure 2: Bottom 5 Nuts III Regions regarding Public Investment Program Distribution for the years 2000-2010 (Data: EPILOGI 2010)

Looking at the two first graphs the inequalities in the distribution of the public investment program are obvious. Regional prosperity depend on the income inequalities and therefore on the public investment not efficient allocation. Looking into this social problem the question arises; is there a method that will result the solution to these welfare equality problem? Does this method has to be complex or it there a way to come to a solution fairly easy?

The following map describes the inequalities of the average PIP per capita distribution for the first decade of twenty first century in Greece. Following, a case study is performed aiming to investigate the solution to the problem in question.

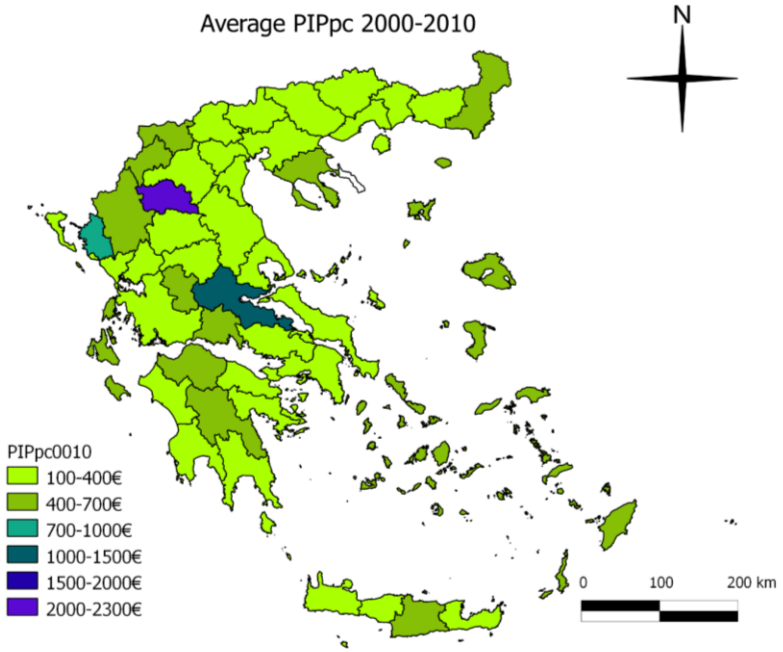


Figure 3: Public Investment Program average distribution for the years 2000-2010(source: own processing, Data: EPILOGI 2010)

Case Study

A case study has been carried out and is presented below in order to verify the applicability of rate of distribution in Greece. The study was performed for all 51 Nuts III regions in Greece.
The relevant parameters are:

P_r = Population in each region (Greek Population Census held in 2001)
M_{WI} = Welfare Index for 2005
M_{PD} = Productive Dynamism for the years 2001-2006
M_{ILE} = Investment Incentives Law - Large enterprises (Law 3908/2011)
M_{IME} = Investment Incentives Law - Medium-size enterprises (Law 3908/2011)
M_{ISE} = Investment Incentives Law - Small and micro enterprises (Law 3908/2011)
M_{PIP} = Public Investment Program in 2010.
e = 0
$(d_r)^e$ = 1
f_{ir} = 0

The policy taken into consideration is the proportional. Moreover five different variables are used to calculate this rate of distribution. For example incorporating the variable of Welfare Index in equation (1) it can be written:

$$E_r = [f_{ir} + (d_i)^e \frac{M_{WI,\min}}{M_{WI,r}}]P_r \Big/ \sum_{i=1}^{n} \left\{ [f_{ir} + (d_i)^e \frac{M_{WI,\min}}{M_{WI,r}}]P_r \right\} \quad (2)$$

This procedure is performed for each one of 5 variables (M_{WI}, M_{PD}, M_{ILE}, M_{IME}, M_{ISE}) described above. The data are used for this research are from EL.STAT (The Hellenic Statistical Service), Polyzos (2011) and from EPILOGI (2010).

