MEASURING THE EFFICIENCY AND PRODUCTIVITY CHANGE OF MUNICIPALITIES:EMPIRICAL EVIDENCE FROM GREEK MUNICIPALITIES OVER THE TIME PERIOD 2013-2016

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Abstract

This paper investigates the relative efficiency and productivity change of municipalities of Greece (regions of Thessaly and Central Greece), during the period 2013–2016. It implements Data Envelopment Analysis (D.E.A.) and Malmquist analysis. Additionally it estimates the effects of the environmental factors on the efficiency using Regression Analysis. The empirical analysis reveals that efficiency and productivity values have gradually improved after the latest reform of Local Government and under restrictive fiscal policy. The average efficiency under constant or variable returns to scale is 0.772 and 0.878 respectively and the mean scale efficiency is 0.883. The total factor productivity has risen by an annual average of 3.3% relatively to the base year 2013. Environmental variables such as type of municipality and population density had a statistically significant positive effect on efficiency. The results of the empirical analysis are consistent to the findings from studies that concern European and other countries. The findings provide benchmarks for policy evaluation and suggestions for region-based approaches.

Keywords: Greek municipalities, efficiency, productivity, DEA, Malmquist analysis
JEL classification: C14, J48, P41, P43

1. Introduction

Measuring relative efficiency and productivity of production systems and identifying its determinants has been the subject of a growing literature in the last decades. Municipalities are units of great importance, with multiple inputs and outputs, since many public functions have been transferred from national to local authorities. Over time, municipalities are facing an increasing pressure to provide more and better quality services to citizens with limited resources, which are even more limited in times of economic crises and restrictive policies.

Greece is a member state of the European Union (1981) and of the Eurozone (2001). The basic administrative division of Greece was formed in 2011. The country is divided into 325 Municipalities (1st Grade Local Authorities), 13 Regions (2st Grade Local Authorities) and 7 Decentralized Government Administrations. The regions of Central Greece (25 municipalities) and Thessaly (25 municipalities) are located in the central zone of Greece and have similar characteristics (area 15.549 and 14.037 Km2, population 546.870 and 730.730, population density 35,17 and 52,06 citizens/ Km2 and GDP 10.537 and 11.608 millions €).

The purpose of this paper is manifold:

I. The measurement of relative efficiency and productivity change of municipalities in the two representative regions (Thessaly and Central Greece) over the period 2013-2016. This period is rather special in the Greek case, for two reasons: firstly Greece has to meet the commitments imposed by the very tight fiscal consolidation program, that has been agreed between European Commission, European Central Bank, International Monetary Fund and Greek government, and secondly a major structural reform had preceded in Greek Local Government. Is the performance of Greek municipalities around the average level of the performance of other countries and especially those of the European Union?
II. Have the municipalities´ performance improved over the period 2013-2016?

III. Does the evaluation of municipalities on the basis of efficiency and productivity criteria and the identification of municipalities constituting benchmarks, contribute to policy formulation?
IV. Are the efficiency and productivity change, of the relatively large municipalities, comparatively higher than those of the relatively small municipalities? Is the policy of municipal mergers verified?
V. Are there environmental variables that affect performance?

To the best of our knowledge, this is the first study which answers to these questions.

The remainder of the paper is organized as follows: Section 2, provides a review of empirical literature; Section 3 presents a short theoretical framework; Section 4 specifies the empirical analysis; Section 5 issues the Second Stage Analysis and Section 6 concludes summarizing the main findings and policy recommendations.

2. Literature Review

Over the last 30 years, there have been many empirical studies, that have focused on the measurement of efficiency and productivity and it is possible to identify two categories of empirical research (De Borger and Kerstens, 1996a). Some studies concentrate on the evaluation of a particular service, such as refuse collection and street cleaning (Worthington and Dollery, 2000b; Benito et al., 2010), water services and street lighting. On the other hand, other studies evaluate local performance considering that municipalities supply a wide variety of services and facilities. The empirical studies (Perpina, 2018) use inputs and outputs from the following:

Inputs: X1: total expenditures, X2: current expenditures, X3: personnel expenditures, X4: capital expenditures, X5: other financial expenditures, X6: local revenues, X7: current transfers, X8: public health services, and X9: area.

Outputs: Y1: global output indicator, Y2: population, Y3: area, Y4: administrative services, Y5: infrastructures (Y5.1: street lighting, Y5.2: municipal roads), Y6: services (Y6.1: waste collection, Y6.2: sewerage system, Y6.3: water supply, Y6.4: electricity), Y7: sports, parks, culture facilities e.t.c. (Y7.1: sport, Y7.2: cultural, Y7.3: libraries, Y7.4: parks, Y7.5 : recreational), Y8 : health, Y9 : education (Y9.1 : kindergartens/nurseries, Y9.2 : primary/secondary education), Y10 : social services (Y10.1 : beneficiaries of grants, Y10.2 : care for elderly, Y10.3 : care for children, Y10.4 : social organizations), Y11 : public safety, Y12 : market, Y13 : public transport, Y14 : environmental protection, Y15 : business development, Y16 : quality index, Y17 : others

Municipalities face different environmental conditions in terms of social, demographic, economic, political, financial, geographical and institutional, among others (Perpina, 2018). The selection of the variables depends on the availability of data. In particular, 6 basic categories of variables are examined:

Z1= Population (Z1.1=Density, Z1.2 =Growth, Z1.3= Size, Z1.4 = Age distribution , Z1.5 = Education level, Z1.6 = Immigration share, Z1.7 = Share of homeowners, Z1.8 = Others)

Z2 = Economic (Z2.1 = Unemployment, Z2.2 = Income, Z2.3 = Economic status, Z2.4 = Tourism, Z2.5 = Commercial activity, Z2.6 = Industrial activity, Z2.7 = Other

Z3 = Political (Z3.1 = Ideological position, Z3.2 = Political concentration, Z3.3 = Voter turnout, Z3.4 = Re-election and number of years for elections, Z3.5 = Other

Z4 = Financial (Z4.1 = Self-generated revenues, Z4.2 = Transfers, Z4.3 = Financial liabilities, Z4.4 = Fiscal surplus, Z4.5 = Infrastructure investments, Z4.6 = Other

Z5 = Geographical (Z5.1 = Distance from centre, Z5.2 = Area, Z5.3 = Type of municipalities (sea, mountain), Z5.4 = Other

Z6 = Institutional (Z6.1 = Computer usage, Z6.2 = Mayor and municipal employees, Z6.3 = Amalgamation, Z6.4 = Municipal externalization, Z6.5 = Other

Table 1 presents the classification of empirical studies (European and non-European Countries).

