DATA ENVIRONMENT ANALYSIS MODELS
FOR PERFORMANCE MEASUREMENT AND
MANAGEMENT OF PUBLIC POLICY
IMPLEMENTATION: EVIDENCE FROM
DELIVERY OF A SOCIAL ECONOMIC
DEVELOPMENT PROGRAM

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DEDICATION

To my son,

Thanasis

… for the summers we did not spent together

and

In the memory of my parents,

Thanos and Cristina
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I declare that this dissertation is the result of my own work and includes nothing, which is the outcome of work done in collaboration except where specifically indicated in the text. It has not been previously submitted, in part or whole, to any university of institution for any degree, diploma, or other qualification.
ΠΕΡΙΛΗΨΗ

Τίτλος: Υποδείγματα της Περιβάλλουσας Ανάλυσης Δεδομένων για την Αξιολόγηση και τη Διοίκηση της Εφαρμογής των Δημόσιων Πολιτικών - Εμπειρικά ευρήματα από την υλοποίηση ενός Προγράμματος Κοινωνικο-οικονομικής Ανάπτυξης

Η Δημόσια Διοίκηση αντιμετωπίζει τεράστιες προκλήσεις και βρίσκεται στο επίκεντρο πολιτικών, οικονομικών και κοινωνικών εξελίξεων. Στην Ελλάδα, παρουσιάζει σοβαρά προβλήματα, την ανάλυση και τη διοίκηση των οποίων απαιτεί την υιοθέτηση και εφαρμογή νέων οργανωτικών δομών, διοικητικών πρακτικών και διεργασιών διακυβέρνησης. Η μέτρηση της απόδοσης αποτελεί ένα σημαντικό οδηγό για τη χρήση πληροφοριών για την αξιολόγηση των εφαρμογών των δημόσιων πολιτικών.

Η εργασία αποσκοπεί να καλύψει το κενό γνώσης που απαντάται στη διεθνή και ελληνική βιβλιογραφία στην αξιολόγηση της Εφαρμογής μιας δημόσιας αναπτυξιακής πολιτικής. Για πρώτη φορά στην ελληνική και διεθνή βιβλιογραφία, η εργασία παρουσιάζει ένα μεθοδολογικό πλαίσιο για την αποτίμηση και την παρακολούθηση της μεταβολής της παραγωγικότητας και της αποδοτικότητας υλοποίησης ενός δημόσιου προγράμματος στήριξης των επενδύσεων καθώς και για τον προσδιορισμό επεξηγηματικών παραγόντων της επίδοσής του. Επικεντρώνεται στο πλαίσιο της πολιτικής αγροτικής ανάπτυξης και εξετάζει την υλοποίηση του επιχειρησιακού προγράμματος LEADER+ 2000-08.

Τα προς διερεύνηση ερωτήματα είναι τα εξής: Είναι οι φορείς διαχείρισης στα τέλη της υλοποίησης αποτελεσματικοί στην αξιοποίηση των πόρων για την αύξηση της αποδοτικότητας των πόρων για την αύξηση της παραγωγικότητας του προγράμματος; Τυχόν μειωμένη αποδοτικότητα, οφείλεται σε κακή αξιοποίηση των πόρων ή σε αδυναμία λειτουργίας ή σε αυξημένη αξιοποίηση των πόρων ή σε αδυναμία λειτουργίας ή σε αυξημένη αξιοποίηση των πόρων ή σε αδυναμία λειτουργίας; Κατά πόσο θα ήταν δυνατόν να αυξηθούν οι υλοποιήσεις με δεδομένη την τρέχουσα αξιοποίηση των πόρων, εάν οι μη αποδοτικοί φορείς λειτουργούσαν σύμφωνα με τις καθήκοντες πολιτικές; Υπάρχει βελτίωση της αποδοτικότητας και της παραγωγικότητας υλοποίησης με την πάροδο του χρόνου; Υπάρχουν συγκεκριμένοι οργανωτικοί και εξωτερικοί παράγοντες που επηρεάζουν την παραγωγικότητα υλοποίησης;

Η αποτίμηση της αποδοτικότητας του συστήματος υλοποίησης γίνεται με την ανάπτυξη και εφαρμογή υποδειγμάτων της Περιβάλλουσας Ανάλυσης Δεδομένων (ΠΑΔ), που αποτελεί μια από τις πιο δημοφιλείς τεχνικές μέτρησης της επίδοσής στην επιχειρησιακή
έρευνα. Η εργασία προσδιορίζει τους μη αποδοτικούς φορείς διαχείρισης και τις πηγές της ανεπάρκειας καθώς και τους φορείς διαχείρισης που εφαρμόζουν βέλτιστες πρακτικές διαχείρισης. Παρέχει εναλλακτικά κριτήρια κατανομής του αποθεματικού επίδοσης και δίνει προβλέψεις για την μέγιστη δυνατή απορρόφηση του προγράμματος και των παρεμβάσεων. Επιπρόσθετα, προσδιορίζει τις οικονομικές κλίμακες λειτουργίας του συστήματος υλοποίησης, παρέχει δείκτες παρακολούθησης της μεταβολής της παραγωγικότητας και αξιολογεί την επίδραση του μεγέθους στην παραγωγικότητα.

Με βάση τα αποτελέσματα της εμπειρικής ανάλυσης, συνάγεται ότι παρουσιάζεται μεγάλη ετερογένεια στην παρατηρούμενη επίδοση των φορέων υλοποίησης του προγράμματος. Το αποκεντρωμένο σύστημα διαχείρισης πάσχει από σημαντικά προβλήματα απορρόφησης που οφείλονται κύρια σε ανεπάρκειες στη διοίκηση. Σημαντικές βελτιώσεις στις υπηρεσίες διαχείρισης του προγράμματος είναι δυνατά να επιτευχθούν με τους υφιστάμενους πόρους. Με την υιοθέτηση της προτεινόμενης μεθόδου βελτιώνεται η αξιοπιστία και η αποτελεσματικότητα των αξιολογήσεων.

Όσον αφορά τη συνεισφορά της εργασίας στο ερευνητικό επίπεδο, η εμπειρική διερεύνηση και ποσοτικοποίηση της αποδοτικότητας εφαρμογής ενός προγράμματος δημόσιων ενισχύσεων με την Περιβάλλοντα Ανάλυση Δεδομένων, δεν έχει εφαρμοστεί στο παρελθόν. Η εργασία συμπληρώνει το εμπειρικό κενό γνώσης σε θέματα αποδοτικότητας των υπηρεσιών διαχείρισης ενός δημόσιου προγράμματος ενισχύσεων. Στην εργασία αναπτύσσονται νέες προσεγγίσεις ελέγχου υποθέσεων που εκμεταλεύονται τον στατιστικό χαρακτήρα της ΠΑΔ και την απομακρύνουν από τον ντερτεμιστικό αρχικό χαρακτήρα της.

Η εργασία συνεισφέρει στο επίπεδο της πρακτικής διότι συμπληρώνει την επίσημη/τυπική αξιολόγηση των επιδόσεων ενός δημόσιου προγράμματος ενισχύσεων, με τη διάσταση της υλοποίησης. Παρέχει στους υπεύθυνους ελέγχου και στους φορείς υλοποίησης ενός προγράμματος δείκτες παρακολούθησης της προόδου υλοποίησης και τεχνικές αποτίμησης της αποδοτικότητας. Παρέχει, επίσης, μια πιο ρεαλιστική εικόνα για την εκτίμηση της επιτυχίας και των ρίσκων αποτυχίας του προγράμματος, έναντι του ευρέως χρησιμοποιούμενου δείκτη απορρόφησης. Προτείνει, αντικειμενικά κριτήρια, βασισμένα στην ΠΑΔ, για την κατανομή του αποθεματικού επίδοσης. Προσφέρει μια εικόνα για τους οργανωσιακούς και εξωτερικούς παράγοντες που επηρεάζουν την παραγωγικότητα του συστήματος υλοποίησης του προγράμματος.
Στο επίπεδο της πολιτικής ηγεσίας, προκύπτει ότι οι επιπτώσεις του μεγέθους δεν μπορούν να αγνοηθούν σε αποφάσεις που αφορούν την κατάρτιση και τον επιμερισμό του προϋπολογισμού του. Υπάρχει ανάγκη ανασχεδιασμού του συστήματος υλοποίησης, στην κατεύθυνση λιγότερων και μεγαλύτερων τοπικών προγραμμάτων, σε αντιδιαστολή με τη διαχρονική πρακτική κατακερματισμού της χρηματοδότησης σε μικρές και αποσπασματικές δράσεις. Επιπρόσθετα, εξάγεται η αναγκαιότητα ενσωμάτωσης στο τυπικό σύστημα παρακολούθησης των προγραμμάτων, ενός υπο-συστήματος παρακολούθησης και αξιολόγησης των επιδόσεων και ιδιαίτερα της αποδοτικότητας.

Λέξεις Κλειδιά: Δημόσια Διοίκηση, Εφαρμογή δημόσιας πολιτικής, Δημόσιο Μάνατζμεντ, Αξιολόγηση δημόσιας πολιτικής, Αποτελεσματικότητα, Παραγωγικότητα, Αποδοτικότητα, Αποτίμηση επιδόσεων, Διοίκηση επιδόσεων, Προσδιοριστικοί παράγοντες επίδοσης, Διαχείριση προγράμματος, Διοίκηση έργου, Συγκριτική αξιολόγηση, Στοχοθεσία, Κατανομή πόρων, Ευρωπαϊκή διαρθρωτική πολιτική, Αγροτική Ανάπτυξη, EU LEADER, Περιβάλλονια Ανάλυση Δεδομένων (DEA)
SUMMARY

Title: Data Envelopment Analysis Models for Performance Measurement and Management of Public Policy Implementation - Evidence from Delivery of a Social Economic Development Program

Public Administration is facing tremendous challenges and it is at the center of political, economic and social developments. In Greece Public Administration presents serious problems, the analysis and elimination of which requires the adoption and implementation of new organizational structures, administrative practices and governance processes. Performance measurement is a significant driver of the use of performance information in management, in particular for decision-making on the delivery of public spending programs.

There is increasing recognition that performance evaluation of public spending programs should emphasize on their implementation rather than focus solely on their outcomes. This study for the first time presents a framework for comparing the delivery or administrative efficiency of public spending programs, based on a novel application of a quantitative operational technique, Data Envelopment Analysis (DEA). It is focused on the European Union context and precisely in the implementation of Greek LEADER operational program.

Research on performance in public spending programs is focused mainly on their effects on target groups and areas. To the best of our knowledge, there is no a study quantifying the delivery efficiency of a public spending program. This research contributes to improve the current methods of public program delivery assessment by exploring new methodologies, based on a frontier technique, which can effectively provide enhanced managerial information to program implementers and managing authorities and recommendations to ministries towards better public policy implementation.

From the alternative frontier methods available, in this study it was chosen to explore in detail the use of Data Envelopment Analysis due to the greater flexibility to incorporate the multidimensional nature of the socioeconomic development policy, the use of minimal assumptions on the shape of the best practice frontier and because it has the advantage of allowing comparisons with the best observed performance by constructing a best practice frontier based on empirical input and output data. Moreover, we apply new nonparametric estimation procedures based on DEA to estimate technical change, relative efficiency change, and productivity change in program delivery as well as the components
of efficiency change. In order to evaluate the impact of contextual variables on program productivity we developed a two-stage method that uses DEA in the first stage and OLS regression in the second stage.

Through the use of linear programming, DEA constructs a frontier from a subset of efficient best practice program implementers and identifies which delivery units are inefficient compared to it. Output oriented CCR and BBC DEA models provide technical efficiency scores which give the magnitude of the inefficiencies present in relation to the distance of the inefficient units to the frontier enveloping them. For each inefficient implementer, DEA gives efficient resource savings and output increases and a reference set or peer group of efficient implementers, which is most similar to it in their mix of services and resources and constitutes a realistic term of comparison.

Strong evidence of operational and scale inefficiencies in mid-term of program implementation is found, suggesting that the delivery system suffers significant absorption problems due to inefficiencies in program administration. These findings emphasize the need to improve program administrative capacities in Greece and suggest adjustments in a number of program implementers charged with the delivery of rural development policy. Furthermore, the study finds significant time improvements in productivity of program delivery. The results of productivity growth and changes in its components from the pre- to post- mid-term implementation period indicate that program implementers experienced a statistically significant increase on average productivity between the two periods. In addition, it is found that the productivity gain may be primarily attributed to a change in relative efficiency rather than to technical progress.

Evidence from the comparison of efficiency scores across the regions indicates that location of implementers and their programs might have influenced their delivery performance.

We also confirmed the presence of economies of scale in program administration which might be a justification for selecting bigger target areas, population and programs, since economies of scale may require a larger program area than it is possible within a particular small local area.

Finally, with respect to factors affecting program delivery productivity, both sizes of delivery mechanism and program budget are significant variables which have implications on program productivity. This infers that local program implementers with
average administration resources and larger program budgets have higher likelihood of being efficient.

Overall, the results of this study illustrate that DEA, in contrast to traditional program performance measures, is an insightful tool in revealing administrative inefficiencies in program delivery by capturing the operational and scale components of performance while taking into account the complex mix of tasks and interventions carried out by its operators and also allowing for innovation and locally designed solutions able to meet community’ needs. Moreover, the proposed technique may be easily integrated into a program evaluation exercise and may be utilized as a knowledge tool to support rational management decision-making and program improvement.