Results

The results of calculating the rate of distribution given from equation (1) are presented in the following table. For some regions the results do not differ a lot but for some other they do. In the last column the allocation of the Public Investment Program in 2010 is presented. In this way it is evitable to compare the theoretical allocation (columns 1 to 5) with the implemented one in 2010(column 6). It can be observed that each region has a different reaction to the change of the variable used to calculate the corresponding rate of distribution. If one compares the results to the applied allocation then it is obvious that the variable used is of great importance to the outcome. It is also observable that some regions were favoured regarding the applied distribution of the funds in 2010 but others were not, considering the accomplishment of balanced development.

The results from Table 2 are graphically depicted in figure 4. As it observed the regions of Fthiotida, Messinia, Serres and Irakleion were favoured from PIP 2010, whereas Thessaloniki and Attica were not. This result is probably due to the use of the per capita variable. The previously are depicted in figure 5, where it can be easily seen which regions were favoured (right side of the bar chart) and which were not

(left side of the bar chart)for each calculation of the rate of distribution.

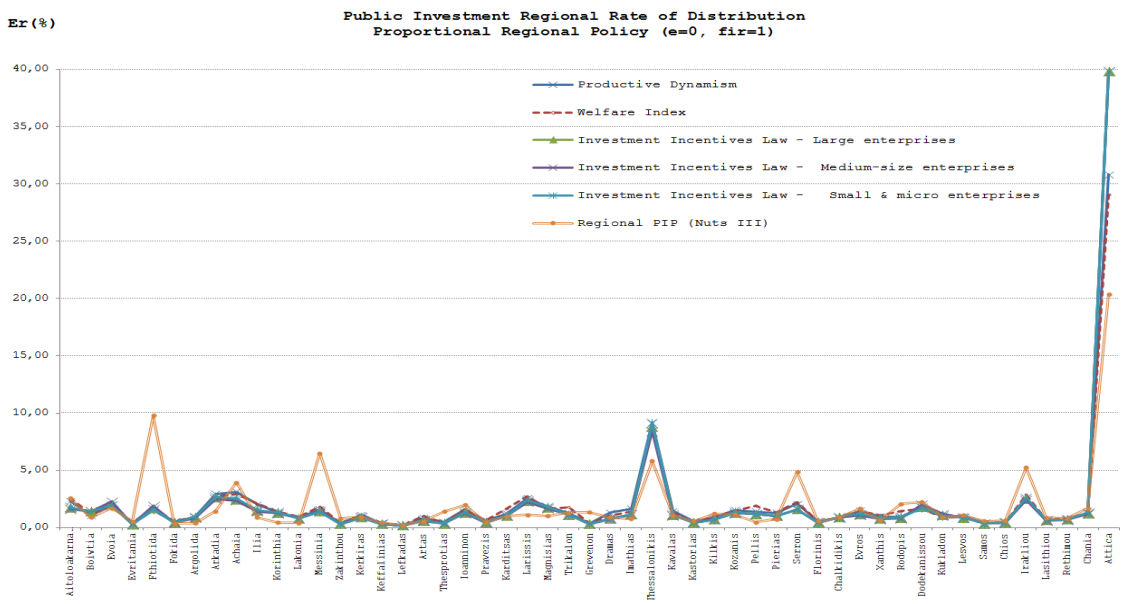


Figure 4: Public Investment Regional Rate of Distribution (for all 51 Nuts III Greek regions)

Taking out of the chart the region of Attica and calculating the actually allocated funds using the rate of distribution and the total available funds in PIP2010, the differences between the used variables are obvious(Figure 5).