Table 1

Authors	Country	Years Reference	No of municipalities	Methodology	Inp	Outp	Envir. Variables
European Countries							
De Borger et al. (1994)	Belgium	1985	589	T.S.A.-F.D.H./T.R.	X_3, X_4	$Y_2, Y_{5.2}, Y_{7.5}, Y_{9.2}, Y_{10.1}$	$Z_{1.3}, Z_{1.5}, Z_{2.2}, Z_{3.1}, Z_{3.2}$
De Borger and Kerstens (1996α)	Belgium	1985	589	T.S.A, F.D.H., D.E.A.-V.R.S.-I.O.,S.F.A., O.L.S. T.R.	X_1	$Y_2, Y_{7.5}, Y_{9.2}, Y_{10.1}, Y_{10.2},$	$Z_{1.1}, Z_{1.5}, Z_{2.2}, Z_{3.1}, Z_{4.1}, Z_{4.2}$
De Borger and Kerstens (1996b)	Belgium	1985	589	T.S.A.-F.D.H./T.R.	X_1	$Y_2, Y_{5.2}, Y_{7.5}, Y_{9.2}, Y_{10.1}, Y_{10.2},$	$Z_{1.5}, Z_{2.2}, Z_{3.1}, Z_{4.1}, Z_{4.2}$
Worthington and Dollery (2000b)	South Wales	1993	173	T.S.A.,D.E.A.-V.R.S.-I.O., T.R.	X_3, X_4, X_5	$Y_2, Y_{5.2}, Y_{6.1}, Y_{6.3},$	$Z_{4.2}, Z_{4.3}, Z_{4.6}, Z_{6.2}$
Prieto and Zofio (2001)	Spain	1994	209	DEA	X_1	$Y_{5.1}, Y_{5.2}, Y_{6.2}, Y_{6.3}, Y_{7.1}, Y_{7.2}, Y_{7.4}$	
A. Michailov, M. Tomova, P. Nenkova (2003)	Sofia	1999-03/ 2002	24	D.E.A. -C.R.S.-V.R.S.-I.O.	X_2	$Y_2, Y_{5.2}, Y_{7.4}, Y_{9.2}, Y_{9.1}, Y_8, Y_{7.3}, Y_3$	
Afonso and Fernandes (2003)	Portugal	2001	51	F.D.H.	X_1	Y_1	
Loikkanen and Susiluoto (2005)	Finland	1994-2002	353	T.S.A, D.E.A.-C.R.S- O.O., O.L.S.	X_2	$Y_{7.3}, Y_8, Y_{9.2}, Y_{10.2}, Y_{10.3}, Y_{10.4}$	$Z_{1.1}, Z_{1.3}, Z_{1.5}, Z_{2.1}, Z_{2.2}, Z_{4.2}, Z_{5.1}, Z_{6.2}, Z_{6.4}$
Geys (2006)	Belgium	2000	304	T.S.A.,S.F.A.,O.L.S.	X_2	$Y_{5.2}, Y_{7.5}, Y_{9.2}, Y_{10.1}$	$Z_{1.1}, Z_{1.7}, Z_{2.2}, Z_{3.1}, Z_{3.2}, Z_{4.2}, Z_{4.3}, Z_{4.4}, Z_{6.3}$
Afonso and Fernandes (2006)	Portugal	2001	51	D.E.A.(I.O.,O.O., VRS)	X_1	Y_1	
Balaguer-Coll et al. (2007)	Spain	1995	414	T.S.A.,D.E.A.(V.R.S.-I.O.), F.D.H.,Kernel regression	$X_2, X_3, X_4, X_7,$	$Y_2, Y_{5.1}, Y_{5.2}, Y_{6.1}, Y_{7.4}, Y_{16}$	$Z_{1.3}, Z_{3.2}, Z_{4.1}, Z_{4.2}, Z_{4.3},$
Gimenez and Prior (2007)	Spain	1996	258	T.S.A.,F.D.H.,T.R	X_3, X_5, X_7	$Y_2, Y_3, Y_{5.2}, Y_{6.1},$	$Z_{1.1}, Z_{1.3}, Z_{2.2}, Z_{2.4}, Z_{2.5}, Z_{2.6}$
Afonso and Fernandes (2008)	Portugal	2001	278	T.S.A.,D.E.A.(I.O.,O.O.,V.R.S.), T.R.	X_1	Y_1	$Z_{1.1}, Z_{1.2}, Z_{1.5}, Z_{2.2}, Z_{5.1}$
Balaguer-Colland	Spain	1992-1995	258	T.S.A.D.E.A.(I.O., V.R.S.).T.R.	X_2, X_3, X_4, X_7	$Y_2, Y_{5.1}, Y_{5.2}, Y_{6.1},$	$Z_{2.1}, Z_{2.2}, Z_{2.4}, Z_{2.5},, Z_{4.1},, Z_{4.2},,$

Authors	Country	Years Reference	No of municipalities	Methodology	Inp	Outp	Envir. Variables
Prior (2009)						$Y_{7.4}$, Y_{16}	$Z_{4.3}$,
Geys, B., Moesen, W., (2009a)	Belgium	2000	304	S.S.A.,D.E.A (I.O.,V.R.S.).,F.D.H.,S.F.A.	X_2	$Y_{5.2}$,$Y_{6.1}$, $Y_{7.5}$, $Y_{9.2}$,$Y_{10.1}$	$Z_{1.1}$, $Z_{1.3}$, $Z_{1.5}$, $Z_{1.7}$, $Z_{2.1}$, $Z_{2.2}$, $Z_{2.4}$, $Z_{2.6}$, $Z_{2.7}$, $Z_{3.1}$, $Z_{4.2}$, $Z_{4.3}$, $Z_{4.4}$, $Z_{6.3}$
Geys, B., Moesen, W., (2009b)	Belgium	2000	304	D.E.A.-I.O.-C.R.S.-V.R.S.,F.D.H.,S.F.-Mean	X_2	$Y_{5.2}$, $Y_{6.1}$,$Y_{7.5}$, $Y_{9.2}$, $Y_{10.1}$	
Zafra-Gomez and Muniz-Perez (2010)	Spain	2000, 2005	923	D.E.A.(I.O.,C.R.S.)	X_2, X_3, X_4, X_7	Y_2, $Y_{5.1}$, $Y_{5.2}$, $Y_{6.1}$, $Y_{7.4}$, Y_{16}	
Benito et al. (2010)	Spain	2002	31	T.S.A.,D.E.A.(V.R.S.,O.O.), Kendall τ test	X_2, X_3, X_7	$Y_{6.1}$, $Y_{6.3}$, $Y_{7.1}$, $Y_{7.2}$, $Y_{7.3}$, $Y_{7.4}$, Y_{11}	$Z_{1.3}$, $Z_{2.2}$, $Z_{2.4}$, $Z_{3.1}$, $Z_{4.1}$, $Z_{4.3}$, $Z_{4.6}$, $Z_{6.4}$
Geys et al. (2010)	Germany	1998,2002, 2004	987	S.S.A.,S.F.A.	X_2	Y_2, $Y_{7.5}$, $Y_{9.1}$, $Y_{9.2}$, $Y_{10.2}$, Y_{15}	$Z_{1.1}$, $Z_{3.1}$, $Z_{3.2}$, $Z_{3.3}$, $Z_{4.2}$
Kalb (2010)	Germany	1990-2004	1.111	S.S.A.,S.F.A.	X_2	Y_2, $Y_{9.2}$, $Y_{10.2}$, Y_{15}	$Z_{1.1}$, $Z_{1.5}$, $Z_{2.1}$, $Z_{2.4}$, $Z_{3.1}$, $Z_{3.2}$, $Z_{4.2}$, $Z_{4.6}$,
Revelli (2010)	England	2002-2007	148	CPA	X_2	Y_1, $Y_{9.2}$	
Balaguer-Coll et al. (2010a)	Spain	1995, 2000	1221	F.D.H.	X_2, X_3, X_4, X_7	Y_2 ,$Y_{5.1}$, $Y_{5.2}$, $Y_{6.1}$, $Y_{7.4}$, $Y_{7.5}$, $Y_{10.4}$, Y_{12}	
Balaguer-Coll et al. (2010b)	Spain	1995,2000, 2005	1.164	M.I.,F.D.H.	X_1	Y_2, $Y_{5.1}$, $Y_{5.2}$, $Y_{6.1}$, $Y_{7.4}$, $Y_{7.5}$, $Y_{10.4}$, Y_{12}, Y_{16}	
Loikkanen et al (2011)	Finland	1994-1996	353	T.S.A.,D.E.A. -C.R.S- O.O., O.L.S.	X_2	$Y_{7.3}$, Y_8, $Y_{9.2}$, $Y_{10.1}$, $Y_{10.3}$, $Y_{10.4}$	$Z_{1.1}$, $Z_{1.3}$, $Z_{1.5}$, $Z_{2.1}$, $Z_{3.1}$, $Z_{3.2}$, $Z_{3.3}$, $Z_{5.1}$, $Z_{6.2}$
Bonisch et al. (2011)	Germany	2004	203	T.S.A.,D.E.A. (I.O,V.R.S.)B.A.-Simar and Wilson,2007	X_3,X_4, X_5	Y_2,$Y_{7.5}$,$Y_{9.2}$,$Y_{10.3}$,Y_{15}	$Z_{1.1}$, $Z_{1.2}$, $Z_{1.4}$, $Z_{2.1}$, $Z_{4.2}$, $Z_{4.3}$, $Z_{6.4}$
ˇStastn´a and Gregor (2011)	Czech Republic	2003-2008	202	S.S.A.,D.E.A-C.R.S.-V.R.S.-,I.O, B.A., SFA-timevariant	X_2	Y_2, Y_3, $Y_{5.2}$, $Y_{6.1}$, $Y_{7.1}$, $Y_{7.2}$, $Y_{7.3}$, $Y_{9.1}$, $Y_{9.2}$, $Y_{10.2}$, $Y_{10.4}$,	$Z_{1.3}$, $Z_{1.5}$, $Z_{3.1}$, $Z_{3.2}$, $Z_{3.3}$, $Z_{4.1}$, $Z_{4.2}$, $Z_{4.3}$, $Z_{4.5}$,$Z_{5.1}$