**Keywords:** Public Administration, Public policy implementation, Public policy evaluation, Public Management, Efficiency, Effectiveness, Performance measurement, Performance assessment, Determinants of Performance, Program management, Project management, Program delivery, Benchmarking, Target setting, Resource allocation, EU Structural Policy, Rural Development, EU LEADER, Data Envelopment Analysis (DEA)
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### List of Abbreviations and Acronyms

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<th>Description</th>
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<tbody>
<tr>
<td>BCC</td>
<td>Banker, Charnes and Cooper (1984)</td>
</tr>
<tr>
<td>CAP</td>
<td>Common Agricultural Policy</td>
</tr>
<tr>
<td>CCR</td>
<td>Charnes, Cooper and Rhodes (1978)</td>
</tr>
<tr>
<td>CDF</td>
<td>Cumulative Density Function</td>
</tr>
<tr>
<td>CRS</td>
<td>Constant Returns to Scale</td>
</tr>
<tr>
<td>CSFs</td>
<td>Common Structural Funds</td>
</tr>
<tr>
<td>DEA</td>
<td>Data Envelopment analysis</td>
</tr>
<tr>
<td>DMU</td>
<td>Decision Making Unit</td>
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<tr>
<td>DRS</td>
<td>Decreasing Returns to Scale</td>
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<tr>
<td>EC</td>
<td>Efficiency Change</td>
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<tr>
<td>EU</td>
<td>European Union</td>
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<tr>
<td>IRS</td>
<td>Increasing Returns to Scale</td>
</tr>
<tr>
<td>IU</td>
<td>Program Implementation Unit / Program Implementation Body / Program Implementer</td>
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<tr>
<td>LAG</td>
<td>Local Action Group</td>
</tr>
<tr>
<td>LAP</td>
<td>Local Action Plan / Local Action Strategy</td>
</tr>
<tr>
<td>LEADER+</td>
<td>EU Community Initiative for rural development (2000-2008)</td>
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<tr>
<td>MA</td>
<td>Program Managing Authority</td>
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<tr>
<td>MLE</td>
<td>Maximum Likelihood Estimation</td>
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<tr>
<td>MPI</td>
<td>Malmquist Productivity Index</td>
</tr>
<tr>
<td>MT</td>
<td>Mid-term</td>
</tr>
<tr>
<td>MTE</td>
<td>Mid Term Evaluation</td>
</tr>
<tr>
<td>NDRS</td>
<td>Non Decreasing Returns to Scale</td>
</tr>
<tr>
<td>NIRS</td>
<td>Non Increasing Returns to Scale</td>
</tr>
<tr>
<td>OECD</td>
<td>Organization for Economic Co-operation and Development</td>
</tr>
<tr>
<td>OLS</td>
<td>Ordinary Least Squares</td>
</tr>
<tr>
<td>OP</td>
<td>Operational Program</td>
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<tr>
<td>PDF</td>
<td>Probability Density Function</td>
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<tr>
<td>PEC</td>
<td>Pure Efficiency Change</td>
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<tr>
<td>PPS</td>
<td>Production Possibility Set</td>
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<tr>
<td>PTE</td>
<td>Pure Technical Efficiency</td>
</tr>
<tr>
<td>RD</td>
<td>Rural Development</td>
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<tr>
<td>Abbr</td>
<td>Term</td>
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<tr>
<td>SD</td>
<td>Standard Deviation</td>
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<tr>
<td>SE</td>
<td>Scale Efficiency</td>
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<tr>
<td>SFA</td>
<td>Stochastic Frontier Analysis</td>
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<tr>
<td>SEC</td>
<td>Scale Efficiency Change</td>
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<tr>
<td>TC</td>
<td>Technical Change</td>
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<tr>
<td>TE</td>
<td>Technical Efficiency</td>
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<tr>
<td>TFP</td>
<td>Total Factor Productivity</td>
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<td>VRS</td>
<td>Variable Returns to Scale</td>
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1. INTRODUCTION

1.1 Background and Motivation of the Study

Public Administration is facing tremendous challenges and it is at the center of political, economic and social developments. In Greece, it presents serious problems, the analysis and elimination of which requires the adoption and implementation of new organizational structures, administrative practices and governance processes.

Recent reforms, intended to promote more accountable and responsive government, have increased public attention to performance analysis and accelerated the production and use of information on agency performance and public program outcomes (Heinrich, 2008). Many studies have investigated the scope and significance of performance measurement in public organizations. Nonetheless, there is more to learn about the challenges facing public managers who want to measure organizational outputs and use the feedback to improve performance (Nicholson-Crotty, Theobald, and Nicholson - Crotty, 2006). As a result, the search for better performance indicators is an ongoing effort (Johnsen, 2005).

The current research on policy implementation and performance and the related discussion are influenced by an ongoing change in policy-making and implementation. More specifically, there is a shift from hierarchical and centrally steered government to more networked governance that overcomes traditional administrative borders and includes different actors from outside the public sector (Aakkula, Kröger, Kuokkanen, & Vihinen, 2006). The evaluation community has responded with a shift from traditional impact analyses to implementation studies that fit within this new, more flexible structure. While impact analysis encompasses the research question most commonly associated with program evaluations - whether the program or policy has the desired effect on critical outcomes, implementation analysis seeks to understand the program in its own right (Corbett & Lennon, 2003).
Although there is a substantial research literature on public policy implementation, this is mainly restricted in the fields of education, health and social issues (Saetren, 2005; Hill and Hupe, 2002). However, the delivery of development programs differs from the provision of other types of public service both in terms of the type of services and in the sense that the implementers of development programs typically focus on their quick and timely delivery. Moreover, the administration of a program is a very demanding highly specialized task in contrast to conventional public administration tasks. Hence it makes sense to study the delivery of such programs systematically.

As stated by Pülzl & Treib (2006), implementation research has a lot to learn from European integration studies because policy making at international level has become increasingly important. Initially, the delegated management of EU public spending programs had been the focus of sustained academic and practitioner criticism for many years (Levy, 2003). Subsequently, the EU implementation literature concentrated on the efficiency dimension of program performance. Studies on the efficiency of implementation mechanisms initially focused on absorption capacity which reflects the ability of member states to fully spend in an efficient and effective way the allocated financial resources provided by the structural funds (Boot de Vet, & Feekes, 2001). More recently, studies by Ferry, Gross, Bachtler, & McMaster, (2007) concentrated on the structures and the determinants of implementation methods in order to improve their efficiency; see ÖIR (2003), Milio (2007) and Lion, Martini, & Volpi (2008).

How best to define program performance measures is a much-debated issue (Sager, Ritz, & Bussmann, 2010) and, typically, absorption indicators of aggregated output value defined as the budgetary funds mobilized in proportion to the funds initially allocated, are used as proxies for the efficiency of implementation of public spending programs. See Milio (2007) and Cace C., Cace S., & Nicolăescu (2010) and the above mentioned EU formal evaluation literature as examples of this approach.

However, an absorption indicator does not consider efficiency. As stated by Fried, Lovell & Schmidt (2008) efficiency is measured in terms of the maximum expansion (minimum contraction) of all outputs (inputs) that is feasible with current inputs (outputs) and technology. Nonetheless, using different performance measures for the same concept can provide different feedback to managers about their organizations (Nicholson-Crotty, S., Theobald & Nicholson-Crotty, J., 2006).
In this background, this study extends the public policy implementation literature by focusing on estimating the delivery of socio-economic development programs from an efficiency perspective. In many cases these programs are delivered at sub-national level by particular public (or non-profit) entities that have to mobilize funds in order to achieve sufficiently broad economic development objectives. Since the performance in any delivery network is largely determined by the operation of the nodes of such a network, we adopt a bottom up approach concentrating on the performance of the implementers themselves.

The main contribution of this study is that, to the best of our knowledge, this approach is the first attempt to use a frontier production model, namely Data Envelopment Analysis (DEA), for evaluating the delivery efficiency of public spending programs. More specifically, our objective focuses on the extent to which DEA can be utilized as a tool to support rational management decision-making and program improvement.

DEA is a well-known non parametric operational technique for evaluating the operational efficiency of a set of comparable units, called Decision Making Units (DMUs) that utilize multiple inputs to produce multiple outputs. DEA generalizes a ‘radial’ approach for estimating efficiency, originally proposed by Farrell (1957). To achieve that, DEA utilizes the concept of maximum equiproportional potential improvements either in inputs or in outputs whereby the emphasis is, in one case, on estimating how much all of the observed outputs can be increased, with no increase in any of the observed inputs. Through the use of linear programming, DEA constructs a frontier from a subset of best practice observations DMUs and identifies which DMUs are not on it. Hence, the subset of DMUs which construct the frontier are deemed relatively efficient while the rest are relatively inefficient within the sample under assessment. DEA provides efficiency scores which give the magnitude of the inefficiencies in relation to the distance of the inefficient DMUs to the frontier that is enveloping them. The underlying reasons for the wide range of DEA applications is the fact that it may handle multiple inputs and outputs without having to specify a priori a production relationship for these inputs and outputs and can be used in cases where public/priceless goods and services are provided. Moreover, since it uses the best and not the average practice for construction of the frontier, it is a more appropriate tool for benchmarking purposes than parametric methods (Bogetoft, 2012).
Numerous DEA extensions have appeared in the literature to include weight restrictions, non-discretionary or categorical variables, and changes in productivity and efficiency over time, etc. More than 4000 published articles on DEA and its applications in measuring efficiency and productivity are listed in Emrouznejad, Parker & Tavares (2007). For a comprehensive review on DEA models and their theoretical extensions over the past three decades see Cook & Seiford (2009). A thorough introduction in DEA can be found in Cooper, Seiford, & Zhu (2004). Banking, education, health care, and hospital efficiency were found to be the most popular application areas (Emrouznejad, Parker & Tavares, 2007).

DEA has also been used for evaluating the performance of various fields of public policy at international, national or local level. Recent examples concern either social welfare programs (Habibov & Fan, 2010), or government-sponsored R&D projects (Hsu & Hsueh, 2009). In particular, as far as economic development is concerned we mention the works of Karkazis & Thanassoulis (1998), Kutan & Yigit, (2007), Cherchye (2001) and Afonso, Schuknecht & Tanzi (2010). This literature is not primarily focused on the implementation phase of the public policy cycle. Most of it rather concentrates either exclusively on the long term outcomes of public policy or its outcomes along with the related outputs in order to measure the (in) efficiency in producing them. Consequently, this literature is not very helpful in management decisions concerning policy or program implementation per se. On the other hand, DEA literature dedicated to the efficiency assessment of public services with an administrative nature is still scarce, as stated by Cordero, Pedraja, & Jiménez, (2011).

1.2 Statement of Research Problem

Public program performance literature has brought forward administration capacity as an explanation for the economy development in countries, regions, policies and programs. Despite its importance in the literature, quantitative evidence on program delivery efficiency measurement is scarce. This study, for the first time, provides a framework for performance measurement and management and direct evidence from delivery of a social economic development program. Data Envelopment Analysis is used to measure efficiency and regressions are used as a second step to link efficiency with its potential correlates.
To study performance measurement and management practices in Greek public administrative sector, the domestic EU policy implementation context seems to be the most promising empirical field. It seems that, compared to the central/core ministerial administrative level, the EU program implementers have adopted performance measurement systems more seriously. Moreover, the requirement for a proper evaluation scheme addressing delivery efficiency from a bottom-up approach along with its complex character makes EU LEADER Operational Program an ideal candidate for empirically assessing our proposed framework. More specifically, Local action Groups (LAGs), as the main actors in the design, monitoring and implementation of integrated local development plans, deserve special attention in this context (OECD, 2014).

Throughout Europe, program implementation units are used for the day to day implementation of the programs. The success of this system for previous programmatic periods has been widely questioned. Moreover, evidence exists of the poor performance of the Greek implementation system. Hence, it would be fair to say that there is still room for significant improvements in general accountability at implementation unit level. Improved efficiency for both the programs and their delivery mechanisms would include performance measurement to promote management, improvement and accountability.

Apart from an extensive array of existing effect-focused research aimed at assessing if EU programs affect local development, this study offers a fresh perspective for understanding efficient utilization of resources throughout the delivery of these programs by including economic models that focus on the productivity of program implementation units in the context of rural development.

1.3 Research Objectives & Questions

The broad objective of this study is to propose a methodology for the evaluation of the delivery performance of public spending programs from an efficiency perspective. A further intention is to evaluate the impact of specific contextual variables on the programs’ delivery performance. Focusing on ways in which program implementation units efficiently utilize resources for program output production will allow practitioners and researchers to approach questions of comparative institutional performance, productivity, and efficiency.
Utilizing Data Envelopment Analysis (DEA), this study adds to Program Administration literature and Program Management discussion on two fronts: 1) to better allow policy makers and managers to identify relatively inefficient program implementation units and highlight areas for future improvement and; 2) to provide policy makers and managers with an alternative tool for assessing performance of program administration, with the aim of facilitating more informed decision making when allocating scarce public resources.

Given these objectives, the research questions are:

i. On average, are program implementers more or less effective at efficiently utilizing resources to maximize program output production and to increase program absorption?

ii. For inefficient implementation units, is overall technical inefficiency due to poor resource utilization as measured from managerial inefficiency or failure to operate at the most productive scale size?

iii. If these inefficient implementation units were to operate according to the best practice, by how much could output be increased given the current input deployment?

iv. How do organizational and other contextual variables account for the differences in their performances of these delivery units?

v. Do economies of scale exist in administration of a complex public spending program?

vi. Do efficiency and productivity improvement over time exist in the administration of a complex public spending program?