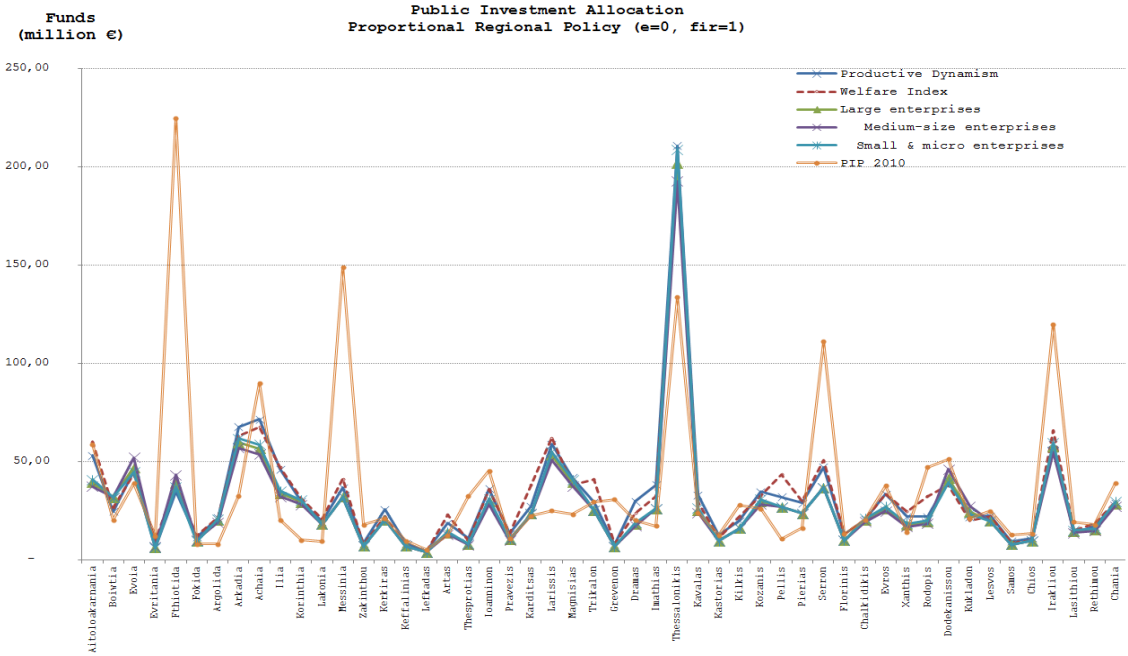
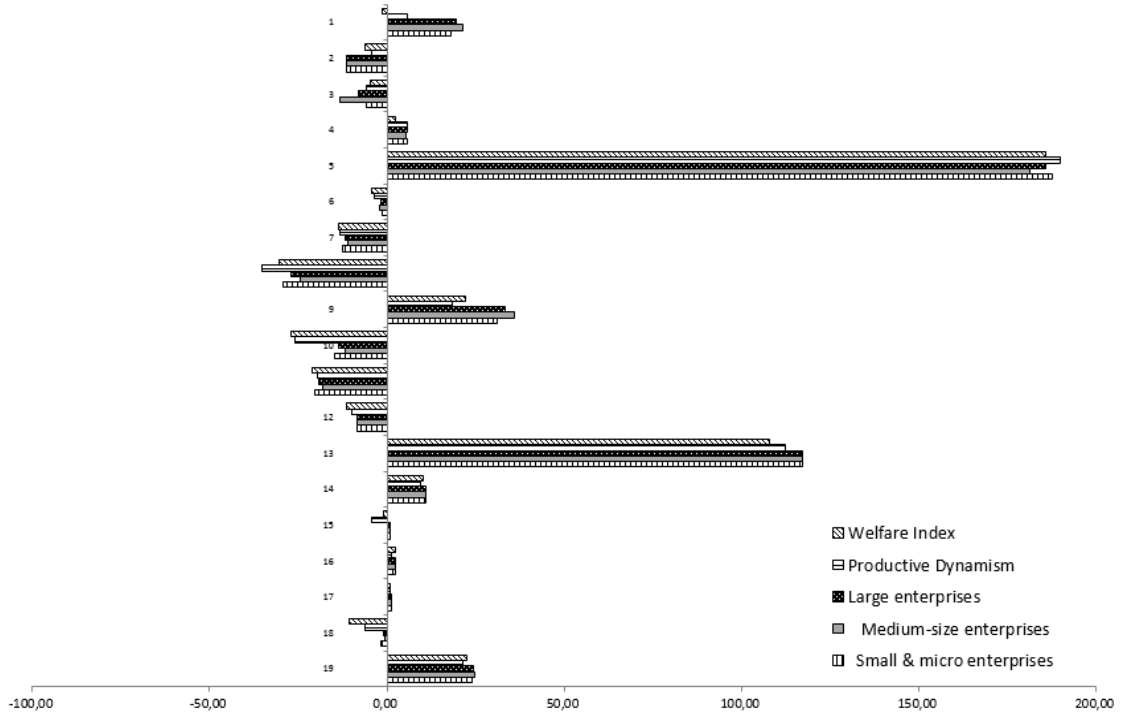