Authors	Country	Years Reference	No of municipalities	Methodology	Inp	Outp	Envir. Variables
Barone and Mocetti (2011)	Italy	2001-2004	1.115	S.F.A.	X_2	Y_{11}, Y_{13}, Y_{14}	
Kalb et al. (2012)	Germany	2004	1.015	S.S.A., S.F.A.	X_2	Y_4, $Y_{5.1}$, $Y_{5.2}$, $Y_{6.1}$, $Y_{9.1}$, Y_{11} Y_2, $Y_{7.5}$, $Y_{9.1}$, $Y_{9.2}$,$Y_{10.2}$, Y_{15}	$Z_{1.1}$, $Z_{2.1}$, $Z_{2.4}$, $Z_{3.1}$, $Z_{3.2}$
Boetti et al. (2012)	Italy	2005	262	T.S.A.,D.E.A. (V.R.S. I.O.), T.R.,S.F.A.	X_2	Y_2, $Y_{5.2}$, $Y_{6.1}$, $Y_{9.1}$, $Y_{9.2}$, $Y_{10.2}$,	$Z_{1.1}$, $Z_{1.3}$, $Z_{2.2}$, $Z_{3.1}$, $Z_{4.1}$, $Z_{4.2}$, $Z_{4.6}$, $Z_{5.1}$, $Z_{5.3}$, $Z_{6.2}$, $Z_{6.4}$
Balaguer-Coll et al. (2013)	Spain	2000	1.198	Order-m	X_2, X_3 X_4, X_7	$Y_{5.1}$, $Y_{5.2}$, $Y_{6.1}$, $Y_{7.4}$, $Y_{7.5}$, $Y_{10.4}$, Y_{12}	$Z_{1.1}$, $Z_{1.2}$, $Z_{2.2}$, $Z_{2.3}$, $Z_{2.7}$
Cuadrado-Ballesteros et al. (2013)	Spain	1999-2007	129	T.S.A., M.I. with D.E.A. Bias-corrected (V.R.S.-I.O.)	X_2,X_4,	Y_2,Y_3,Y_4, $Y_{10.4}$,Y_{11}, Y_{14}	$Z_{2.2}$, $Z_{2.4}$, $Z_{3.2}$, $Z_{6.4}$
Bischoff et al. (2013)	Germany	2004	46 &157 municipal associations	D.E.A. Bias-corrected (I.O. - V.R.S.)	X_3, X_4, X_5	Y_2, $Y_{9.2}$, $Y_{10.3}$, Y_{15}	$Z_{1.1}$, $Z_{1.2}$, $Z_{1.4}$, $Z_{4.2}$, $Z_{4.3}$, $Z_{6.4}$
Geys et al. (2013)	Germany	2001	1.021	S.S.A.,S.F.A.	X_2	Y_2, $Y_{7.5}$, $Y_{9.1}$, $Y_{9.2}$, $Y_{10.2}$, Y_{15}	$Z_{1.1}$, $Z_{2.1}$, $Z_{3.2}$
LoStorto (2013)	Italy	2011	103	D.E.A (I.O., V.R.S., C.R.S.)	X_2	Y_2, Y_3, $Y_{5.2}$, $Y_{9.1}$, Y_{14}	
Ashworth et al.(2014)	Belgium	2000	308	T.S.A.,D.E.A. - C.R.S. - O.O., B.A.- Simar and Wilson,2007	X_1	$Y_{5.2}$, $Y_{6.1}$, $Y_{7.5}$, $Y_{9.2}$, $Y_{10.1}$, $Y_{10.2}$	$Z_{1.1}$, $Z_{1.3}$, $Z_{2.2}$, $Z_{3.1}$, $Z_{3.2}$, $Z_{4.1}$, $Z_{4.2}$, $Z_{4.3}$, $Z_{4.4}$,
DaCruzand Marques (2014)	Portugal	2009	308	T.S.A.,D.E.A. super-efficiency (I.O.,VRS,C.R.S), T.R., O.L.S. ,B.A.(95% CI)	X_3, X_4, X_5	Y_2, $Y_{6.1}$, $Y_{6.2}$, $Y_{6.3}$, $Y_{7.5}$	$Z_{1.1}$, $Z_{1.4}$, $Z_{1.5}$, $Z_{1.8}$, $Z_{2.2}$, $Z_{2.3}$, $Z_{2.7}$, $Z_{3.1}$, $Z_{3.3}$, $Z_{3.4}$, $Z_{4.1}$, $Z_{4.2}$, $Z_{4.3}$, $Z_{4.6}$, $Z_{5.2}$, $Z_{5.3}$, $Z_{6.3}$
Carosi et al. (2014)	Tuscan	2011	285	T.S.A.,D.E.A.(I.O , V.R.S),T.R.	X_2	Y_2, $Y_{5.2}$, $Y_{9.1}$, $Y_{9.2}$, $Y_{10.2}$, $Y_{10.4}$,	$Z_{1.1}$, $Z_{1.3}$, $Z_{2.4}$, $Z_{3.4}$, $Z_{4.1}$, $Z_{5.3}$
Seifert&Niswand (2014)	France	2008	96	D.E.A.(I.O.,V.R.S.)	X_1	Y_2, $Y_{5.2}$, $Y_{7.5}$, $Y_{9.2}$, $Y_{10.1}$	
Pevcin (2014a)	Slovenia	2011	200	S.S.A.,S.F.A.	X_1	Y_2, $Y_{9.2}$, $Y_{10.2}$, Y_{15}	$Z_{1.1}$, $Z_{2.1}$,
Pevcin	Slovenia	2011	200	S.S.A.,D.E.A	X_1	Y_2, $Y_{9.2}$,	$Z_{1.1}$, $Z_{2.1}$