1.4 Design and Methodology

Although productivity efficiency is only one among many public concerns (besides effectiveness, equity, responsiveness, adequateness, appropriateness, and so on), it has received increasing amounts of attention in recent years. Given this increased interest in and awareness of efficiency, also a need arises to measure it and develop an understanding concerning the factors that affect or influence it.
Moreover, the proper measurement of public sector efficiency is a difficult empirical issue and the literature on it is rather scarce (Alfonso, Schuknecht & Tanzi, 2006). Researchers and international organizations have made some progress in this issue by shifting the focus of performance analysis from the amount of resources used by ministry or program to the services delivered or outcomes achieved (see, for instance, OECD (2003), Afonso, Ebert, Thöne and Schuknecht (2005), and Afonso, Schuknecht and Tanzi (2005)).

The present study takes one step further to address these performance issues and analyse the variation in delivery performance of a social economic development program via an efficiency approach. Our contribution is essentially multi-fold and is described as a program performance measurement framework with the following methodological stages (see Fig. 1.1):

- First, focusing on the implementation stage of the public policy cycle, we survey and discuss conceptual and methodological issues related to the measurement and the analysis of public sector performance.
- Second, using a public spending program monitoring data set consisting of program inputs (administration resources) and outputs (investments) from mid-term time period of program implementation (year 2005), we develop a Data Envelopment Analysis (DEA) approach in order to construct composite performance indicators for the efficiency assessment of program delivery.
- Third, adding to our analysis a second data set of program inputs and outputs from the following time period of program delivery (year 2006), we apply a DEA-Malmquist approach, in order to estimate the overall productivity change in program delivery and decompose this change in its efficiency, technological and scale components. Statistical tests are applied in order to verify the significance of our results.
- Fourth, using the pooled data from the two years, we perform returns to scale DEA-based statistical tests in order to explore the economies of scale of program administration services.
- Finally, using the pooled dataset, we apply Banker’s DEA approach to compute productivity scores of program delivery, which in a second regression stage, are combined with a set of contextual variables to see whether operational and
Introduction

Exogenous (non-discretionary) factors play a significant role in explaining inefficiencies of program delivery.

Figure 1.1: Methodology of Research

All the above DEA-based performance results are firstly statistically tested, and then further analysed and connected with policy and managerial decisions in order to improve the program implementation. To our knowledge, such an efficiency analysis has not been applied before to public spending program settings.

1.5 The Study’s Contributions to Knowledge

This study argues that issues arising during a public program evaluation should also include the efficiency perspective of its delivery performance. In this respect, a main question is whether the program is administrated / delivered in an efficient way. Focusing on administrative costs this general question could become more specific; “Has the
provision of implementation services or outputs been achieved at the lowest cost? How much cost reduction is possible to provide the same level of services or outputs?” On the other hand, focusing on output expansion, relative questions might be: Could delivery services and/or program outputs have been provided promptly, at the same cost? How much output increase is possible by using the available inputs?” Possibly due to methodological issues, these kinds of questions have not been adequately addressed, even though a large amount of past research has reviewed the delivery of transfer programs and particularly of EU Structural and Cohesion Funds. In contrast to previous approaches, which do not consider the measurement of efficiency of program implementation, to the best of our knowledge, this is one of the first attempts to use frontier efficiency models to assess the delivery of public programs from an efficiency perspective. In this paper we propose and discuss a framework for estimating the operational efficiency of programs at individual implementation level. This framework is based on Data Envelopment Analysis (DEA) and it is illustrated on the Greek LEADER+ program. The study is contributing to the field of data envelopment analysis and public performance evaluation in a number of ways. Empirical investigation of efficiency performance of program implementation using data envelopment analysis, as far as we know, has never previously been applied. This study therefore:

- Fills the empirical knowledge gap to efficiency issues of public program administration services.
- Demonstrates that data envelopment analysis is a useful tool for identifying the most and least efficient program implementers and strategies for increasing outputs and/or saving resources.
- Provides insight into operation policy, organizational and contextual factors that influence productivity performance of program implementation units.
- Provides DEA - based criteria to Management Authority for program resource allocation.
o Yields a more realistic picture for policy makers and program implementer’s managers than setting an absorption standard that LAGs may or may not be able to achieve.

o Supports that an efficiency-oriented monitoring and evaluating (M&E) system should be a key component in an official M&E system.

o Serves as a significant compendium of ideas, facts and figures that can be used by development professionals, managers, policy makers and academics in understanding the nature and efficiency performance of delivery units in managing public programs.

o Provides an impetus for further discussion on public program efficiency.

1.6 Outline of the Study
To achieve the research objectives, the study is organized in nine core chapters as follows.

Chapter 2 reviews the public policy implementation literature and positions the study as an assessment of the policy implementation phase in a policy cycle. It provides the basic policy implementation concepts and main research approaches while it underlines the important shift of contemporary public administration and the new modes of EU policy implementation. Emphasis is given on the weak points of the Greek public administration system.

Chapter 3 presents the literature of performance measurement in public context for a program and managerial perspective. It explains how performance in the public sector is measured, while it attempts to provide a clear picture of the definitions of performance measurement and performance management. It follows a discussion upon the importance of performance information in public administration as it improves decision making and leads to greater public value. It explains the key purposes of organisational performance management. Subsequently, the performance measurement in the Greek public service sector and the EU program absorption problems in relation to weak administrative capacity are presented.

Chapter 4 presents theoretical concepts of production and studies the alternatives methods for nonparametric efficiency estimation which served as the main research tool for the model application. Chapter 4 gives insights on overall, technical and scale efficiency as
well as on economies of scale, target setting and benchmarking. More precisely, chapter 4 illustrates the technical side of data envelopment analysis (DEA).

Chapter 5 deals with the EU LEADER operational program, the case study of this thesis. It discusses the socio-economic development policy in EU context and the new rural development paradigm, along with the Leader approach to rural development policy and its main key features. Finally, the weaknesses in relation to official performance evaluations are offered.

Chapter 6 introduces the proposed methodology for program performance measurement adopted in this research. It conceptualizes the program implementation phase, selects the DEA method as a program efficiency measurement approach, develops an output oriented DEA specification, chooses Local Action Group (LAG) as the unit of assessment and describes the input and output variables included in the analysis and the data sources.

Chapter 7 reports the midterm (MT) DEA empirical findings and discusses their managerial and policy implications. It provides an analytical presentation of the obtained results contrasting and combining traditional absorption and DEA ratings. Moreover, chapter 7 gives insights on an array of program operational themes such as ranking of LAGs, allocating reserve fund, calculating potential improvements and risks, identifying good delivery practices, and assessing regional performance.

Chapter 8 includes the theoretical framework for efficiency and productivity change measurement of program delivery and presents their empirical estimations. Theoretical considerations are given upon the decomposition of Malmquist Productivity Index as well as its approximation using DEA frontiers. Evidence on empirical estimation of efficiency and productivity change refers to hypothesis tests for productivity change, changes in efficiency and overall productivity change from the pre-MTE to post-MTE period.

Chapter 9 describes the methodology for the estimation of contextual variables in productivity, hypothesis formulation, regression models and their results. Precisely, the hypothesis tests refer to organizational and program size, local area characteristics, competitive programs, island based LAG, pre-selection procedure of LAGs, LAG’s management experience, and intervention- mix differences. Subsequently, chapter 9 provides empirical evidence upon the estimation of global economies of scale for program administration services, the comparison of time-period efficiencies differences, and the second stage regression results.
Chapter 10 provides a summary of the study and its key contributions. The chapter concludes the thesis, highlighting the main findings and stating their policy and managerial implications. It presents the main conclusions of the study and discusses some future research directions.
2. PUBLIC POLICY IMPLEMENTATION

2.1 Policy Implementation Concepts and Definitions

Policy processes include policy making and policy implementation. Policy implementation has been defined as “the carrying out of a basic policy decision” (Mazmanian and Sabatier, 1983). It has also been defined as those actions by people that are directed at achievement of objectives set forth in the policy decision (van Meter and van Horne, 1974). Thus, policy implementation is what develops between an intention of the government to do something and its ultimate impact following action (O’Toole, 2000). Implementation is said to commence once goals and objectives have been established by policy decisions and funds committed (Van Meter and Van Horn, 1974). Implementation literature shows that failure of policy implementation is common, non-random and patterned (De Leon and De Leon, 2002).

Implementation implies processes and ability to convert policy into action by operationalising the strategy in the form of programs (Schofield and Sausman, 2004). Programs can vary in scale and can be structured simply or be complicated with a broad variety of activities.

The concept “implementation organization” has been identified by researchers of policy implementation. An implementation structure is the entity used by implementers to achieve the program objectives. Using this as a unit of analysis facilitates evaluation of programs (Hjern and Porter, 1981). It is known that applying public policies includes a much larger number of agencies and actors many of which would be outside the formal hierarchical control of the lead management unit, thus involving formal and informal networks (Granatham 2001; Meier and O’Toole, 2001). The management and coordination among these is called governance (Brinkerhoff 1999). The study of networks is a growth area in public management (Meier and O’Toole, 2001).
2.2 Implementation Research

Implementation studies are to be found at the intersection of public administration, organizational theory, public management research and political science studies (Schofield and Sausman, 2004). The literature that addresses policy implementation has grown over the last decades (Barret, 2004; Hill & Hupe 2002; O’Toole, 2004; Sabatier, 1986; Sinclair 2001), with each contribution providing new insights and highlighting shortcomings of previous research. Implementation research has become multidisciplinary and dispersed. The most important areas studied are education, health, social, economics and environment (Saetren, 2005).

Many authors (De Leon, 1999; Hill and Hupe, 2002) offer a useful synthesis of how this cross-disciplinary and non-standardized field of study evolved. In the literature review study of McDonald et al. (2013) three generations of policy implementation studies are described as follows. The first generation conceptualizes the complexities involved in program implementation and how they were carried out at local level. A second generation of studies focuses on refining frameworks and applying them to different program areas. These studies introduce more structured variable definitions and data collection methods and, sometimes, quantitative analysis, often in the context of program evaluations, program performance analysis, and/or analysis of community and systems change. The most recent third generation studies use a combination of qualitative and quantitative approaches to more systematically analyse implementation, program operations, service delivery, and links between program implementation factors and individual-level outcomes and/or program performance.

The three generations of implementation research presented earlier can be subdivided into three distinct theoretical approaches to the study of implementation (Püllzl & Treib, 2006):

1. Top-down models put their main emphasis on the ability of decision makers’ to produce unequivocal policy objectives and on controlling the implementation stage.

2. Bottom-up models view local bureaucrats as the main actors in policy delivery and conceive of implementation as negotiation processes within networks of implementers.

3. Hybrid approaches try to overcome the divide between the other two approaches by incorporating elements of top-down, bottom-up and other theoretical models.
The top down approach assumed that implementation begins with policy objectives and implementation will follow in a linear fashion—a product of a rational public administration model which assumes distinct policy formulation and implementation. The top down approach lays emphasis on the actors who design the policy and the factors which can be manipulated from the centre. The emphasis in such a case is more on the rational design of the policy (Schofield, 2001). Top down models consider policy as hierarchical and linear and look primarily into how to maximize the translation of policy objectives into practice (Fitz, 1994).

Bottom up models developed from the main criticism of top down models which ignored the behavioural aspect of implementation and the key role of local implementers (Schofield 2001). Their main focus was on the motives and actions of actors involved in implementation and assume that formulation and implementation are an integrated process and are descriptive in nature as emphasis is on explaining the role of factors causing difficulty in implementation (Matland, 1995). The bottom up approach (Hjern and Porter, 1981; Hull and Hjern, 1982) lays emphasis on the target groups and service deliverers and state that policy is made at this level. ‘Bottom up’ models are more descriptive in nature and state that implementation can be better understood by looking at the policy from the viewpoint of target groups and service deliverers. ‘Bottom-up’ approaches, by contrast, emphasize the importance of ‘street-level bureaucrats’ (Lipsky, 1980) and local organizations for the re-interpretation of policy and the success or otherwise of policy implementation, as the agents that are closer to the policy target groups.

There have been attempts to explain ‘implementation gaps’ and policy failures (Gunn, 1978; Lipsky, 1980; Pfeffer, 1992). Some researchers consider that policy failure due to non-implementation or unsuccessful implementation become more often (Saetren, 2005; Winter, 2003).

Policy implementation research has changed by expanding the scope of questions being addressed. A broader theme of governance takes into account the design and operation of structures and processes of policy action. Programs are used as units of analysis. Governance is concerned with creating the conditions for ordered rules and collective action often including agents in the private and non-profit sectors as well as within the public sector. The focus is on governance mechanism—grants, contracts and agreements.
Statistical modelling is used to analyse how evidence-based program models are systematically institutionalized, adopted, and scaled (Fixsen et al., 2009; Bloom, Hill, and Riccio, 2003; Weaver, 2010; Durlak and DuPree, 2008). Currently, a body of implementation science literature has emerged from education, criminal justice, and social services program studies that systematically analyse the adoption of practices and models that have been proven to be effective (Fixsen et al., 2005).

The impact of how a program is intending to achieve its policy objectives depends upon the receptivity of the local environment to its means and its mix of incentives and constraints. Programs are applied unevenly across units because each local unit can react differently to the mix of constraints and incentives depending upon the needs and management of the local context (Sinclair 2001). The implementation of a policy through a series of programs is influenced by the role played by various stakeholders and interest groups (Ryan, 1996). Hence, management of these groups and the characteristics of the program / policy - which involve the amount of change being introduced and the number and variety of components in the program, influence the degree of complexity and dynamism to be managed in the local context.