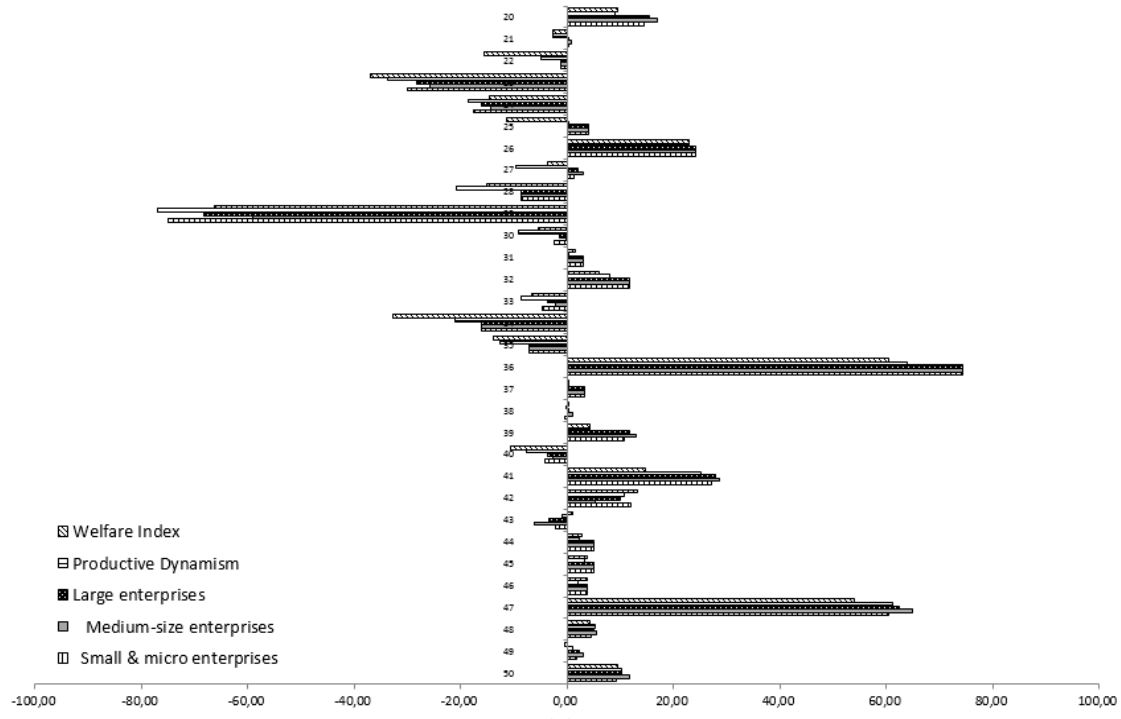