Authors	Country	Years Reference	No of municipalities	Methodology	Inp	Outp	Envir. Variables
(2014b)				(I.O., C.R.S., V.R.S.,) S.F.A..		$Y_{10.2}$, Y_{15}	
ˇStastn´aan dGregor (2015)	Czech republic	1995-1998, 2003-2008	202	S.S.A.,SFA-time variant	X_2	Y_3,$Y_{5.2}$,$Y_{6.1}$,$Y_{7.1}$,$Y_{7.2}$,$Y_{7.4}$,$Y_{9.1}$,$Y_{9.2}$,$Y_{10.2}$,$Y_{10.4}$,Y_{11},Y_{13},	$Z_{1.3}$, $Z_{1.5}$, $Z_{3.1}$, $Z_{3.3}$, $Z_{4.1}$, $Z_{4.2}$, $Z_{4.5}$, $Z_{5.1}$
Arcelus et al. (2015)	Spain	2005	260	S.S.A.,S.F.A.	X_2	Y_3, Y_4, $Y_{5.1}$, $Y_{5.2}$, $Y_{6.3}$, $Y_{10.2}$, Y_{15}	$Z_{1.1}$, $Z_{4.1}$, $Z_{4.5}$, $Z_{5.4}$, $Z_{6.4}$, $Z_{6.5}$
Perez-Lopez et al. (2015)	Spain	2001-2010	1.058	T.S.A.,Order-m, B.A.- Simar and Wilson,2007	X_2	Y_2, Y_3, $Y_{5.1}$, $Y_{6.1}$, $Y_{6.3}$, $Y_{7.4}$, Y_{17}	$Z_{1.3}$, $Z_{2.1}$, $Z_{2.4}$, $Z_{3.1}$, $Z_{3.2}$, $Z_{4.1}$, $Z_{4.2}$, $Z_{4.3}$, $Z_{4.4}$,$Z_{4.6}$, $Z_{6.4}$
Asatryan and DeWitte (2015)	Germany	2011	2.000	Conditional FDH	X_1	$Y_{7.5}$, $Y_{9.1}$, $Y_{9.2}$, $Y_{10.2}$	$Z_{1.3}$, $Z_{2.2}$, $Z_{3.1}$, $Z_{3.3}$
Lampe et al.(2015)	Germany	2006-2008	396	S.S.A., S.F.A.	X_1, X_2	Y_2, $Y_{7.5}$, $Y_{9.1}$, $Y_{9.2}$, $Y_{10.2}$, Y_{15}	$Z_{1.1}$, $Z_{1.6}$, $Z_{2.1}$, $Z_{2.4}$
Andrews and Entwistle (2015)	England	2007	386	T.S.A.,Ratios, OLS	X_1	Y_1	$Z_{1.1}$, $Z_{1.3}$, $Z_{1.4}$, $Z_{1.6}$, $Z_{1.8}$, $Z_{2.3}$, $Z_{3.1}$, $Z_{4.6}$, $Z_{5.1}$, $Z_{6.4}$, $Z_{6.5}$
Agasisti et al. (2015)	Italy	2010-2012	331	T.S.A.,B.A. DEA (I.O, C.R.S, V.R.S) M.I.	X_2	Y_2, $Y_{5.2}$, $Y_{6.1}$, Y_{11}	$Z_{1.1}$, $Z_{1.4}$, $Z_{1.8}$, $Z_{2.2}$, $Z_{3.1}$, $Z_{3.4}$, $Z_{4.1}$, $Z_{4.2}$, $Z_{4.4}$, $Z_{4.5}$, $Z_{4.6}$, $Z_{5.3}$, $Z_{5.4}$, $Z_{6.2}$, $Z_{6.4}$, $Z_{6.5}$
Cordero et al. (2016)	Portugal	2009-2014	278	Conditional efficiency	X_1, X_3	Y_2, Y_4,$Y_{6.1}$, $Y_{6.3}$	$Z_{1.1}$, $Z_{2.1}$, $Z_{2.2}$, $Z_{3.1}$, $Z_{4.3}$, $Z_{5.3}$
Lo Storto (2016)	Italy	2013	108	T.S.A.,D.E.A. (I.O, C.R.S, V.R.S) B.A.- SimarandWilson, 2007	X_2	Y_2, Y_3	$Z_{1.1}$, $Z_{1.8}$, $Z_{2.3}$
Cordero et al. (2017)	Portugal	2009-2014	278	Conditionalefficiency, M.I.	X_1, X_3	Y_2, Y_4,$Y_{6.1}$, $Y_{6.3}$	
Carosi et al. (2018)	Tuscan	2011	282	D.E.A. (I.O, V.R.S)	X_2	Y_2, $Y_{5.2}$, $Y_{9.1}$, $Y_{9.2}$, $Y_{10.2}$, $Y_{10.4}$,	
Non-European Countries							
Kalseth and Rattsø (1995)	Norway	1988	407	D.E.A. (I.O.,V.R.S.), O.L.S.	X_1	Y_4	

Authors	Country	Years Reference	No of municipalities	Methodology	Inp	Outp	Envir. Variables
Grossman et al. (1999)	U.S.A.	1967,1973, 1977,1982	49	S.S.A.,S.F.A.	-	Y_{17}	$Z_{1.3}, Z_{3.5}, Z_{4.2}, Z_{5.1}, Z_{6.2}$
Ibrahim and Karim (2004)	Malaysia	2000	46	T.S.A.,D.E.A., I.O.,V.R.S,T.R.	X_2	$Y_2, Y_{5.2}, Y_{6.1}, Y_{7.4}, Y_{12}$	$Z_{1.5}, Z_{2.2}, Z_{5.2}, Z_{6.1}, Z_{6.2},$
De Sousa et Stosic (2005)	Brazil	1991	4796	DEA - FDH "Jackstrap"- I.O.,C.R.S,V.R.S	X_2, X_3, X_8	$Y_2, Y_{6.1}, Y_{6.2}, Y_{6.3}, Y_{9.2}, Y_{10.1}$	
De Sousa et al (2005)	Brazil	2000	4796	T.S.A.,DEA "Jackstrap"I.O.,C.R.S,V.R.S, Quantile regression	X_2, X_3, X_8	$Y_2, Y_{6.1}, Y_{6.2}, Y_{6.3}, Y_{9.2}, Y_{10.1}$	$Z_{1.1}, Z_{2.2}, Z_{2.3}, Z_{2.4}, Z_{2.7}, Z_{5.1}, Z_{5.4}, Z_{6.1}, Z_{6.2}, Z_{6.4}, Z_{6.5}$
Moore et al.(2005)	U.S.A.	1993-1996	46	T.S.A.,D.E.A.- O.O.- V.R.S ,T.R.	X_2, X_3	$Y_4, Y_{5.2}, Y_{6.1}, Y_{6.3}, Y_{7.3}, Y_{7.4}, Y_8, Y_{11},$	$Z_{4.1}, Z_{5.2}, Z_{5.4}, Z_{6.5}$
Ibrahim and Salleh (2006)	Malaysia	2000	46	S.F.A.	X_2	$Y_2, Y_{5.2}, Y_{6.1}, Y_{7.4}, Y_{12}$	
Sung (2007)	Korea	1999-2001	222	T.S.A.,M.I. with D.E.A.,T.R.	$X_1, X_3,$	$Y_4, Y_{5.2}, Y_{6.2}, Y_{6.3}, Y_{7.4}, Y_{10.4}$	$Z_{1.1}, Z_{1.3}, Z_{2.5}, Z_{4.1}, Z_{5.2}, Z_{6.1}$
Revelli and Tovmo (2007)	Norway	-	205	T.S.A., RATIO, O.L.S.	X_6	Y_1	$Z_{1.1}, Z_{3.2}, Z_{3.3}, Z_{4.1}, Z_{4.3}$
Seol et al. (2008)	Korea	2003	106	T.S.A.,DEA-based DT approach (I.O.-V.R.S.),T.R.	X_1,X_3	Y_4	$Z_{6.1}$
Borge et al. (2008)	Norway	2001-2005	362-384	T.S.A.,RATIO ,O.L.S.	X_6	Y_1	$Z_{3.1}, Z_{3.2}, Z_{3.3}, Z_{4.1}, Z_{4.2}, Z_{4.6}$
Nijkamp and Suzuki (2009)	Japan	2005	34	DEA- DFM-GA (I.O./O.O.- C.R.S.)	X_1, X_3, X_4	Y_1, Y_{17}	
Dollery and van der Westhuizen (2009)	South Africa	Fiscal 2006/2007	231 local+46 regional	D.E.A(I.O.,O.O,V.R.S.,C.R.S)	X_3	$Y_{6.4}$	
Shiyi and Jun (2009)	China	1978-2005 1993-2005	27	D.E.A.(V.R.S.,O.O.)	X_2	$Y_{9.2}, Y_8, Y_3, Y_{6.4}, Y_{13}$	
Liu et al. (2011)	Taiwan	2007	22	D.E.A. super-efficiency (C.R.S.-V.R.S.-O.O.)	X_3	$Y_{6.2},$	
Bruns and Himmler	Norway	2001-2005	362-384	T.S.A.,RATIO,O.L.S.	X_6	Y_1	$Z_{1.1}, Z_{1.3}, Z_{1.4}, Z_{1.5}, Z_{1.6}, Z_{1.8},$