2.3 Evaluation of Implementation

Hargrove (1975) held that understanding policy implementation is “the missing link” or “black box” in policy analysis and program evaluation. Implementation analysis is sometimes referred to as a branch or type of program evaluation; but it also is referred to as implementation research, implementation evaluation, process analysis, management research, organizational analysis, or case study research (McDonald et al., 2013). Corbett and Lennon (2003), broadly define implementation analysis as “evaluative strategies that, in effect, explore the translation of plausible concepts into functioning policies and programs.”

Rossi, Freeman, and Lipsey (2004), define implementation analysis more programmatically, to examine how well or efficiently a program is implemented, whether a program was implemented as intended and how, and why a program may have changed over time. A program-focused implementation analysis is offered by Patton (2008): an “evaluation that focuses on finding out if a program has all its parts, if the parts are functional, and if the program is operating as it’s supposed to be operating.” Fischer
(1995) defines policy evaluation as ‘the activity of applied social science typically referred to as “policy analysis” or “policy science”. Implementation analysis methods have grown from mostly qualitative descriptive studies of a single program to multi-site, multi-method interdisciplinary studies focusing on every feature of program and system design, operations, performance and effectiveness.

Policy evaluation can focus on, (Lippi, 2007): a) the “products” generated by the policy (outputs) or the effects on the recipients (the outcomes and impacts); b) the implementation, that is the actions and decisions culminating in the launch of a policy, such as the provision of a service, the enactment of a law, and so forth; or c) the phases in which the political agenda takes shape (issue-making and decision-making).

Depending on when it is carried out, an evaluation can be ex post, when it analyses the results (outputs, outcomes and impacts); interim, when it is ongoing and conducted during implementation; or, ultimately, ex ante, when it is carried out before the implementation phase. Typically, ex ante and ex post evaluations aim to confirm or revoke decisions already made. The interim evaluation – which generally responds to a broader cognitive need – seeks to account for what happens as the implementation of the policy unfolds (Sorrentino and Passerini, 2010).

Mazmanian and Sabatier (1983) formulate a set of six sufficient conditions of effective implementation:

- The enabling legislation or other legal directive mandates policy objectives which are clear and consistent or at least provide substantive criteria for resolving goal conflicts.

- The enabling legislation incorporates a sound theory identifying the principal factors and causal linkages affecting policy objectives and gives implementing officials sufficient jurisdiction over target groups and other points of leverage to attain, at least potentially, the desired goals.

- The enabling legislation structures the implementation process so as to maximize the probability that implementing officials and target groups will perform as desired. This involves assignment to agencies with adequate hierarchical integration, supportive decision rules, sufficient financial rules, and adequate access to supporters.
• The leaders of the implementing agency possess substantial managerial and political skill and are committed to statutory goals.

• The program is actively supported by organized constituency groups and by a few key legislators (or a chief executive) throughout the implementation process, with the courts being neutral or supportive.

• The relative priority of statutory objectives is not undermined over time by the emergence of conflicting public policies or by changes in relevant socioeconomic conditions which weaken the statute’s causal theory or political support.

The concept of the ‘perfect’ model of public policy implementation, developed by Gunn (1978), focuses on the pre-conditions that would ensure the successful implementation of a policy or strategy. Like Sabatier and Mazmanian, these propositions can be read as recommendations to policy makers.

According to Pülzl and Treib, Oliver (2007), a separate analysis of implementation is useful since the actors involved in policy formation and implementation, while partly overlapping, are certainly not always exactly the same. Hence, keeping the stages of the policy process separate and focusing on one of them in more detail seems to be worthwhile, although the interdependencies between the stages have to be taken into account as well.

2.4 The Economic and Political Context

The economic and political context is significant for public administration and has established certain big changes, which especially in the past few years originate from economic crises and the measures of austerity that followed. The organizations of public services focus on the challenges often faced by those stepping into first line management roles in order to correspond in that.

Despite the fact that public sector organizations, due to their special nature, usually face unique operational, cultural and strategic concerns, nowadays, their organizational goals and main objectives tend to become more and more similar to those of private sector enterprises (Chatzoglou, Chatzoudes, Vraimaki and Diamantidis, 2013), and they have been under pressure to deliver quality services, while improving their efficiency (Robinson, 2003).
More often, an inflated, ineffective and inefficient public sector has been presented as a symptom, if not the cause, of economic problems, which can be faced through radical budgetary restrictions (Ashworth et al., 2013). However, the downsizing of budget of public service does not automatically imply important reform of the system (Pollitt and Bouckaert, 2011), although we appear to witness a further turn in the ideological perception of state. More precisely, the role and the planning of public services are once again under revision, while the governments initiate a lot of reforms in order to trim, marketize and innovate service delivery. According to Ashworth et al. (2013), this trend might cause potentially no reversible consequences for the size, the form and the operation of organizations of public service.

2.5 The Repositioning of Contemporary Public Administration

Public administration is an evolutionary discipline which has passed through different phases. Frederickson (1999), argued that public management definition is a based on a wider re-conceptualization of what it traditionally means to be "public". In traditional public administration literature, the word public was meant to be "government." Nowadays, public management includes government but also all of those institutions that works in multi-organizational settings such as networks of agencies serving public activities in the larger interest of people (Kettl, 1993).

Generally speaking, public sector includes government and all publicly controlled or publicly funded agencies, enterprises, and other entities that deliver public programs, goods, or services. It is very difficult to distinguish institutions that are essentially public in character with institutions that are private and profit making (Bozeman, 1987; Frederickson, 1997). The discrimination between the public and the private can be done using three criteria (van Dooren, 2006). (a) According to the legal definition, public sector includes government organizations and organizations governed by public law. (b) According to the financial definition, public sector includes all organizations that are (mainly) funded by public means. (c) According to the functional definition, public sector includes all organizations that deal with the main functions of government -irrespective from the funding or the legal form of the supplier. Thus, public service is a more general designation than public sector.
Public policies and programs are being administered to an increasing extent through complicated webs of states, regions, special districts, service delivery areas, local offices, nonprofit organizations, collaborations, networks, partnerships, and other means. (Lynn, Heinrich, and Hill, 2001). This phenomenon has been referred to as “the fragmented and disarticulated state” (Frederickson, 1999) or “the hollow state” (Milward and Provan, 2001). It is characterized by an increasing irrelevance of jurisdictional borders and a related diminishing capacity of the state to manage complex social and economic issues, the blurring of public and private sectors, and increased contracting-out (Frederickson, 1999).

EU regulations concerning the rules for participation in the implementation of EU funded programs, define a public body, as a public sector body or a legal entity governed by private law with a public service mission. Therefore, there are two clear cases of entities that are considered as public bodies: public sector bodies and legal entities established under private law with a public service mission and providing adequate guarantees.

2.5.1 The EU Policy Implementation

During the previous years, policy-making at European levels has experienced the rise and increase of flexible, non-hierarchical forms of policy-making. These “new modes of governance” share a number of features that distinguishes them from traditional methods of policy-making. According to Treib, Holger and Gerda, (2005), “old” governance modes are typically characterised by legally binding legislation and a top-down approach to policy execution involving little or no participation by private actors in both decision-making and implementation. New modes of governance, in contrast, are usually not based on binding legislation but rely on “soft” law as well as on the self-regulation of private actors, the co-regulation of private and public actors or the delegation of tasks to regulatory agencies in policy formulation. At the implementation stage they use non-hierarchical and less formal modes of steering based on the creation of incentive structures and non-legal sanctioning methods, such as naming and shaming, as well as learning, arguing and persuasion.

The partnership principle in EU cohesion policy was introduced in order to involve sub-national authorities and interest organizations in policy formulation and implementation. In this section we examine how researchers have reacted to this call for a new way of assessing public policy implementation.
Yesilkagit and Blom-Hansen, (2007), argue that the multi-level governance literature and the critics of the multi-level governance framework have not examined implementation structures properly, but have focused on regional influence. Their findings show that when examining implementation structures it becomes clear that member states are in full control of the re-allocation of EU funds. One central theoretical implication of their study is that the focus of studies of any fundamental re-allocation of power resources in cohesion studies should comprise the entire network of implementation rather than the strategies of its individual component actors.

Batory and Cartwright (2011), investigate the horizontal dimension of partnership arrangements in cohesion policy in three EU Member States (Austria, Hungary and Slovakia). The focus is on the practice of the monitoring committees (MCs), the primary institutional expression of partnership in the distribution of Structural Funds. The main findings are that in each country NGO participation in the MCs remained contentious, the working of the committees was rather formalistic, and the bodies' purpose and role conceptions were ambiguous. The implication is that partnership as currently practised does not live up either to normative expectations suggested by the EU regulation of the committees or to the expectations of civil society partner organizations themselves.

Cohesion policy has caused a lot of changes in Greek public administration. Following the reforms introduced during the second CSF, the establishment of a semi-autonomous ‘parallel administration’ in 2000–2001, generated top-down processes of substantive learning and led to the proliferation of new practices and policy improvements. These effects are evident in the areas of management and implementation (Andreou, 2014).

There is already a significant amount of literature on EU cohesion policy and issues relating to multilevel governance in Greece. This literature focuses on the vertical dimension of multilevel governance and has demonstrated that the most tangible EU effect on governance during the implementation of cohesion policy in Greece has been the establishment and/or proliferation of special structures and supporting mechanisms operating at various territorial levels outside the mainstream public administration- such as the Managing Authorities of Operational Programmes, the Management Organization Unit (MOU), semi-independent companies managing major infrastructure projects and various Development Companies operating at the sub-national level (Andreou, 2006; Andreou, 2010).
2.6 The Greek Public Administration

The Greek administrative legal system is adapted from the French system (OECD, 2001). The majority of studies state that Greek public administration is a bureaucratic, highly centralized, inflexible and inefficient system (Argyriadis, 1971, 1998; Mouzelis, 1978; Makrydimetres, 1991). The malfunctioning of the Greek administrative system has been documented by numerous experts’ reports, as well as by academic analyses and the public opinion. The key factors responsible for this quality deficit include the general degree of state intervention in economy and society, which has been excessive by any means and standards of comparison, as well as the elongated tradition of legalism, rigidity and formalism of administrative behaviour almost at any level and feature of state action. Furthermore, the penetration of political parties’ interests into the operation of state agencies and institutions at the centre and the periphery of the administrative apparatus of the country does only exaggerate the condition of limited professionalism and low performance in public administration.

Excessive size, political dependence, legalistic culture and lack of professionalism, if combined as they actually are, become factors which explain much of the predicament of public administration in Greece (Makrydimetres, 2013).

Manojlović (2011) deals with the last three decades of public sector reforms in Greece, explaining their progress - from the limited reforms of the 1980s, intensive reforms between 1990 and 2009, and new reforms of the entire public sector that were launched in 2010 in response to the economic crisis. Various reform measures are mentioned, but the focus is put on the Greek privatization policy, the three big reforms of regional and local government and planned reform of the civil service. He also mentions the main long lasting negative characteristics of the Greek public sector, such as high centralization, over-staffing and low efficiency of the civil service and high level of corruption. According to Makrydimetres (2013), despite the many public administration reforms that take place in recent decades the worst symptoms of bad administration and bureauopathology have not been overcome. Recent reforms projects of the Greek public administration such as the Administrative Reform 2013 and the Greek National Reforms Programme (2014) highlight the need for downsizing the Greek public administration and reducing the resources utilised, with the objectives of the achievement of a more efficient and less costly public administration.
According to Papadopoulou, Papalexio and Hasanagas (2009), although the Greek rural development delivery system is a centralised system, the regions and prefectures contribute substantially in some cases. In the previous programming periods there was a division of competences between the central and regional and sub-regional levels. This system has been changed in designing the new programming phase and now the division of competences is based on the investment size: investments in small holdings, especially in the field of quality products, have been moved to the central structures, whereas large-holding applications are more decentralised.

2.7 Concluding Remarks

We summarise the significant points in the field of policy implementation literature as follows: Policy implementation has been defined as “the carrying out of a basic policy decision”. Implementation implies processes and ability to convert policy into action by operationalising the strategy in the form of programs. The contemporary concept of public sector is broader than the narrow traditional definition of core government and may overlap with the not-for-profit or private sectors. It is recognised that implementing public policies involves a much larger number of agencies and actors. Moreover, in recent years, policy-making at European level has witnessed the emergence and proliferation of flexible, non-hierarchical forms of policy formulation and implementation. The methodology followed in implementation literature is mainly qualitative while some studies are quantitative. Little has been done in public policy implementation analysis in order to inform practice although a separate analysis of implementation is useful.

The present study introduces, apply and validate a bottom-up evaluation framework for the assessment of public spending programs delivery, from an operational and managerial perspective.
Public Policy Implementation
3. PUBLIC SERVICES PERFORMANCE MEASUREMENT

3.1 Introduction
Over recent decades, performance has become a central topic in the public debate (Baekgaard and Serritzlew, 2015). Occasionally, it is characterized as a performance movement in which a primary task has been how to measure and compare performance in public service organizations (Nielsen, 2013; Radin, 2006; Van Dooren, 2008). Performance management and the creation of executive agencies have been two of the most widespread international changes in public administration. (De Bruijn, 2002; Holzer and Yang, 2004; Ingraham, Joyce and Donahue, 2003; OECD, 2002; Pollitt and Bouckaert, 2004; Pollitt and Talbot, 2004; Pollitt, Talbot, Caulfield and Smullen, 2004; Van Thiel, 2004, Yesilkagit, 2004). These two trends enforced the passage from the government to governance (Rhodes, 1997) while the growth of collaborations within sector, networks and public-private partnerships (Agranoff and McGuire, 2001; Ansell and Gash, 2008; Vangen and Huxham, 2012) have been established in the literature. These changes emphasize collaborations and reflect basic significant new public management concepts, such as performance management (Newman and Clarke, 2009). Bouckaert (1992) illustrates the history of performance measurement and demonstrates the value of tracking organisational performance on certain indicators (Newcomer, 1997; Wholley, 1997).