Figure 5: Public Investment Allocation (for the 50 Nuts III Greek regions)



(i)



(ii)

Figure 6: Favoured and unfavoured regions from the allocation of PIP 2010 compared to the allocation results from the calculation of the rate of distribution (a) using WI – Welfare Index and (b) using the PD- Productive Dynamism, c) Investment Incentives Law - Large enterprises d) Investment Incentives Law – medium size enterprises e)Investment Incentives Law - small enterprises i) regions 1-19, ii)regions 20-50

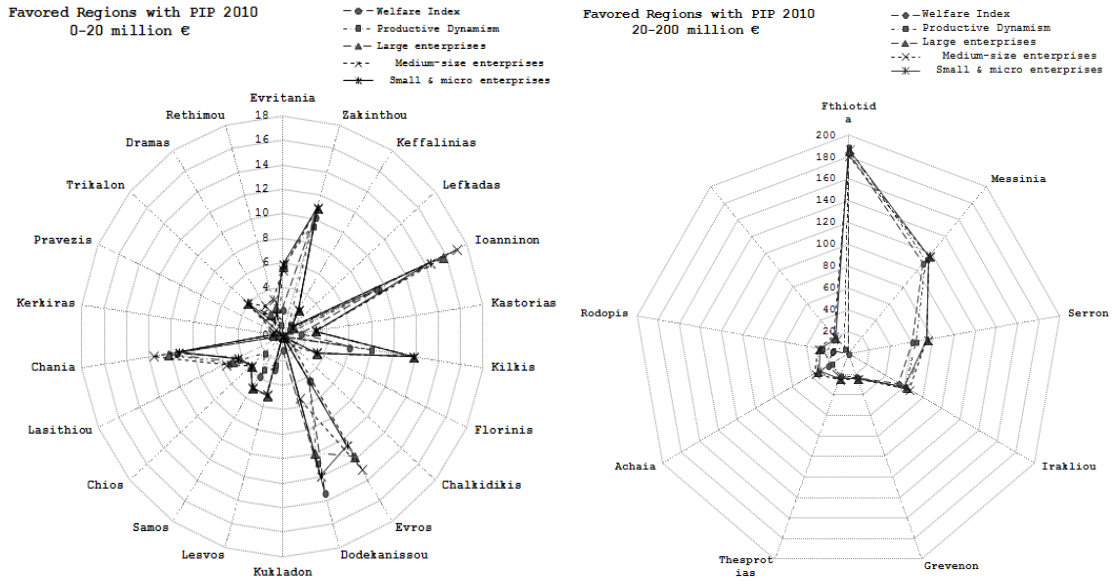
Table 2: Public Investment Regional Rate of Distribution