Authors	Country	Years Reference	No of municipalities	Methodology	Inp	Outp	Envir. Variables
(2011)							$Z_{2.2}$, $Z_{3.1}$, , $Z_{3.2}$, $Z_{3.5}$
Lin, Ming-Ian & Lee, Yuan-Duen & Ho, Tsai-Neng, (2011)	China	2005-2006	31	DEA (V.R.S.,C.R.S.,O.O.) και AHP, MPI	X_4	Y_{17}	
Kutlar and Bakirci (2012)	Turkey	2006-2008	27	D.E.A., C.R.S., V.R.S, I.O.,O.O, M.I.	X_1, X_2, X_3, X_4, X_7	Y_2, $Y_{9.2}$, $Y_{10.2}$, Y_8	
Haneda et al. (2012)	Japan	1979-2004	92	D.E.A. (I.O.,V.R.S.,C.R.S .), M.I.	X_3, X_9	Y_2, Y_{16}	
Nakazawa (2013)	Japan	2005	479	S.S.A,S.F.A., O.L.S, HCSEs	X_1, X_3	Y_1	$Z_{1.3}$, $Z_{1.4}$, $Z_{1.8}$, $Z_{5.2}$, $Z_{6.3}$
Fogarty and Mugera (2013)	Australia	2009-2010	98	T.S.A.,D.E.A.(I.O .,V.R.S.,C.R.S.), O.L.S.	X_3, X_4, X_5	Y_2, Y_3, $Y_{5.2}$	$Z_{1.1}$, $Z_{2.3}$, $Z_{4.1}$, $Z_{6.2}$
Nikolov and Hrovatin (2013)	Macedonia	-	74	T.S.A.,D.E.A.-V.R.S-O.O., S.F.A.	X_2	Y_2, $Y_{5.2}$, $Y_{9.1}$, $Y_{9.2}$, $Y_{10.2}$	$Z_{1.6}$, $Z_{2.2}$, $Z_{3.2}$, $Z_{4.1}$
Nakazawa (2014)	Japan	2005	479	S.F.A., O.L.S, HCSEs	X_1, X_2	Y_1	
ElMehdiandHafner (2014)	Morocco	Fiscal 1998-1999	91	D.E.A (I.O., V.R.S.), F.D.H. bias -corrected B.A.	X_6	Y_{17}	
Mahabir (2014)	South Africa	Fiscal 2005/2006 - 2008/2009	129	F.D.H.	X_1	$Y_{6.1}$,$Y_{6.2}$, $Y_{6.3}$,$Y_{6.4}$	
Monkam (2014)	South Africa	2007	231	T.S.A.,D.E.A.(I.O., V.R.S.), T.R.	X_2	Y_2,$Y_{6.1}$,$Y_{6.2}$,$Y_{6.3}$, $Y_{6.4}$	$Z_{1.2}$, $Z_{1.5}$, $Z_{2.2}$, $Z_{3.2}$, $Z_{4.1}$
Sørensen (2014)	Norway	2001-2010	430	T.S.A.,O.L.S ,F.E.R	X_6	Y_1	$Z_{1.3}$, $Z_{3.1}$, $Z_{3.2}$
Pacheco et al. (2014)	Chile	2008-2010	309	S.S.A., S.F.A.	X_2	Y_2, $Y_{6.1}$, $Y_{6.2}$, $Y_{7.4}$, Y_8, $Y_{9.2}$,	$Z_{3.2}$, $Z_{4.2}$, $Z_{4.5}$, $Z_{5.1}$
Yusfany (2015)	Indonesia	2010	491	T.S.A.,D.E.A. - VRS, O.O.,T.R.	X_1	Y_1	$Z_{1.1}$, $Z_{2.2}$, $Z_{3.2}$, $Z_{4.1}$, $Z_{4.2}$, $Z_{4.4}$,
Helland and Sørensen (2015)	Norway	2001-2010	430	T.S.A.,O.L.S , F.E.R	X_6	Y_1	$Z_{3.1}$, $Z_{3.2}$
RadulovicandDragutinovic (2015)	Serbia	2012	143	S.S.A.,S.F.A.	X_2	Y_2, $Y_{5.2}$, $Y_{6.3}$, $Y_{9.1}$, $Y_{9.2}$, $Y_{10.4}$	$Z_{1.1}$, $Z_{1.4}$, $Z_{1.5}$, $Z_{2.1}$, $Z_{5.1}$,

Authors	Country	Years Reference	No of municipalities	Methodology	Inp	Outp	Envir. Variables
Marques et al. (2015)	Tasmania	1999-2008	29	shared input D.E.A.(V.R.S.,I.O.)	X_2	Y_4, $Y_{5.2}$, $Y_{6.2}$, $Y_{6.3}$, Y_8,	

Notes: D.E.A.= Data Envelopment Analysis, S.F.A.= Stochastic Frontier Analysis, F.D.H.= Free Disposal Hull, I.O.= Input Oriented, O.O.= Output Oriented, C.R.S.= Constant Returns to Scale, V.R.S.= Variable Returns to Scale, S.E.= Scale Efficiency, M.I.= Malmquist Index, T.R.= Tobit Regression, B.A.= Bootstrap Approach, C.P.A.= Comprehensive Performance Assessment, D.F.M.= Distance Friction Minimization, G.A.= Goals Achievement, A.H.P.= Analytic Hierarchy Process, HCSEs= Heteroscedasticity - Consistent Standard Errors, O.L.S.= Ordinary Least Squares, D.T.= Decision Tree, T.S.A.= Two Stage Approach, S.S.A=Single Stage Approach, F.E.R.= Fixed effects regressions

More specifically, as can be inferred from Table 1, the large majority of the studies have used only one approach (Data Envelopment Analysis –DEA =43% or Stohastic Frontier Analysis – SFA=18% or Free Disposal Hull – FDH=10%) and the rest 29% combine more than one method. From the studies which employ DEA, about 70% uses Input Orientation (I.O.), 20% uses Output Orientation (O.O.) and 10% both I.O. and O.O. approach. About 10% uses Constant Returns to Scale (C.R.S.), 60% Variable Returns to Scale (V.R.S.) and 30% both V.R.S and C.R.S. approach. Local governments' efficiency analysis, is best studied in Europe, especially in Spain, followed by Germany and Belgium. The most popular methods of estimating the influence of the environmental variables on efficiency are Tobit & Ordinary Least Squares (O.L.S.)