3.2 Measuring Performance in the Public Sector
Neely et al. (1995) define public performance measurement as the process of quantifying the efficiency and effectiveness of action while performance dimensions according to Boyne (2003) are efficiency, responsiveness, or equity. Forbes, Hill, & Lynn (2006), include quantity and quality of outputs, efficiency, equity, outcomes, value for money,
and consumer satisfaction. Pollitt (2000) in his review study defines performance improvement as: savings, improved processes, improved efficiency, greater effectiveness, and an increase in the overall capacity/flexibility/resilience of the administrative system as a whole. Boyle (2007), approaches performance from the side of productivity and argues that productivity of the public sector is as important to the economic performance of a country as the productivity of the private sector. From the same aspect Thornhill (2006) argues that changes in public sector productivity can have significant implications for the whole economy. Performance introduction into public sector has been one of the key reform drivers (Gianakis, 2002). Public sector reforms are producing a new model of public governance due to the incorporation of a more modest role of the state as direct public service provider and a strong role of performance measurement (Sanderson, 2001).

Performance measurement is an important tool for increasing accountability and might provide data on how effectively and efficiently public services are delivered and fostered to a move towards a contract culture within public. Gaebler and Osborne (1992) advocate the power of result-oriented government. However, performance measurement has not only benefits but also deficits (Gianakis, 2002). Meyer (2002) argues that performance measurement rarely lives up to the high expectations. De Bruijn (2002) states that the perverse effects of performance measurement in the public sector will in the long run diminish the beneficial effects and that the more the political level intends to steer with the help of performance measurement, the more it is inviting perverse behaviour. Nicholson-Crotty et al (2006) investigate the problems that public organisations face when they try to develop and use performance measures. Others, have highlighted the ways in which entrepreneurial public managers have taken the lead in performance measurement, whereas previously others have illustrated the many organisations and programs that still fail to benefit from this growing tendency (Ammons, 1995; Murphy, 1999).

A common finding in performance literature is that there is no one measure sufficient to answer all questions that are asked about the performance of an organisation or program (Kravchuk & Schack, 1996) while the selection of these measures depends on their specific purposes (Behn, 2003; Hatry, 1999). Different types of measures could be used to gather information about different components of public-service delivery (Berman &
Wang, 2000; De Lancer & Holzer, 2001). It is up to the managers to select the appropriate performance measure by defining the activities they want to know more about and the purpose to which they want to put that information (Hyland, Ferrer, Santa, & Bretherton, 2009).

A number of frameworks have been developed for performance measurement and performance management, such as strategic measurement and reporting technique (Cross & Lynch, 1989), the performance measurement matrix (Keegan, Eiler & Jones, 1989), results and determinants framework (Fitzgerald et al., 1991), balanced scorecard (Kaplan & Norton, 1996; Kaplan & Norton, 2001; Keegan, Eiler & Jones, 1989) Cambridge performance measurement systems design process, (Neely et al., 1996) integrated performance measurement system reference model (Bititci, Carrie & Mcdevitt, 1997), performance prism (Neely & Adams, 2001) and the European business excellence model (EFQM, 1999). Holloway (2001) argues that little has been done to describe and analyse problems with the application of these models and frameworks. Bourne (2001) defines as successful a performance measurement system, the one that can be used by the management team on a regular base in order to help management.

3.2.1 What are Performance Measurement and Performance Management?
Performance measurement is in the core of performance management. Performance cannot be assessed without the establishment of both performance data and meaningful system of program metrics (Harbour, 1997). Thus performance measurement is a crucial element of a performance management system. Performance monitoring shows where change is required and which will in turn produce the desired behaviour that will improve performance (Lemieux-Charles et al, 2003). Many authors use the concepts of performance measurement and performance management interchangeably. However, they are different concepts. Performance measurement is about the past, and performance management extrapolates the data to provide information about the future (Lebas, 1995). Performance measurement is quantifying, either quantitatively or qualitatively, the input, output or level of activity of an event or process while performance management is action, based on performance measures and reporting, which results in improvements in behaviour, motivation and processes and promotes innovation (Radnor and Barnes, 2007).
Neely (1998) identify the activities required to measure performance by defining a performance measurement system as consisting of three inter-related elements:

- Individual measures that quantify the efficiency and effectiveness of actions;
- A set of measures that combine to assess the performance of an organisation as a whole;
- A supporting infrastructure that enables data to be acquired, collated, sorted, analysed, interpreted and disseminated.

Ittner, Larcker and Randall (2003), Gates (1999) and Otley (1999) broaden the scope of performance measurement to include strategy development and the taking of action. Although some authors (Johnson and Broms, 2000) question the value of basing management on performance measures, it is clear that a performance measurement system can form “the information system that is at the heart of the performance management process, and integrates all the relevant information from all the other performance management systems” (Bititci et al., 1997).

Fryer, Antony and Ogden (2009), review the literature and identify the key criteria of a successful performance management system as being: a) alignment of the performance management system and the existing systems and strategies of the organisation; leadership commitment, b) a culture in which it is seen as a way of improving and identifying good performance and not a burden that is used to punish poor performers, c) stakeholder involvement and d) continuous monitoring, feedback, dissemination and learning from results.

They argue that there is a lack of literature about the interpretation, reporting and statistical validity of indicators and further empirical research is needed to assess the current state of performance management within public sector organizations.

3.2.2 Why do Public Managers use Performance Information?
In the past, it was often assumed that the existence of performance information would lead to its use by decision makers. While the supply side (production) of performance information has received considerable attention in the public sector service performance measurement and management literature, the demand side (actual use) of this information has traditionally not been very high on the research agenda (Van de Walle and Van Dooren, 2008). Moreover, many organisations collect a vast amount of information, but
do not have an effective system for translating this feedback into a strategy for action (Hyland et al., 2009). Although, the link between performance measurement and the use of this information in decision making is often assumed, actual use is often the weak point in performance information systems. The majority of OECD countries use performance information in order to manage public program/agencies and to redistribute public budget resources (OECD, 2007). This supply evidence that some countries prioritize, assign and manage resources using quantitative performance evidence (Sanchez, 2009). However, according to de Lancer Julnes and Holzer (2001), evidence on whether performance information is actually used in decision making is scarce, while opinions on whether performance measurement actually matters for decisions are divided (Askim, 2007; Ho, 2006; Moynihan and Ingraham, 2004; Pollitt, 2006).

Patterns of use of performance information are different at the various stages of the decision-making process (Melkers and Willoughby, 2005). There are also important sectoral differences, which means that performance information is more embedded in some policy areas than in others (Askim, 2007a; Davies, Nutley and Smith, 2000; Van Dooren, 2004). Individual organizations have different organizational cultures, affecting the use of performance information (Moynihan, 2005) and large differences exist between countries (Pollitt, 2005). There are also different types of end-users (Van de Walle and Van Dooren, 2008) such as managers and other public employees who make operational or strategic decisions, politicians who decide about budgets and should be accountable in the public and citizens who want to be informed on how their taxes are used and how the public services they use are performing.

Performance measurement and management have multi-dimensional characteristics and performance information may be used for different reasons. Behn (2003) identified the following eight reasons why managers may use performance measurement:

- Evaluate: How well is my public agency performing?
- Control: How can I ensure that my subordinates are doing the right thing?
- Budget: On what programs, people, or projects should my agency spend the public’s money?
• Motivate: How can I motivate line staff, middle managers, non-profit and for-profit collaborators, stakeholders, and citizens to do the things necessary to improve performance?

• Promote: How can I convince political superiors, legislators, stakeholders, journalists, and citizens that my agency is doing a good job?

• Celebrate: What accomplishments are worthy of the important organizational ritual of celebrating success?

• Learn: Why is what working or not working?

• Improve: What exactly should who do differently to improve performance?

When we analyse how performance information is used to improve front-line service delivery, we are in fact studying a phenomenon that is fundamentally different from a situation where performance information is used for advocacy or accountability purposes.

3.2.2.1 Performance information for management improvement

The introduction of performance information in public administrations was based on the idea that information on organizational performance may improve decision making and ultimately lead to greater public value for taxpayer money (Kettl 1997; Moynihan 2006). In order to attain this goal, performance information usually takes the form of quantitative indicators of performance, although a more qualitative assessment of performance is also often carried out (Heinrich 2012). In practice, performance information may describe outputs, outcomes, and/or responsiveness of public services (Nielsen 2013).

The use of performance information in decision-making is a management behaviour that has received much attention in public administration research and practice. Kroll, (2015), based on a systematic review of 25 empirical studies identified that measurement system maturity, stakeholder involvement, leadership support, support capacity, an innovative culture, and goal clarity are factors that have repeatedly shown a positive impact in performance information use.

When speaking of performance data, the literature refers to feedback information on outputs and outcomes of the public service as well as its efficiency and its effectiveness (Kroll, 2015). This is in line with established definitions which highlight that performance information is more than just financial data and has a specific focus on the results and
achievements of public administration (Hatry, 2006; Pollitt & Bouckaert, 2011). A second characteristic is that performance information is in a quantitative, aggregated format, and it is made transparent through reports or data bases. Its collection is not ad-hoc but follows a systematic control-cycle logic where indicators for goal achievement are defined, and performance information is collected and analysed, and it is supposed to be used for future decision-making (Kroll, 2015) (see Figure 3.1).

**Figure 3.1: Deming’s PDSA cycle**

![Deming's PDSA cycle diagram](image)

Source: Deming’s (1994) adapted from Kroll (2015) to the case of performance management

Performance data could be used to serve many functions, such as to improve services through better informed decisions, goal-based learning, or sanctioning and rewarding. Van Dooren et al. (2010) identify learning (which is mostly concerned with future improvements) as well as steering and controlling (keeping track of present activities) as functions of performance information.

### 3.2.2.2 Performance management as management control

Mackie (2008) argue that the key purpose of organisational performance management is to introduce systematic controls in the management process to guide and regulate the activities of an organisation or any of its parts, by means of management judgement, decision, and action for the purposes of attaining agreed objectives. Control can take place before, during or after an event, but many controls can only realistically be introduced after organisational activity has taken place as they gauge the effect of organisational actions.
According to Hicks and Gullett (1981) the three respective types of control based on timing are:

Pre-control: This is essentially pre-emptive, as in planning, as it sets out the future direction, goals, targets, outputs and outcomes and identifies potential difficulties and risks in advance.

Concurrent control: This mode or phase of control is exercised while an event is taking place or as soon as possible after the event. This monitoring could be daily or weekly reports on aspects of public service activity. Concurrent controls are primarily quantitative focusing on inputs, process and outputs.

Post-control: This is the poorest from of control in terms of corrective action as it is exercised after the event. However it focuses on quantitative and qualitative evaluations and therefore is an essential component of a ‘holistic’ approach to organisational performance management. The public service has been delivered to clients and this review and evaluation activity attempts to assess the extent to which the organisation or sub-unit achieved its objectives and the desired outputs and outcomes were attained.

Performance measurement and management control are critical components of improving organizational performance.

3.2.3 Challenges of Measuring Performance

It is important to provide some clarity and distinction between performance terms. Efficiency and effectiveness should be treated as related but separate concepts. Efficiency describes the degree to which an activity generates a given quantity of outputs with a minimum consumption of inputs, or generates the largest possible outputs from a given quantity of inputs. Effectiveness, in turn, indicates the ability to attain a goal or a purpose. Effectiveness relates the output to the goal set for the operation, whereas efficiency relates the output to the resources used (input). Efficiency is about doing things right and effectiveness is about doing the right things. There is also a distinction between effectiveness and productivity: effectiveness is referred to the ability of an organization to attain its specified objectives, whereas productivity concerns the relationship between outputs and inputs (Vuorinen et al. 1998). Moreover, the concept of efficiency in the public services is more complex than the concept of efficiency in the private, profit-oriented sector. Consequently, the measurement of efficiency in the public services is
very difficult and implies more effort in the identification of relevant outputs and inputs (Mihaiu, 2010; Pestieau, 2009).

The performance rating has to be easily comparable with the performance level of similar organizations (social comparisons) or the organizational performance in previous years (historical comparisons) (Nielsen, 2013; Charbonneau and Van Ryzin 2015). Without such benchmarks, it is difficult to conclude whether a given performance result is credible.

Performance information may consist of only one simple indicator, or it may be complex and cover multiple dimensions or indicators of performance at once. In the former case, it is easy at the outset to interpret performance, but when there are many simple indicators, difficulties in their assessments are observed when conflicts in their ratings exist. Fryer, Jiju & Ogden (2009), argue that there is a lack of literature about the interpretation, reporting and statistical validity of performance indicators and further empirical research is needed to assess the current state of performance management within public sector organizations.

3.3 Performance Management Cycle and Performance Information

Organizations in public and non-profit sector typically go through a performance management cycle which contains budgeting, managing, and reporting their results (McDavid, Huse & Hawthorn; 2013).

The performance management cycle begin and end with formulating strategic objectives for organizations and, hence, for programs and policies. Strategic objectives are specialized into programs in order to achieve those objectives and are connected with resources. Ex ante evaluation assesses program or policy options before their selection for implementation. Program evaluation and performance measurement provide important information to decision makers who are engaged in leading and managing organizations. Implementation-focused assessments evaluate the extent to which intended program or policy designs are successfully implemented. Implementation is not the same thing as outcomes/results. Implementation evaluations can also examine the ways that existing organizational structures, processes, and cultures either facilitate or impede program implementation.
Monitoring performance is an important way to tell how a program is tracking over time. Performance data can be useful for evaluations, as well as for making management-related decisions. Performance measurement and reporting is expected to contribute to real consequences for programs. Among these consequences is program adjustment. All can be thought of as parts of the accountability phase of the performance management cycle. Finally, strategic objectives are revisited, and the evidence from earlier phases in the cycle is among the inputs that may result in new or revised objectives—usually through another round of a strategic planning process.