	Region (Nuts III)	Er(%)*					
		Welfare Index (M_{WI})	**Productive Dynamism (M_{PD})**	**Large enterprises (M_{ILE})**	**Medium-size enterprises (M_{IME})**	**Small & micro enterprises (M_{ISE})**	**PIP 2010**
		[1]	[2]	[3]	[4]	[5]	[6]
1	Aitoloakarnania	2,63	2,32	1,72	1,63	1,78	2,57
2	Boiwtia	1,17	1,08	1,39	1,39	1,39	0,90
3	Evoia	1,91	1,96	2,05	2,28	1,95	1,70
4	Evritania	0,43	0,28	0,28	0,30	0,28	0,53
5	Fthiotida	1,71	1,52	1,70	1,89	1,62	9,79
6	Fokida	0,54	0,51	0,43	0,45	0,42	0,36
7	Argolida	0,95	0,93	0,88	0,84	0,91	0,36
8	Arkadia	2,75	2,95	2,61	2,49	2,70	1,42
9	Achaia	2,95	3,12	2,47	2,35	2,56	3,92
10	Ilia	2,06	2,02	1,48	1,41	1,53	0,89
11	Korinthia	1,36	1,29	1,29	1,23	1,33	0,44
12	Lakonia	0,92	0,86	0,79	0,79	0,79	0,42
13	Messinia	1,80	1,61	1,40	1,40	1,40	6,50
14	Zakinthou	0,34	0,38	0,31	0,31	0,31	0,79
15	Kerkiras	0,97	1,12	0,89	0,89	0,89	0,93
16	Keffalinias	0,31	0,38	0,31	0,31	0,31	0,42
17	Lefkadas	0,18	0,20	0,18	0,18	0,18	0,23
18	Artas	1,01	0,82	0,60	0,57	0,62	0,55
19	Thesprotias	0,44	0,48	0,35	0,34	0,37	1,41
20	Ioanninon	1,57	1,58	1,30	1,24	1,35	1,98
21	Pravezis	0,59	0,59	0,45	0,43	0,47	0,47
22	Karditsas	1,67	1,20	1,03	1,03	1,03	0,98
23	Larissis	2,71	2,57	2,33	2,22	2,40	1,10
24	Magnisias	1,66	1,83	1,72	1,64	1,78	1,02
25	Trikalon	1,79	1,29	1,11	1,11	1,11	1,29
26	Grevenon	0,36	0,35	0,30	0,30	0,30	1,35
27	Dramas	1,04	1,30	0,80	0,76	0,83	0,89
28	Imathias	1,41	1,67	1,14	1,14	1,14	0,76
29	Thessalonikis	8,72	9,18	8,80	8,40	9,10	5,83
30	Kavalas	1,29	1,44	1,11	1,06	1,15	1,05
31	Kastorias	0,48	0,55	0,43	0,43	0,43	0,55
32	Kilkis	0,96	0,87	0,71	0,71	0,71	1,22
33	Kozanis	1,43	1,52	1,30	1,24	1,34	1,14
34	Pellis	1,90	1,40	1,18	1,18	1,18	0,47
35	Pierias	1,32	1,27	1,03	1,03	1,03	0,72
36	Serron	2,21	2,06	1,61	1,61	1,61	4,85
37	Florinis	0,58	0,57	0,43	0,43	0,43	0,58
38	Chalkidikis	0,89	0,90	0,89	0,85	0,92	0,90
39	Evros	1,46	1,46	1,14	1,09	1,19	1,65
40	Xanthis	1,08	0,96	0,78	0,74	0,81	0,62
41	Rodopis	1,42	0,96	0,85	0,81	0,88	2,06
42	Dodekanissou	1,67	1,77	1,81	2,01	1,72	2,24
43	Kukladon	0,88	0,96	1,07	1,19	1,02	0,93
44	Lesvos	0,97	0,98	0,87	0,87	0,87	1,09
45	Samos	0,40	0,42	0,35	0,35	0,35	0,57
46	Chios	0,42	0,49	0,42	0,42	0,42	0,59
47	Irakliou	2,87	2,56	2,51	2,40	2,60	5,23
48	Lasithiou	0,66	0,62	0,63	0,61	0,66	0,85
49	Rethimou	0,80	0,75	0,68	0,65	0,70	0,79
50	Chania	1,28	1,25	1,25	1,19	1,29	1,70
51	Attica	29,08	30,84	39,83	39,83	39,83	20,40

Proportional Regional Policy (e=0, fir=1)