3. Methodology and models

The techniques adopted to assess efficiency are usually classified in parametric (Stohastic Frontier Analysis-S.F.A.) and nonparametric methods (deterministic frontier – D.E.A. model). We estimate here the functional form of the best-practice frontier, relying on the nonparametric technique of DEA.

Efficiency measurement begins with Farrell (1957), who drew upon the work of Debreu (1951) and Koopmans (1951), to define a simple measure of firm efficiency which could account for multiple inputs. Data Envelopment Analysis (DEA) is widely accepted and used by scholars for its strengths, and well recognized as a valuable decision support tool for managerial control and organizational diagnosis, and for conducting benchmarking studies (Lo Storto, 2013). DEA measures the efficiency of different units, called "Decision Making Units" (DMUs). DEA is the non-parametric deterministic mathematical linear programming approach that estimates the relative efficiency of homogeneous DMUs. It introduces very weak assumptions related to the estimation of an empirical production function which converts the inputs into outputs, assuming the existence of a convex production frontier and strong free disposability in inputs and outputs (Charnes, Cooper, & Rhodes, 1978). The piecewise-linear convex hull approach to frontier estimation receive wide attention. The production frontier is generated by solving a sequence of linear programming problems, one for each municipality, while the relative Technical Efficiency (T.E.) (the ability of a unit to produce a given set of outputs with minimum consumption of a set of corresponding inputs, independently of any input prices) of the municipality is measured by the distance between the actual observation and the frontier obtained from all the municipalities under examination. Thus, a municipality results efficient if TE=1, but it is inefficient or technically not efficient if TE < 1. DEA calculates the efficiency of a DMU by dividing a weighted sum of its outputs by a weighted sum of inputs. Weights of inputs and outputs are not given in advance, but they are determined as part of the solution to the optimizing problem. In the simplest case, each DMU is allowed to weigh its inputs and outputs freely to maximize its relative efficiency.

DEA models can be either input (determination of minimum inputs for producing a given level of output) or output (maximization of outputs with given levels of inputs) oriented. However, in this study an input orientation is adopted because municipal administrations have greater control over inputs than they do over outputs and the production function is constructed by searching for the maximum possible proportional reduction in input usage, while output levels are held fixed. As the sample includes municipalities having very different sizes, the efficiency score is calculated adopting two conceptualizations, the first one suggested by Charnes et al. (1978) (CCRmodel) that assumes constant returns to scale (CRS) and the second one that follows Banker, Charnes, and Cooper (1984) (BCC model), assuming variable returns to scale (VRS), In particular, an input-oriented VRS model is defined as:

- Input – oriented – CRS

  min θ, λ, θ

  Yλ ≥ Yi

  s.t. Xλ ≤ θXi

  λ ≥ 0

- Input – oriented – VRS

  min θ, λ, θ

  Yλ ≥ Yi

  s.t. Xλ ≤ θXi

  N1'λ = 1

  λ ≥ 0

where λ is the vector of relative weights (N × 1) given to each unit and N is the number of unit. Assuming that there data on I inputs and O outputs: X represents the matrix of inputs (I × N) and Y is the matrix of outputs (O × N). For the ith unit these are represented by the column vectors Xi for the inputs and Y i for the outputs. These refer to CRS model. The CRS assumption is avoided in the VRS model (Banker et al., 1984) by the introduction of an additional constraint on the λ, allowing returns to scale, i.e., N1′λ = 1, where N1′ is a vector of ones. This restriction imposes convexity of the frontier. Finally, the efficiency score (θ) is a scalar and estimate the technical efficiency by assuming values between 0 and 1, with a value of 1 indicating a point on the frontier and hence a technical efficient unit (Farell, 1957). In our analysis, we computed both CRS and VRS efficiency scores. Also, we interpret the ratio CRS/VRS as the scale efficiency (SE), that refers to the ability of each unit to operate at its optimal scale of operations. In order to find out whether a municipality is scale efficient and qualify the type of returns of scale, a DEA model under the non-increasing returns to scale (NIRS) can be implemented by replacing the N1′λ=1 restriction with N1′λ ≤ 1, putting SE= TECRS / TENIRS. As Fare, Grosskopf, and Lovell (1985) suggest the following rule can be applied: a) if SE = 1, then the municipality is scale efficient, both under CRS and VRS; b) if SE = 1 the municipality operates under increasing returns to scale; c) if SE<1 the municipality operates under decreasing returns to scale.

After the DEA analysis, we carry out also an analysis using the Malmquist productivity index (MPI) to evaluate the possible changes in the efficiency level or technological progress (TC). Technological changes might occur and could affect and shift the frontier. The MPI is introduced as a theoretical index by Caves et al. (1982) and became more popular as an empirical index by Fare et al. (1994). In order to measure the change in the efficiency score, the latter should be split into two components: change in productivity (efficiency) and change in production frontier. Fare et al. (1994) defined the I.O. MI between year t and t + 1 as the ratio of the distance function for each year relative to a common technology, as follows:

$$M^t = \frac{M_1{}^t(x_t + 1, y_t + 1)}{D_1{}^t(x^t, y^t)}$$

If the base year is the t + 1, then the MI for the t + 1 period is as follows:

$$M^{t+1} = \frac{D_1{}^{t+1}(x_t + 1, y_t + 1)}{D_1{}^{t+1}(x^t, y^t)}$$

where the subscript I indicates an input-oriented, M is the productivity of the most recent production point (xt+1, yt+1) (using period t + 1 technology) relative to the earlier production point (xt, yt) (using period t technology), D are input distance functions, x is the inputs, y is the outputs, and t is the current period.

Following Fare et al. (1994) the MI can be expressed as a geometric mean of the two indices, evaluated with respect to period t and period t + 1 technologies as follows:

$$M_I(x^{t+1}, y^{t+1}, x^t, y^t) = \frac{D_1{}^t(x^{t+1}, y^{t+1})}{D_1{}^t(x^t, y^t)} \frac{D_1{}^{t+1}(x^{t+1}, y^{t+1})^{1/2}}{D_1{}^{t+1}(x^t, y^t)}$$

Fare et al. (1994) further suggested that this index can be decomposed further into two components: one describing the technical efficiency change (EC) (improvements in efficiency relative to the frontier) and another reflecting on the technological change (TC) (shifts in the frontier) of the different units under study, as follows:

$$M_I(x^{t+1}, y^{t+1}, x^t, y^t) = \underbrace{\frac{D_1{}^{t+1}(x^{t+1}, y^{t+1})}{D_1{}^t(x^t, y^t)}}_{\text{Efficiency change}} \underbrace{\frac{D_1{}^t(x^{t+1}, y^{t+1})}{D_1{}^{t+1}(x^{t+1}, y^{t+1})} \times \frac{D_1{}^t(x^t, y^t)^{1/2}}{D_1{}^{t+1}(x^t, y^t)}}_{\text{Technological change}}$$

The methodology can be further extended by decomposing the efficiency change into scale efficiency (SEC) and pure technical efficiency (PEC) components. The appropriate required distance functions can be estimated via DEA technologies, as described above (Fare et al., 1994; Coelli et al., 2005). Note that MI > 1 denotes progress in the Total Factor Productivity (TFP) change (net effect is positive). MI = 1 denotes no change in TFP, while MI < 1 denotes productivity decline from period t to t+1 (Worthington, 2000).

4. Empirical analysis

The study uses DEA and Malmquist Analysis (MA) in order to measure the relative TE, SE and the Total Factor Productivity Change (TFP change) of the investigated municipalities. Methodologically, we use a two step procedure in empirical analysis. Our decision making units are municipalities. In the first stage, we only use information of their output and input volumes and apply Data Envelopment Analysis (DEA) to derive frontier production functions and related efficiency scores for each municipality. In the second stage we use regression model to explain the variation of efficiency scores among municipalities.