3.4 Performance Problems of EU Programs

Cohesion policy impact is conditional on good management practices or, more generally, on the institutional or absorption capacity of the recipient regions and member states (Wostner, 2008). Absorption capacity is the extent to which a Member State and its regions are able to spend the financial resources allocated from the Structural and Cohesion Funds (SFs) in an effective and efficient manner. This capacity is necessary for making a maximum contribution to economic, social and territorial cohesion with the resources available from the EU funds. The most disadvantaged regions and micro-regions lack the financial and human resources and administrative support needed to make good use of the EU funds accessible to them (European Parliament, 2011).

According to Wostner (2008), absorption capacity determines what it calls the micro-efficiency of the policy. Cohesion policy micro-efficiency is determined by the institutional or absorption capacity of recipient regions and member states. This, in turn, co-determines the policy’s macro-economic impact.

Institutional capacity of the public sector at national, regional and local level and the technical and administrative capacity of the participating public authorities and beneficiaries are key to the successful development, implementation and monitoring of the policies. Administrative capacity, especially in terms of project planning and implementation, is a key issue for absorption capacity and needs to be strengthened, with particular emphasis on those Member States lagging behind and that have low absorption rates (European Parliament, 2011).
According to European Parliament (2011), absorption problems have been caused by the following main factors:

- difficulties with completing the compliance assessment procedures concerning the new management and control system, that generally fall at the beginning of the programming period;
- global economic recession, which has a direct effect in the form of the budgetary restraint measures applied to public budgets and difficulties in obtaining internal financing;
- insufficient resources to co-finance projects;
- delays in the establishment and introduction of EU and national rules or related guidance, and incomplete or unclear rules;
- delays in the translation of the guidance notes and in obtaining clarification from the Commission, and inconsistency of Commission guidance;
- over-complicated and over-strict national procedures, and frequent changes therein;
- the need to establish new institutions to implement programmes, which can delay their launch and running;
- insufficient separation between the authorities in the Member States, hierarchy problems between the institutions and internal difficulties over the allocation of tasks and responsibilities;
- insufficient involvement of the regional and local level in the establishment of the operational programmes;
- limited staff numbers, inadequately trained staff at national and regional level, and difficulties with staff retention;
- difficulties with establishing information technology systems;
- disproportion between the degree of control and the scale of the project;
- insufficient initial preparation for implementation of projects, and missing project pipeline;
• politically motivated changes in investment priorities.

The absorption capacity of Member States and their regions to absorb such large-scale transfers in a productive way is in fact an issue occasionally investigated and questioned. Reszkető (2008) argues that significant part of absorption problems emerge due to government failures. Different evaluation studies and reports have been prepared and published by the European Commission or by consultants working in charge of the Commission that focus on factors influencing absorption capacity and efficiency related to management of EU SFs. These evaluations are, therefore, looking for efficiency improvements on the basis of particular implementation system problems and possible threats. However, according to Wostner (2008), there is limited research into what exactly micro-level efficiency refers to and especially what it depends on.

In the ÖIR (2004) study on the efficiency of the implementation methods for EU structural funds the following elements of EU program implementation systems that have not worked, are recognized:

• The long approval process for programming documents, frequently resulting in late starts for programs. Also, the Commission is too involved in the programming process itself.

• Financial flows are considered to be very long and complex. The certification of expenditure is seen as being excessive. There should be a greater use of sample audits based on reliable sampling techniques and a greater acceptance of the standards already existing within public systems at national and regional level.

• Financial control mechanisms are characterised as being risk averse in the extreme, with no built-in risk management model as one would find, for example, in the state of the art venture funds, which build in risk into their calculations.

• The 7% advance of funds is seen as too little and too slow by project promoters. This reflects more on the transfer of funds within the Member States and regions than from the Commission to the Member State.

• There is evidence of the existence of double accounting systems in a number of regions. This is particularly true in decentralised systems. The implementation system does not seem to be capable of accepting the reliability, quality and
legality of the accounting systems that are already in place within the region concerned and does not adapt to the diversity of legal systems in this regard.

- There are too many audits of a very exhaustive nature from a variety of different actors. It should be possible to achieve greater coordination between the various actors who require accountable reporting and a greater recognition of their mutual standards and processes in order not to have to repeat audit exercises at the great inconvenience and cost to the project implementation system.

- The application of the N+2 (the duration of the programic period plus two years) rule in an indiscriminate way is seen as working against innovation and quality. Some more risky and complex innovative projects take a bit longer to implement. There is a need for flexibility with regard to these.

- Proportionality is an issue at programme and project level. This approach does not take into account, that for small programmes and projects the level of funding is disproportionate to the administrative effort involved.

- The completion of the previous programming periods is seen as taking too long and the ex post evaluation is of no use in preparing for the following period.

- There is not enough attention paid to providing project promoters with easily understandable information on the process and educating them to be able to take full advantage. This will require a considerable amount of effort to achieve a greater shared understanding and a greater shared vision of what is being done and the reasons.

The ÖIR (2004) study also finds that, while there is universal agreement about the need for program monitoring as an important dimension to accountability, there is little evidence that the outcomes of the monitoring system are being fed back into the management process. The costs and benefits of the monitoring and control system are frequently referred to as being out of balance. It is the perception of program and project managers that the actual use to which the data produced by the monitoring system does not justify the enormous amount of energy, time and human resources that is put into collecting them. Smaller projects in particular are seen as being overly monitored relative to the value of the investment. There is the additional and related problem of the lack of integration between the monitoring systems that have been
implemented. The study concludes that the problem is not that monitoring should not be done but rather that the systems that are used should be more integrated and the outputs of the system should be available for improving management performance.

3.4.1 EU Programs in Greece

Greece is widely perceived as a consistently under-performing member state, as far as the implementation of EU programs is concerned (Dimitrakopoulos, 2001). A study of Management Organisation Unit (MOU, 2005) on the managerial capability of the beneficiaries of Community support, found that a large number of organisations, approximately 22% were not capable in managing projects and an even larger percentage (30% to 65%), are not using modern or efficient project management practices. The main reasons that contribute to program delays in implementation are identified as follows (Fitsilis, Krytopoulos & Leopoulos, 2011):

- Lack of formally defined processes or of a defined quality management system.
- Unavailability of internal auditing and review procedures
- Loose project schedule control
- Informal communication (meetings, minutes of meetings, etc.)
- Project organisation and project teams not formally appointed or unavailable and project manager authority not well established.
- Lack of modern project management information systems
- Unavailability of legal support in a rather complex legal and contractual context.
- Inability of applying an effective and efficient change management system both at the operational and at the contractual level.
- Difficult, complex and time consuming project initiation processes requiring involvement of many heterogeneous stakeholders.
- A large number of involved public services, project stakeholders, and lack of projects’ champion.

In order to tackle the absorption problems and improve the performance of organisations that undertake projects of public interest, it has been decided by the Greek Ministry of Economy and Finance (ministerial decision published in Hellenic Official Journal part B
55/18.1.2008) to develop a new standard, named “ELOT-1429”, that will define the requirements and capabilities needed by organisations implementing projects of public interest. Moreover, Law 3614/2007 – Article 22 states that organisations wishing to implement projects funded by the Community Support Framework will have to comply with this standard. According to Fitsilis et al. (2008), the application of the standard, (ELOT-1429) will assist organizations undertaking projects of public interest to improve their managerial capability and, at the same time, it will offer a focal point of reference for assessing an organisation’s maturity and performance.

Although notable decentralisation efforts are in progress, rural development in Greece seems to maintain its primarily state-emanated design and implementation, in a centralised logic (Papadopoulou et al., 2009). Long standing top-down and sectoral orientation in the formulation of this policy still holds, permeating the attitude of a number of actors, whose traditional role is challenged in the new setting (Karanikolas and Hadjipanteli, 2006).

A report for the Economic Adjustment Programme for Greece submitted by the Greek government in February 2011, claims that Greece intensified efforts to increase the absorption of EU structural and cohesion funds. Technical meetings with competent authorities, significant beneficiaries and the Secretaries General of the Operational Programs were organized on a regular basis, while Managing Authorities were requested to submit monthly reports to the National Coordination Authority in order to monitor targets and address potential deviations. In addition, in order to prioritize public investment spending for projects benefiting from EU funds, a central bank account has been created at the Bank of Greece for orienting national eligible expenditure exclusively to co-financed projects. Moreover, legislation has been adopted in order to tackle delays in the implementation of public works by facilitating and accelerating the conduct of any kind of archaeological research and work required to implement co-financed operations. According to this report, these efforts raised the absorption rate of programs.

3.5 Performance Measurement in Greek Public Services
Spanou (2008) assesses the impact of reforms of the last 25 years on Greek administration and finds that the state's share in the economy has been reduced and decentralisation reforms are more important in political than administrative view. She also finds out that
citizens’ rights and service delivery have been conceived rather as forms of democratisation and modernisation than as managerial reforms. Furthermore, she states that aspects such as “agencification” are constantly ignored. The author concludes that the “Napoleonic” features of the state have not been seriously affected and reforms have hardly been reshaped by the new managerial paradigm.

Performance measurement and management were introduced in the Greek public administration by Law 3230/2004, establishing the yearly elaboration of goals and targets, the effectiveness and efficiency measurement and the adoption of performance indicators. The core of the system is based on Kaplan and Norton’s approach for strategic performance measurement, named «The Balanced Scorecard». The Law has been rather well implemented – at least formally (OECD, 2011).

In the context of the Greek public sector, organizational performance is measured by providing data on financial indicators, derived from budget, concerning public spending/expenditures and resource utilization (Sotirakou & Zeppou, 2006).

Greek politicians, citizens and other stakeholders agree that public administration must transform itself from a centralized inward looking, bureaucracy to a strategically thinking, open, transparent and flexible organization that satisfies the demands of citizens (Argyriadis, 1998; Makrydimitris, 1999, 2003).

Especially as a member of the EU, Greek public administration should comply with the European practices on public service delivery and adapt its legal and administrative procedures according to European guidelines and standards. A lot of efforts, such as the Modernizing Government Act in 2001, have been done in order to converge with the European common public management policies and practices, already implemented by other member states. The Modernizing Government Act required every public organization to set goals, to measure performance and report on accomplishments (Ministry of Public Administration, 2001).

Among the main responsibilities of the Greek public administration is to formulate new approaches for managing and measuring public programs performance and to build the administrative capacity for doing so (Makrydemetres et al., 2016). It is required a holistic framework of managing and measuring performance. This framework should comprehend the two main responsibilities of contemporary public administration: responsiveness to market conditions and assurance of citizens' rights and wellbeing.
(OECD, 1997; Ammons, 1996; Greimer, 1996; Poister and Streib, 1999; Denhardt and Denhardt, 2000). However, with regard to Greek Public Administration, empirical evidence on the use and usefulness of performance outputs are quite limited (Argyriadis, 1971, 1998; Mouzelis, 1978; Makrydemetres, 1991, 1999; Sotirakou and Zeppou, 2004, 2005).

In the context of the Greek public sector, there is a lot of research considering the performance measurement and management area. In this section, the literature related to performance measures and measurement in Greek public service operational settings is overviewed. The review results are presented in the following two sub-sections.

3.5.1 Overall Performance Measurement
Chatzoglou et al. (2013), measure the level of public service quality in a unique body of service provision, namely the Citizen’s Service Centers (CSCs) of Greece. Their study aims to underline the importance of citizen participation in service planning and provision processes. Their study utilized a slightly modified SERVQUAL instrument that was distributed to citizens visiting a representative sample of CSC branches. More specifically, CSCs were visited by the members of the research team and usable questionnaires were collected from citizens. It is found that, although citizen expectations are not met in three of the five SERVQUAL dimensions, the overall service quality performance is well above average, allowing one to claim that CSCs have achieved their initial target. The methodological contribution of the paper lies in the implementation of the SERVQUAL instrument in the context of public services and its subsequent validation with the use of exploratory and confirmatory factor analysis. On a theoretical level, it enhances the current literature by arguing that citizens should actively participate in the processes of service planning and service provision.

Cohen and Karatzimas (2016), examine the standard-setting process during the recent reform of Greek government accounting standards in Greece which was the result of the Troika’s demands for modernization of Greek public sector, including making structural reforms to financial management. The Greek central government changed its government financial accounting reporting system in 2011 from a cash basis to a modified cash basis. The process is viewed through the lens of the ‘garbage can’ model, informed by interviews, informal discussions and archival data. Their findings indicate a lack of
effective monitoring of the process by politicians and external lenders (the ‘Troika’), and an outcome that favoured the bureaucrats and consultants involved.

Dimitriades (2007) investigated the concept of Organizational Citizenship Behavior (OCB) in Greek public organizations. The researcher explored the relationship between service climate, job involvement and customer-focused organizational citizenship behaviors of frontline - contact personnel. The results suggest that service climate and job involvement were significantly related to OCB, with job involvement partially mediating the relationship between service climate and OCB.