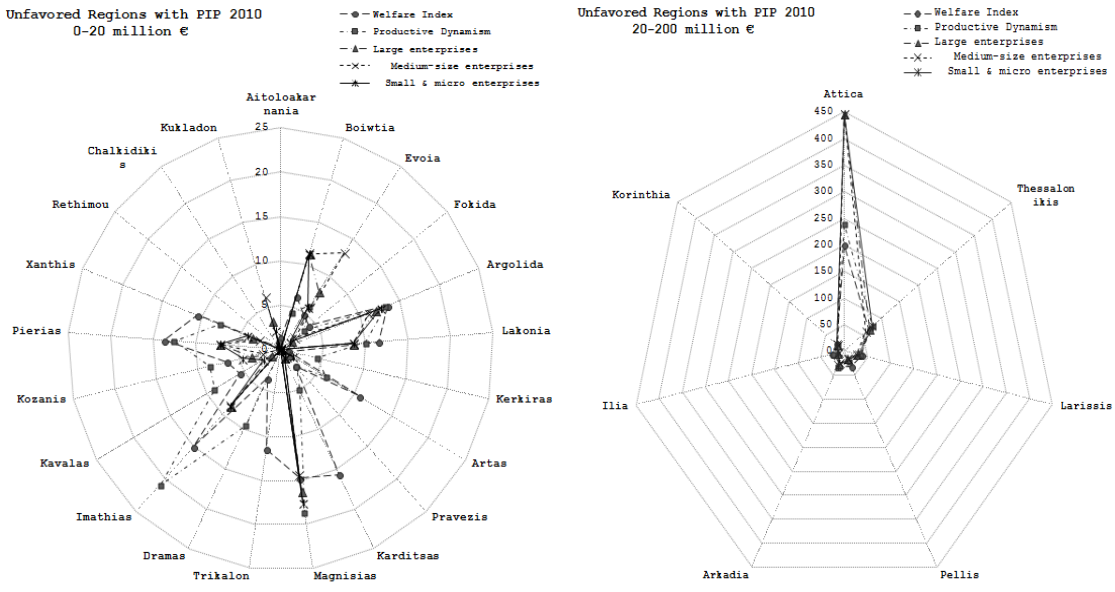
In general, the last three variables M_{ILE}, M_{IME} and M_{ISE} seem to give same results, which results differ from the ones taken from using the first two variables. The general conclusion is that the variable used is significant for the calculus of the investigated rate of distribution. The favoured regions and the unfavoured regions from the distribution of the PIP 2010 can be seen in figures 7 and 8. Figure 7 shows the

favoured regions, the ones that were funded with greater subsidies where as **figure** 8 shows the unfavoured regions, the ones that took fewer subsidies from the PIP 2010 than the theoretical method indicates.



(a) (b)

Figure 7: Favoured regions from PIP 2010 compared to Public Investment Allocation deriving using the Welfare Index, the Productive Dynamism, and the Investment Incentives Law for Large, Medium – Size and Small enterprises (Law 3908/2011) (a)0-20 and (b) 20-200 million €



(a) (b)

Figure 8: Unfavoured regions from PIP 2010 compared to Public Investment Allocation deriving using the Welfare Index, the Productive Dynamism, and the Investment Incentives Law for Large, Medium – Size and Small enterprises (Law 3908/2011) (a)0-20 and (b) 20-200 million €

Sensitivity Analysis

Following a sensitivity analysis will be presented aiming to discover the effect of variables e and f_{ir} in the calculation of the examined rate of distribution. Using equation (1) the relevant parameters are stable and only the variables e and f_{ir} change. The rate of distribution is calculated using the M_{WI} – Welfare Index and it is formed as follows.

$$E_r = [f_{ir} + (d_i)^e \frac{M_{WI,\min}}{M_{WI,r}}]P_r \Big/ \sum_{i=1}^{n}\left\{[f_{ir} + (d_i)^e \frac{M_{WI,\min}}{M_{WI,r}}]P_r\right\} \quad (3)$$

The values of the variables for the cases examined are presented in Table 3.