4.1. Data and sources

In Greece, municipalities provide a wide array of essential services. In this study we use three input and four output variables per inhabitant:

X1: total annual expenditures,

X2: total number of employees,

X3: the number of vehicles-machinery

Y1: the number of pupils enrolled in the pre-primary / primary / secondary municipal infrastructures,

Y2: The total quantity of mixed waste in tons leading to landfill or to uncontrolled disposal,

Y3: The number of pre-primary / primary / secondary municipal infrastructures and
Y4: The number of beneficiaries from municipal grants.

In particular, the variables are derived from: X1, X3 the municipalities, X2 the Ministry of Administrative Reconstruction, Y1, Y3 the Regional Education Directorates, Y2 the Solid Waste Management Associations, Y4 the Ministry of Labor, Social Security and Social Solidarity. These variables have been used, measured by several authors in order to formulate, analyze and measure efficiency and productivity change of municipalities.

For the data analysis we use the DEAP Version 2.1 software package (Coelli, 1996).

4.2. Descriptive Statistics

Table 2 reports descriptive statistics of inputs and outputs (means, standard deviations maximums and minimums). The findings show that the average trend for X1, X2, Y1, Y2 and Y4 is downward, since most output variables tend to decrease over the period with the exception of the X3 and Y3 that remain more stable.

Table 2:

Variables / Statistics	Inputs			Outputs			
	X1	**X2**	**X3**	**Y1**	**Y2**	**Y3**	**Y4**
2013							
Mean	573,31	0,0055	0,0025	0,1082	0,3564	0,0017	0,0059
St. dev	273,85	0,0028	0,0017	0,0458	0,1946	0,0004	0,0143
Max	1.381,43	0,0152	0,0112	0,1991	1,2259	0,0027	0,0682
Min	212,09	0,0022	0,0008	0,0030	0,0325	0,0004	0,0000
2014							
Mean	515,56	0,0052	0,0025	0,1074	0,3549	0,0017	0,0058
St. dev	253,16	0,0025	0,0017	0,0460	0,1964	0,0004	0,0136
Max	1.685,90	0,0142	0,0112	0,2000	1,2549	0,0027	0,0610
Min	152,87	0,0019	0,0008	0,0031	0,0317	0,0004	0,0000
2015							
Mean	467,89	0,0052	0,0025	0,1061	0,3467	0,0017	0,0057
St. dev	199,30	0,0025	0,0018	0,0465	0,2128	0,0004	0,0133
Max	1.155,63	0,0144	0,0112	0,2036	1,3553	0,0027	0,0576
Min	145,35	0,0019	0,0008	0,0024	0,0291	0,0004	0,0000
2016							
Mean	456,45	0,0051	0,0025	0,1051	0,3536	0,0017	0,0066
St. dev	194,45	0,0025	0,0018	0,0473	0,2077	0,0004	0,0129
Max	1.220,09	0,0144	0,0117	0,2055	1,3491	0,0027	0,0523
Min	205,36	0,0019	0,0009	0,0022	0,0276	0,0004	0,0000

Source: Author's calculation

4.3. First stage: Measuring Relative Efficiency, Productivity Change and Discussion

The analytical results (CRSTE, VRSTE, SE, EC, TC, PEC, SEC, TFP change) of the Municipalities for each of the four years are presented in the Appendices. The average performance values for the period 2013-2016 are presented in the table 3.

When focus is on the whole sample, average CRSTE efficiency score is 0.772 (77.2%). This means that municipalities could produce the same quantities of outputs with 0.228 (22.8%) less quantities of inputs. Minimum efficiency score is 0.320 and maximum 1.000. The number of 100% efficient municipalities is 7 (DMUs: 1, 4, 8, 16, 31, 33, 50). Average VRSTE efficiency score is 0.878 (87.8%). This means that municipalities could produce the same quantities of outputs with 0.122 (or 12.2%) less quantities of inputs. Minimum efficiency score is 0.437 and maximum 1.000. The number of 100% efficient municipalities is 20 (DMUs: 1, 4, 8, 13, 14, 16, 26, 29, 30, 31, 33, 34, 35, 36, 39, 40, 44, 45, 47, 50). Furthermore, Municipalities operate close to the optimal scale, SE=0.883 (refrain 11.7% from the optimal scale).The results are consistent with previous studies (Worthington and Dollery (2000b), Seifert & Nieswand (2014), Pevcin (2014b), Lo Storto (2016)).

The findings also shows that relatively large municipalities with population criteria (population>average population) have comparatively higher efficiency rates (CRSTE=0.876, VRSTE=0.917, SE=0.953) than smaller municipalities (CRSTE=0.739, VRSTE=0.866, SE=0.862). Relatively small municipalities are wasting more resources than relatively large ones. Also municipalities of Thessaly could on average produce the same quantity of outputs with 5.1% less quantity of inputs, whereas municipalities of Central Greece with 19.2%. Table 4 reports the number of municipalities and the average efficiency scores and shows that 17 municipalities have average CRSTE ranging between 0.600 and 0.800, 28 municipalities have average VRSTE ranging between 0.900 and 1.000 and 33 municipalities have average SE ranging between 0.900 and 1.000.

Table 4:

EFFICIENCY SCORE	CRSTE	VRSTE	SE
[0 - 0.600)	8	3	3
[0.600 – 0.800)	17	11	7
[0.800 – 0.900)	10	8	7
[0.900- 1.000]	15	28	33

Source: Author's Calculation

The Malmquist TFP results (Agasisti et al (2015), Sung (2007), Kutlar and Bakirci (2012)) presented in Table 3. The findings indicate that municipalities on average experienced an approx. 3.3% increase in average productivity. In addition we found that the productivity gain may be primarily attributed to a change in relative efficiency and to technical progress. EC increased by 18% while average technological progress improved by 14%. On average, improvements in PEC are the main reasons for the improvements in EC. The average PEC, which measures changes in VRSTE indicates that there is an improvement of 12% over the examined period. Municipalities of Central Greece have higher values of TFP change than municipalities of Thessaly. Also Municipalities of Central Greece have higher values of EC and lower values of TC than municipalities of Thessaly. Table 5 reports that 38 Municipalities have TFP change >1, ranging between 0,10% and 14,10%.

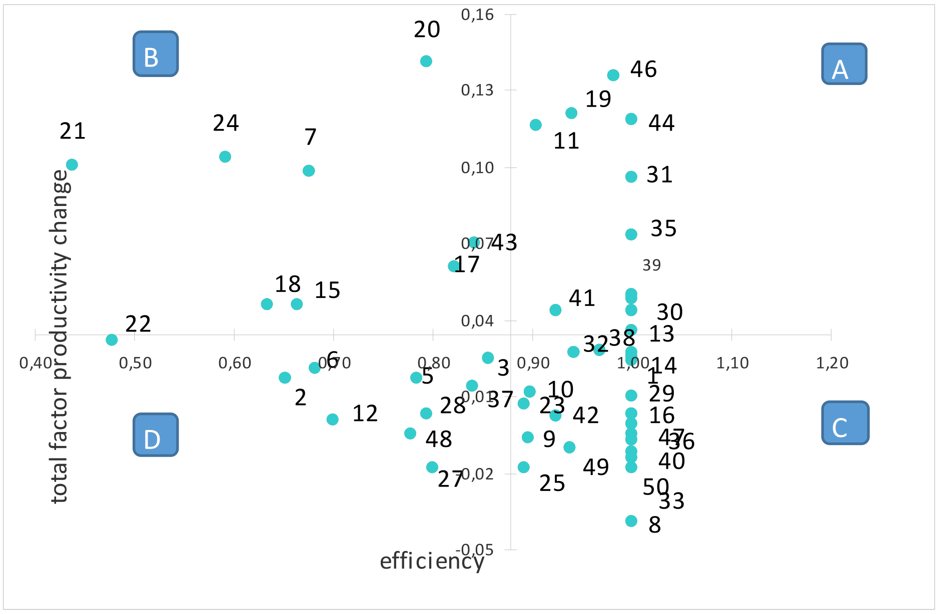
Table 5:

TFP CHANGE / No of municipalities	TFP > 1		TFP < 1		EC >= 1	EC > 1
	TECHCH > 1	EC > 1	TECHCH < 1	EC<1		
	30	8	7	5	32	18

Source: Author's Calculation

12 Municipalities have TFP change < 1 ranging between –0.10% and –3.90%. This means that it was poor technology which needed to be updated or that it has not been used best-practice technology in the management. 16% of Municipalities have no change in efficiency, 48% of Municipalities (experience increase (EC > 1) and the remaining 36% decrease (EC < 1). As a next step, we classify Municipalities on the basis of their average VRSTE in the years 2013-2016 and the results of the average TFP change in the period 2013–2016.

Figure 1: Average VRSTE and TFP change



Source: Author's calculation

The incision of the axes is the point O (mean VRSTE = 0.878, mean TFP = 0.034). The four groups in Figure 1 are characterized as follows:

Quadrant A: High efficiency and positive productivity growth.

Municipalities (DMUS: 11, 19, 46, 44, 31, 35, 3, 30, 41) have the best performance and can be benchmarks for other municipalities. This suggests that they should maintain their position by continuing to implement good strategies so as to fulfill their mission.

Quadrant B: Low efficiency and positive productivity growth.

Municipalities (DMUS: 20, 17, 43, 15, 18, 7, 24, 21, 22,) with medium to low efficiency, have positive productivity growth. Special consideration should be given to these municipalities in order to improve their efficiency by implementing current strategies of productivity improvement.

Quadrant C: High efficiency and negative productivity growth.

Municipalities (DMUS: 10, 23, 42, 9, 25, 49, 32, 38, 14, 1, 29, 16, 47, 36, 40, 33, 50, 8) still maintains a good efficiency in managing their resources, in spite of their productivity decline. Moreover, if they do not want to lose their current position they have to maintain a rapid growth, by maintaining positive technological change.

Quadrant D: Low efficiency and negative productivity growth

Municipalities in the bottom-left quadrant (DMUS: 2, 6, 12, 27, 48, 28, 5, 3) are those that have medium-low efficiency in managing their resources. Special attention should be given to those municipalities so as to diagnose their problems and to improve their efficiency.

5. Second Stage: OLS Analysis

At the second stage of our two step analysis, differences in the DEA efficiency scores are explained by characteristics of municipalities. The regression model explaining variation of efficiency scores among municipalities were estimated with the 2013-2016 data. OLS being the estimation method.

Table 6: OLS Regression analysis results

Variables	Coefficient
Z1	0.195 *(1.122)* *n.s.*
Z2	-0.197 *(-1.406)* *n.s.*
Z3	0.307 (2.070) **
Z4	0.298 *(1.835)* **
Z5	0.151 *(1.108)* ns
Z6	-0.094 *(-0.064)* ns
Z7	-0.188 (-1.286) ns
R	0.261
Adj. R^2	0.138
F	2.122

Note: 1)***, **, * level of statistic significance 1%, 5% και 10%, n.s. non-significant
2) Numbers in parentheses show the t- statistic values
3) Source: Author's calculation

Table 6 reports the results of the OLS regression analysis and presents the variables that were considered in the DEA second stage analysis: number of unemployed as percentage of population (Z1), education level of mayor (Z2), type of municipality (Z3), population density (Z4), mayor's gender (Z5), number of amalgated municipalities (Z6), distance from the center of the region (Z7). The use of these variables are consistent with the existing literature. For this purpose, the exogenous variables regressed with efficiency score includes values between zero and one. Relationships between these variables in the regression model formulated as follows:

$$T.E.i = a + b_1Z_1 + b_2Z_2 + b_3Z_3 + b_4Z_4 + b_5Z_5 + b_6Z_6 + b_7Z_7 + e_i$$

where, i is the municipality to i (i = 1, ..., 50), T.E is the efficiency score, and є is the error term. A positive sign of the coefficient indicates that this latter is positively associated to VRSTE while a negative sign denotes an unfavorable association. The value of R2 is satisfactory, since the data are cross-section. It turned out that number of unemployed as percentage of population, education level of mayor, mayor's gender, number of amalgated municipalities and distance from the center of the region did not explain efficiency differences and had no effect on efficiency. Of the variables examined, only Z3, Z4 have statistically significant and positive effect on VRSTE (Z3 higher statistical effect than Z4). As expected, the type pf municipality and the population density is related to high efficiency. Our location variable (Z3) proved to be the most significant explanatory variable in our estimation results, getting high t-value. For variable population density (Z4) statistically positive and significant impact on the efficiency of local government. This relationship according to Borger and Kerstens (1996) and Afonso and Fernandes (2008) interpreted that a dense residential structure with a portion of the population who live in it, has relatively higher positive effect on efficiency that have a population structure that is relatively less dense.

6. Concluding remarks and policy implications

This paper contributes to the literature on the empirical understanding of relative efficiency and productivity change in the two Greek representative regions (Thessaly and Central Greece). Additionally it determinates the factors, which affects the efficiency coefficients. From empirical analysis and discussion, the following key conclusions are drawn:

i. The average values of technical efficiency under variable and constant returns to scale, scale efficiency and total factor productivity change of the municipalities are in line with the results of European and non- European countries.
ii. Over the four years considered, there was a gradual improvement (year by year) of the average efficiency and productivity of the municipalities.
iii. The best performance (efficiency> mean VRSTE, productivity> mean TFP) have 9 of the 50 municipalities (18%), and can be benchmarks for the other municipalities. The rest of them should try to learn from best practices in order to improve their own performance. That is paramount for a better use of scarce public resources in the context of the European Union's strategic direction to optimize resource use.
iv. Relatively large municipalities with population criteria have comparatively better performances on average than relatively small ones
v. The environmental variables, population density and type of municipality, have statistically significant positive effect on the municipality efficiency score.
vi. Municipalities of Thessaly have on average better performance than municipalities of Central Greece

In fact, by giving insight into the causes of inefficiency, this helps to further identify the reasons for local inefficient behaviour and may support effective policy measures to correct and or control them. Our study, also helps to the ongoing discussion about the need and form of reforms in basic service provision. The proposals have included increasing municipality sizes by mergers or increasing voluntary cooperation of municipalities to make them more efficient. Decision makers at both municipal and central government levels, have to recognize the significance of the findings. Appropriate policy measures will lead to an improvement in the performance of all municipalities and, especially, those with low performance. By merging two or more municipalities into a single new municipality or sharing the provision of public services creating an association or a consortium of municipalities has also benefits in terms of elimination of administrative and political body duplication. Also the establishment of an observatory that aims to systematically measure and monitor the efficiency and productivity change of municipalities, contributes positively to linking performance to resource allocation. In this direction, the introduction of an incentive-based system which will reward efficient municipalities and trigger surveillance programs for those who need to improve, is very important.

Undoubtedly, a need exists to continue the study and to improve certain factors that have not been adequately considered herein. Further research is needed to broaden the scope of services analyzed, with different combinations of inputs and outputs. Besides, repeating the survey year after year would enhance comparisons and allow investigating the evolution of municipal efficiency while the country has come out of the strict monitoring of the memorandums.

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