Kontogeorgos, Tselempis and Aggelopoulos (2014), investigate how Greek farmers perceive service quality provided by the Greek Ministry of Agriculture. A questionnaire based on the SERVQUAL scale, was used to determine farmers’ perceptions of service quality in the area of central Macedonia in Greece. The analysis has shed some light on the quality gaps for the services provided by the Greek Public sector, suggesting that there is scope for improvement strategies. The results revealed a three-dimensional structure instead of the five dimensions of the SERVQUAL instrument. “Social skills” of the human factor were revealed as being the most critical dimension of quality. Their paper provides guidelines for policymakers to develop strategies to identify service quality gaps, while the decrease of such gaps could result in the public services’ improvement.

Sotirakou and Zeppou (2005), seeks to show that Greek public administration is aiming to investigate the organizational competencies needed for the successful alignment of the Greek civil service with EU directions. The methodology approach is survey research conducted within Greek public administration. The STAIR (strategy, targets, assignment, implementation, results) model has been used as the appropriate performance management framework. They suggests that the HRM role in the contemporary public sector environment is to develop a strategic performance management framework for changing performance at organizational level and make human resources active drivers of this process. Their results reveal that convergence with EU policies draws heavily on how human resource executives can manage the following three soft organizational capabilities: competence, commitment and continuity – the STAIR model’s 3“Cs”. They contribute to the literature on directions for public sector management in Greece.

Sotirakou and Zeppou (2006), investigate the factors under which performance management and measurement systems (PMMS) work in a functional way and push
through the modernization process. They present the results of a qualitative research undertaken in the Greek public administration. The STAIR (strategy, targets, assignment, implementation, results) model was used as a conceptual tool for critical reflection on the issue of performance management and measurement. Their qualitative research identified three groups of factors to be important in turning the PMS from a symbolic exercise to an effective tool for administrative reform: the cognitive, the behavioural and the ethical elements of the PMS. The quantitative approach specified the nature of these three groups of factors and revealed 11 factors in total that play crucial roles in the organizational success. Their paper helps researchers and practitioners to better understand the dynamic nature of performance measurement and highlights the need to view the PMS as a vehicle for critical reflection, questioning and challenging all the aspects of the organization rather than a mechanistic instrument for control.

Zampetakis and Moustakis (2007), extend earlier research to the empirical assessment of entrepreneurial behaviour among front line staff in the Greek public sector. The research findings demonstrate that the concept of “public entrepreneurship” is relevant for the average civil servant and reveals facets of entrepreneurial behaviour of front line staff. Moreover, the study finds evidence that there is a positive correlation between the supportive context, as expressed by encouragement of initiatives and access to managerial information, and entrepreneurial behaviour among public servants.

3.5.2 Efficiency Measurement

Athanassopoulos (1995), develops an interface between Goal programming and DEA in order to integrate target setting and resource allocation in multi-level planning problems. The method was originally developed as an aid to the reorganisation of the allocation of central funds to local authorities in Greece.

Athanassopoulos and Triantis (1998), apply a two stage methodology as a comprehensive approach to measure the performance of Greek local municipalities. During the first stage, efficiency performance is measured using mathematical programming and econometric frontier approaches. A second stage is proposed where the impact of policy making factors on the efficiency measures obtained from the first stage is evaluated. The policy implications of cost efficiency are investigated by grouping local municipalities within clusters of similar performance characteristics and also by identifying the determinants of their cost efficiency using censored regression models.
Dimitriadis et al. (2013), investigate the case of the agencies for aliens and immigration of the Decentralized Administration of Macedonia and Thrace applying a quality adjusted DEA model. The results reveal those departments that more efficiently carry out their activities as well as those found to be relatively less effective. For the latter, QE-DEA recommends specific potential improvements in order to operate at what appears to be the best practice.

Giokas (2001), uses two different estimation methods (parametric and non-parametric), as means of ascertaining relative efficiency, as well as specific estimates of the efficient marginal costs of hospital services of public, general and teaching hospitals in Greece. In addition, the efficient cost of hospitals is estimated and compared with the actual cost. The study came to the following conclusions, among others: there are significant potential savings on hospital spending; non-efficient hospitals could produce the same result, if the daily cost per patient was reduced by 26%. The results, also, indicated that at least 4.1% of health care costs in the gross domestic product are due to inefficiencies created by public, general and teaching hospitals.

Halkos and Tzeremes (2005), research is based on the effect of fiscal policies on the Greek prefectures. Using DEA methodology they compare the efficiency of the prefectures over the last three decades. Moreover, they determine where the resources are distributed in an efficient way and /or have been used efficiently by the local authorities in order to stimulate regional development and provide quality of life to the Greek citizens. The efficient prefectures seem to have definite and strong characteristics, which are determined and discussed in detail. Their empirical results imply that the resources of a prefecture don’t necessarily ensure its efficiency.

Katharaki (2008), determines the areas of activity of 32 Greek Public Obstetrical and Gynaecological Units which present problems with regard to their performance using DEA. Based on the results information is provided to their managers, which refer to: (i) the degree of utilization of their production factors, (ii) the particular weight of each factor of production in the formation of the relative efficiency score, (iii) the utilization level of each factor of production, and (iv) those hospital units that utilize their factors of production in an optimal way and constitute models for the exercising of effective management. The derived information assists in the formulation of an appropriate policy.
Public Services Performance Measurement

mix per hospital unit which should be applied by their management teams along with a set of administrative measures that need to be undertaken in order to promote efficiency.

Katharaki and Katharakis (2010), estimate the efficiency of 20 public universities in Greece through quantitative analysis (including performance indicators, DEA and econometric procedures). The findings show inefficiency in terms of human resources management while also identifying a clear opportunity to increase research activity and hence research income. In addition to the immediate findings, this paper more broadly discusses the methodology behind the evaluation process used in this investigation and its potential to more consistently and reliably evaluate the efficiency of resource management by public universities.

Katharaki and Tsakas (2010) evaluated the efficiency of 27 tax offices in Greece during the period 2001–2006 by using output-oriented CCR and BBC DEA, window analysis and also Tobit regression in order to explain non-discretionary factors.

Michaelides et al. (2010), estimate the technical efficiency of trolley buses of the Athens and Piraeus area (TBAPA) in Greece using panel data set consisting of the monthly observations of the 20 lines of TBAPA for the year 2003. The estimation of technical efficiency is based on the Stochastic Frontier Analysis (SFA) and employs the Cobb-Douglas specification of the production function. Meanwhile, an attempt is made to investigate the explanatory power of other factors on the organization’s technical efficiency, such as the impact of other competitive means of transportation and the distance of the areas that each line connects. Their findings are compared with those from DEA.

Karkazis and Thanassoulis (1998), use DEA to assess the comparative effectiveness of public investment in infrastructure and investment incentives to attract private investment in regions of Northern Greece. DEA makes it possible to identify regions where the incentives and infrastructure expenditure attract successfully private investment so that the factors of this success may be analysed in order to improve the Greek government’s regional development policy.

Kontodimopoulos et al. (2007), compare technical and scale efficiency of primary care centers from the two largest Greek providers, the National Health System (NHS) and the Social Security Foundation (IKA) in order to determine if, and how, efficiency is affected by various exogenous factors such as catchment population and location. The sample
comprised of 194 units (103 NHS and 91 IKA). Efficiency was measured with DEA. In a second stage analysis, technical and scale efficiency scores were regressed against facility type (NHS or IKA), size and location using multivariate Tobit regression.

Kontodimopoulos and Niakas (2005), in their paper report on a study of DEA for measuring efficiency of the public and private sector haemodialysis units in Greece. The DEA model selected was input oriented, allowed for variable returns to scale and the units were ranked according to a benchmarking approach.

Lyroudi et al. (2006), focuses on investigating the productivity performance of 10 clinics in a public hospital located in Thessaloniki. They applied DEA to measure the Malmquist productivity index. The results indicated that the efficiency of the hospital clinics has improved. However, clinics' efficiency varies a lot from month to month. They concluded that in a competitive environment, these differences need to be addressed, investigated and reduced in order to improve total efficiency.

Makrydemetres, Zervopoulos and Pravita (2016), evaluate the efficiency and effectiveness of Central Government Departments in Greece. Their measurements are compared with those defined by the Administrative Reform which took place in 2013 to assess whether the changes introduced by the Reform to the Central Government Departments attain the objectives of efficiency and effectiveness. The efficiency and effectiveness measurements of 19 CGDs drew on four DEA models. Their methodology provides a concrete analytical framework for evaluating the performance of public organisations, suggesting reforms that promote efficiency and effectiveness, and advance managerial capacity.

Miliotis (1992) used DEA to evaluate efficiency measures for the 45 distribution districts of the Greek Public Power Corporation (PPC). Results are derived under different sets of assumptions and are compared with simple productivity indices used by PPC and with efficiency measures produced by econometric methods. DEA scores appear to be more reliable than simple productivity indices. Comparison of the different cases explains the reason for the low efficiencies, which can be due to the management of controllable inputs, the design of the supply system or other environmental factors.

Panta et al. (2011), argue that existing framework for the procurement of products and services for the Greek Public Organizations suffers from specific shortcomings (it overestimates the price, it is very sensitive to small changes to performance indicators
and especially for the services, is not able to incorporate variable price information). They develop a DEA model that overcomes these shortcomings. It uses variable weights that are estimated in favor of each evaluated bid and are properly restricted to comply with the existing framework and to reflect criteria priorities. It also encounters ranges for prices that correspond to minimum and maximum expected number of service calls. For illustration purposes they provide a real case application for the assessment of courier service providers.

Tsakas and Katharaki (2014), examine the performance of tax organizations in Greece, based on data obtained from a sample of 35 tax offices. Performance evaluation was conducted using DEA with bootstrap methods. In addition, Tobit regression analysis was employed to examine the environmental variables that impact on the efficiency performance of these tax offices. From the analysis, weaknesses, and management issues are derived from the tax offices inefficiency. The general conclusion is that a robust governance structure within the tax office operational framework is needed in order to improve organisational efficiency.

Tzeremes and Halkos (2010), uses DEA in order to determine the performance levels of 16 departments of a public owned university. Particularly, the constant returns to scale and variable returns to scale models have been applied alongside with bootstrap techniques in order to determine accurate performance estimates. The study illustrates how the recent developments in efficiency analysis and statistical inference can be applied when evaluating institutional performance issues. The results reveal the existence of misallocation of resources or/and inefficient application of departments’ policy development.

Vasilakis (2005), investigate the rapid changes in life-long training and performance measurement where the work environment of public sector managers undergoes fundamental changes. A combined DEA and Balanced Scorecard performance measurement framework is proposed and applied in order to support effective strategic management and assist in strengthening customer thinking and ways of operating at the case organization. This paper illustrates empirical evidence on few selective key performance indicators, which finally measure the performance of public training programs.
3.6 Concluding Remarks

Currently, there is a great interest in performance measurement of public organizations. The purposes of performance measurement and management can be related to subjects of learning, coordination and control or motivation. When we analyse how performance information is used to improve front-line service delivery, we are in fact studying a phenomenon that is fundamentally different from a situation where performance information is used for advocacy or accountability purposes. The performance measurement and management is commonly used today to describe a range of managerial activities designed to monitor, measure and adjust aspects of organisational performance through management controls of various types.

Although, the improvement of Greek public administration constitutes integral part of many past public reforms, the institutional capacity in Greece is considered inefficient and ineffective both inside and outside of the government. Findings of the Greek public service performance literature reveals that although a respectable volume of public service performance research exists, there are only few studies on the efficiency of the Greek public sector and only three of administrative nature (Makrydemetres et al., 2006 and Katharaki & Tsakas, 2010 and Dimitriadis et al., 2013). Moreover, although EU Structural funds literature has examined delivery structures of programs with the lenses of multi-level governance approach, there are no studies upon administrative efficiency measurement in the context of a public spending program. The administrative capacity of member States and their regions to absorb EU SFs in a productive way is in fact an issue occasionally investigated and questioned. All these findings suggest that more empirical research is needed to provide insights on how public programs work efficiently and how to measure the efficiency of their delivery.

This study tries to fill the above mentioned knowledge gaps in the public policy literature, by introducing a performance evaluation framework which is based on production theory and measures the actual delivery efficiency of public spending programs from a managerial perspective.
4. NONPARAMETRIC PERFORMANCE MEASUREMENT

4.1 Introduction
This chapter provides the basis of the performance measurement methods that will be used throughout the study. The approaches to evaluate performance using frontier techniques were first developed in the 1970s. Frontier techniques estimate the maximum level of output that a production unit can obtain for a given level of resources, or the minimum level of resources that is required to achieve a given level of outputs.

These approaches to evaluate performance followed two distinct routes that differ in the way the frontier is estimated, corresponding to a parametric (econometric) or a nonparametric (mathematical programming) approach. This chapter provides an introduction to performance measurement using frontier techniques, focusing on the nonparametric approach, as the models developed in this study followed this route.

Particular emphasis is given to Data Envelopment Analysis (DEA), as it is the core method used throughout the thesis. The theory of production underlying the DEA method relies on the axiomatic approach of Shephard (1970), which is based on productions sets.

4.2 Production Theory Considerations

4.2.1 Productivity and efficiency concepts
Generally speaking, production consists of the transformation of resources (also called inputs) into products or services (also called outputs). The transformation is affected by non-controllable variables as well as non-observable skills and efforts in the organization. The idea is to measure the inputs, the outputs and the exogenous factors and hereby to get an idea of the non-measurable managerial characteristics, the skills and effort as illustrated in Figure 4.1 below.
In the assessments, we shall therefore try to account for all the inputs, all the outputs and all the exogenous factors simultaneously. Only this way can we avoid the limitations of making partial evaluations. The systemic view, however, makes comparisons more complicated since we have to handle the multiple dimensions, and production units may be good in some dimensions and bad in others.