Table 3: Sensitivity analysis' variables

	Variables	
	e	f_{ir}
Case 1	0	1
Case 2	0	2
Case 3	0	10
Case 4	0	100
Case 5	0.2	0
Case 6	0.5	0
Case 7	0.8	0
Case 8	1	0
Case 9	1	1
Case 10	1	100

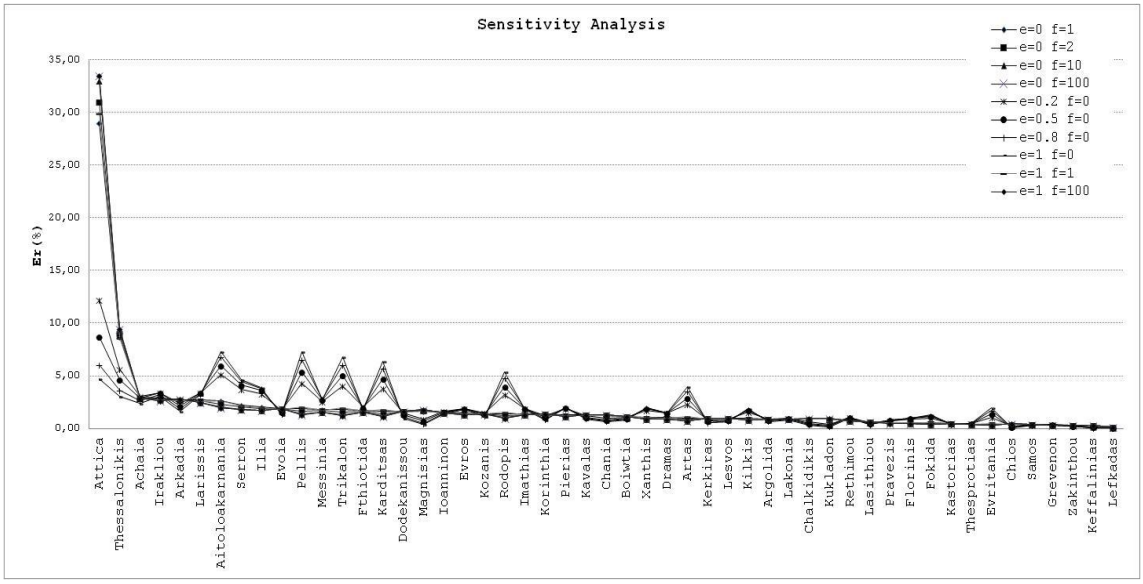


Figure 9: Sensitivity analysis results

The results are depicted in figure 9. It is observable that the regional policy taken into consideration is of great significance. When variable e changes, the results of the method give significant

differentiated values compared to when e=0. As it can be seen in figures 9, cases 5,6,7 and 8 give significantly different values for the rate of distribution compared to cases 1,2,3 and 4 even though the variable f_{ir} is changed.

Conclusions

The optimization problem of allocation of public investment is very complicated. A large number of criteria must be taken into consideration in order to reach a conclusion. A method used in literature is the calculation of the corresponding rate of distribution. A case study is performed using five different variables for the calculation of the investigated rate of distribution. The results are compared to the Greek Public Investment Program allocation in 2010. A sensitivity analysis is finally performed aiming to determine the use of the parameters e and f_{ir}, used in the calculation of the rate of distribution.

Public investment in Greece over the last decade seem to favour some regions but some others not. Some regions accepted small budgets and during the last years of this decade large ones, whereas other regions take constantly large amounts of subsidy. Calculating the corresponding rate of distribution it is observed that the regions of Fthiotida, Messinia, Serres and Irakleion were favoured from PIP 2010 but Thessaloniki and Attica were not. This result is probably due to the use of the per capita variable. The last three variables used in the case study M_{ILE}, M_{IME} and M_{ISE} (The Investment Incentives Law for Large, Medium size and small enterprises) seem to give the same results, which results differ from the ones taken from using the first two variables (Welfare Index for 2005, Productive Dynamism for the years 2001-2006).

This research shows that some regions were favoured and others were not from the PIP 2010. In any case, the use of the convenient variable is significant for the occurring results. Moreover, the use of the regional policy and therefore the corresponding parameters are important for the calculation of the rate of distribution. A question for further research is in which way the used parameters affect the calculation of the corresponding regional rate of distribution.

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