Production technology is, in its most general form, a description of the relationship between input and produced output. Productivity and efficiency are the two most important concepts in measuring performance (Wang et al., 2002). According to Fried et al. (2008) - the productivity of a decision-making unit varies due to (i) differences in production technology, (ii) differences in the efficiency of the production process, and (iii) environmental differences; in other words, efficiency is one component of the productivity of a decision-making unit.

Efficiency can be defined as relative productivity over time or space, or both. For instance, it can be divided into intra- and inter-firm efficiency measures. The former involves measuring the use of the firm’s own production potential by computing the productivity level over time relative to a firm-specific Production Frontier, which refers to the set of maximum outputs given the different level of inputs. In contrast, the latter measures the performance of a particular firm relative to its best counterpart(s) available in the industry (Lansink et al, 2001).
As in Coelli et al. (2005), the distinction between these two terms can be simply illustrated, as shown in Figure 4.2. Points A, B and C refer to three different producers. The productivity of point A can be measured by the ratio $DA/OD$ according to the definition of productivity where the x-axis represents inputs and the y-axis denotes outputs.

**Figure 4.2: Efficiency and Productivity Concepts**

![Diagram of efficiency and productivity concepts](image)

Source: Coelli et al., 2005

Given the same input, it is quite clear that productivity can be further improved by moving from point A to point B. The new level of productivity is then given by $BD/OD$. Clearly, productivity can be represented, therefore, by the slope of the ray through the origin which joins the specific point under study. The efficiency of point A, on the other hand, can be measured by the ratio of the productivity of point A to that of point B, i.e.,

$$\frac{AD/OD}{BD/OD}.$$

The above efficiency is normally termed technical efficiency in economics, and includes output- and input-oriented technical efficiencies, i.e., the producer can either improve output given the same input (output-oriented, point A to B) or reduce the input given the same output (input-oriented, point A to E) by improving technology.
All the points on the production frontier are technically efficient, whilst all the points below or lying to the right of the efficient frontier are technically inefficient. The production frontier reflects the current state of technology in the industry.

The ray through the origin and point C in Figure 4.2 is at a tangent to the production frontier, and hence defines the point of maximum possible productivity. This leads to another important concept, scale efficiency, which relates to a possible divergence between actual and ideal production size.

Allocative efficiency is another important concept in the context of production economics. Unlike technical and scale efficiencies, which only consider physical quantities and technical relationships and do not address issues such as costs or profits, allocative efficiency studies the costs of production given that the information on prices and a behavioural assumption such as cost minimisation or profit maximisation is properly established. For instance, allocative efficiency in input selection occurs when a selection of inputs (e.g. materials, labour and capital) produce a given quantity of output at minimum cost given the prevailing input prices (Coelli et al., 2005).

4.2.2 Definitions and Measures of Technical Efficiency

Debreu (1951) and Koopmans (1951) were the first to discuss the measurement of productivity and efficiency in the economic literature. However, the standard efficiency measurement literature was started by Farrell (1957) and built upon Debreu (1951) and Koopmans (1951).

Economic efficiency has technical and allocative components (Fried et al., 2008). The technical component refers to the ability to avoid waste, either by producing as much output as technology and input usage allow or by using as little input as required by technology and output production. Thus the analysis of technical efficiency can have an output augmenting orientation or an input conserving orientation.

Koopmans (1951) provided a formal definition of technical efficiency: a producer is technically efficient if an increase in any output requires a reduction in at least one other output or an increase in at least one input, and if a reduction in any input requires an increase in at least one other input or a reduction in at least one output. Thus a technically inefficient producer could produce the same outputs with less of at least one input, or could use the same inputs to produce more of at least one output.
Debreu (1951) and Farrell (1957) introduced a measure of technical efficiency. With an input conserving orientation their measure is defined as (one minus) the maximum equiproportionate (i.e., radial) reduction in all inputs that is feasible with given technology and outputs. With an output augmenting orientation their measure is defined as the maximum radial expansion in all outputs that is feasible with given technology and inputs. In both orientations a value of unity indicates technical efficiency because no radial adjustment is feasible, and a value different from unity indicates the severity of technical inefficiency.

4.2.3 Parametric and Nonparametric Frontiers
There are two main approaches to estimate relative efficiency: Stochastic Frontier Analysis (SFA) and Data Envelopment Analysis (DEA) and which employ quite distinct methodologies for frontier estimation and efficiency measurement, each with associated strengths and weaknesses. The parametric approach relies on econometric techniques and includes simple regression analysis and SFA. Whilst simple regression analysis typically seeks to estimate a production or cost function, SFA is an extension of that methodology to estimate the “frontier” of a set of functions with different underlying levels of efficiency. The non-parametric approaches use mathematical programming techniques, and the main nonparametric frontier analysis technique, known as Data Envelopment Analysis, can be seen as an extension of the simple technique of index numbers (Sarafidis, 2002). A taxonomy of efficiency measurement techniques is presented in Figure 4.3.

More specifically, in order to measure the technical of any observed input-output bundle one needs to know the maximum quantity of output that can be produced from the relevant input bundle. One possibility is to explicitly specify a production function. The value of this function at the input level under consideration denotes the maximum producible output quantity. One approach is to estimate the parameters of the specified function empirically from a sample of input-output data. Because the least squares procedure permits observed points to lie above the fitted line, in a stochastic frontier model one includes a composite error, which is a sum of a one-sided disturbance term representing shortfalls of the actually produced output from the frontier due to inefficiency and a two-sided disturbance term representing upward or downward shifts in the frontier itself due to random factors. For the econometric procedure requirements one must select a particular functional form (e.g., the Cobb Douglas) out of a number of
alternatives. At the same input bundle the value attained by the production function will depend on the functional form chosen. Further, the parameter estimates are also sensitive to the choice of the probability distributions specified for the disturbance terms.

**Figure 4.3: Taxonomy of Efficiency Measurement Techniques**

Data Envelopment Analysis is an alternative nonparametric method of measuring efficiency that uses mathematical programming rather than regression. In DEA, we construct a frontier from the input-output observations in the sample. For this we make some fairly weak assumptions about the production technology without specifying any functional form. Original DEA has been criticized for its deterministic nature, because it assumes no measurement error and other noisy components. However, a number of examples can be easily found to show that the DEA input and output variables are commonly of a stochastic nature. The original DEA models focused primarily on the estimation of the production frontier and relative efficiency and all deviations from the frontier are assumed to be due only to technical inefficiencies.

Table 4.1 presents the most important differences between DEA and SFA. SFA is a stochastic model and therefore is able to differentiate between inefficiency and noise. On the other hand DEA is a non-parametric model and thus a function need not be defined.
Therefore the effects of the form might not get mixed with those of inefficiency (Fried, Lovell, & Schmidt, 2008).

**Table 4.1: Distinction between DEA and SFA**

<table>
<thead>
<tr>
<th>Elements</th>
<th><strong>Data Envelopment Analysis (DEA)</strong></th>
<th><strong>Stochastic Frontier Analysis (SFA)</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Multi outputs and inputs</td>
<td>Single input (output) and multiple output (input)</td>
</tr>
<tr>
<td>Algorithm</td>
<td>Linear programming</td>
<td>Regressions (typically using maximum likelihood estimation)</td>
</tr>
<tr>
<td>Consideration of noise</td>
<td>Noise is included in the efficiency score rather than accounted for directly (deterministic model)</td>
<td>Explicitly accommodates noise (stochastic model)</td>
</tr>
<tr>
<td>Functional form/input-output-relation</td>
<td>Not specified (everything that might be linearized)</td>
<td>Functional form is specified (e.g. linear, semi-log, double-log)</td>
</tr>
<tr>
<td>Factor weights</td>
<td>Individual factor weights for each unit (non-parametric)</td>
<td>No individual factor weights in the basic model (parametric)</td>
</tr>
</tbody>
</table>

Source: Lampe and Hilgers (2015)

DEA have the disadvantage of assuming no statistical noise, but have the advantage of being non-parametric and requiring few assumptions about the underlying technology. SFA on the other hand has the advantage of allowing for statistical noise, but have the disadvantage of requiring strong assumptions as to the form of the frontier. DEA is favoured where measurement error is unlikely to pose much of a threat and where the assumptions of neoclassical production theory are in question. Conversely, SFA should have the advantage in coping with severe measurement error and where simple functional forms provide a close match to the properties of the underlying production technology. Gong and Sickles (1992), argues that as misspecification of functional form becomes more serious, DEA’s appeal (vis-à-vis SFA) becomes more compelling.

Actually some even claim that DEA may perform better than the stochastic frontier approach in certain cases. On this issue we refer to Suza (2001) who quotes Coelli, Rao,
and Battese (1998, p. 219): “Stochastic frontiers are likely to be more appropriate than DEA in agricultural applications, especially in developing countries, where the data are heavily influenced by measurement error and the effects of weather, disease, etc. However, in the non-profit service sector, where random influences are less of an issue; multiple-output production is important; prices are difficult to define; and behavioural assumptions, such as cost minimization or profit maximization, are difficult to justify, the DEA approach may often be the optimal choice. Hence, the selection of the appropriate method should be made on a case-by-case basis.”

Bogetoft (2012) believe that DEA has somewhat more to offer managers than SFA because, besides others, there is no small group of specific peers in a SFA analysis. All production units have an impact on the estimated production function, and one cannot identify which of the specific units a given unit should learn from in the same way as can been done in DEA.

4.3 DEA Technology

The following sections deal with the measurement of efficiency through the nonparametric, mathematical programming-based technique that is best known as data envelopment analysis (DEA), after the developments of Charnes et al. (1978).

4.3.1 Constant returns to scale technology

Consider a set of $n$ observations of actual production units $(X_j, Y_j), j=1, \ldots, n$, where the vector of outputs $Y_j=(y_{1j}, \ldots, y_{nj}) \geq 0$ is produced from the vector of inputs $X_j=(x_{1j}, \ldots, x_{mj}) \geq 0$. In order to assess them by DEA we begin by constructing what is known as the production possibility set (PPS) within which the units operate.

The production possibility set contains all the correspondences of input and output vectors that are feasible in principle even if not actually observed in practice. Once the PPS is known, the location of a production unit within the PPS will provide the answers as to its relative performance, for example, relative efficiency and local returns to scale.

Let us denote the PPS, $T$, such that

$$T = \{(X, Y) \mid \text{the inputs } X \geq 0 \text{ can produce the outputs } Y \geq 0\}. \quad (4.1)$$
Nonparametric Performance Measurement

*T*, often also referred to as production technology, may also be represented from two other perspectives: input requirement set and output correspondence set. An input set \( L(y) \) is the subset of all input vectors \( X \geq 0 \) yielding at least \( Y \geq 0 \), and a production set \( P(x) \) is the subset of all output vectors \( Y \geq 0 \) that are obtained from \( X \geq 0 \). The input and output sets are therefore defined, respectively, as

\[
L(Y) = \{X/ (X,Y) \in T \}, \quad (4.2)
\]

\[
P(X) = \{Y/ (X,Y) \in T \}. \quad (4.3)
\]

Thus, a production technology can have alternative and equivalent representations highlighting different aspects of that technology. “The input set models input substitution, and the output set models output substitution.

A production technology defined by \( L(y) \), \( P(x) \), or \( T(x, y) \) has some relevant subsets that are useful for efficiency measurement. For the present purpose, we are mainly interested in two subsets: the isoquant and the efficient subset.

The input isoquant corresponding to \( Y \geq 0 \) is written as

\[
I(Y) = \text{Isoq} L(Y) = \{X/ X \in L(Y), \lambda X \not\in L(Y), \text{if } \lambda \in [0,1)\}. \quad (4.4)
\]

The output isoquant corresponding to \( X \) is defined by

\[
I(X) = \text{Isoq} P(X) = \{Y/ Y \in P(X), \theta Y \not\in P(X), \text{if } \theta \in (1,+)\}. \quad (4.5)
\]

The efficient subsets of \( L(y) \) and \( P(x) \) are defined as

\[
E(Y) = \{X/ X \in L(Y), X' \leq X \text{ and } X' \neq X \Rightarrow X' \not\in L(Y)\}. \quad (4.6)
\]

\[
E(X) = \{Y/ Y \in P(X), Y' \geq Y \text{ and } Y' \neq Y \Rightarrow Y' \not\in P(X)\}. \quad (4.7)
\]

These definitions imply that \( \text{Isoq} L(Y) \supseteq E(Y) \) and \( \text{Isoq} P(X) \supseteq E(X) \) for input and output case respectively.

Figure 4.4 and Figure 4.5 illustrate the input and output correspondences, respectively, for the typical case of constant returns to scale (CRS) technology. Under CRS and efficient production, scaling of input levels by a certain factor leads to the outputs being scaled by that same factor.

In Figure 4.4, the input set \( L(y) \) is the space to the right and above the piecewise linear boundary (SABS'). The input isoquant \( I(y) \) is the boundary SABS'. The efficient subset
of the input isoquant $E(y)$ is the part of the isoquant ABC (without the vertical and horizontal extensions).

**Figure 4.4: Input Space Representation**

In Figure 4.5, the output set $P(x)$ is the space enclosed by the axes and the piecewise linear boundary SABS’. The output isoquant $I(x)$ is the boundary SABS’. The efficient subset of the output isoquant $E(x)$ is the part BCD (without the vertical and horizontal extensions).

**Figure 4.5: Output Space Representation**
The efficient subsets $E(y)$ and $E(x)$ of $L(y)$ and $P(x)$, respectively, in Figure 4.4 and Figure 4.5 are efficient in a Pareto-Koopmans sense. Pareto-Koopmans efficiency, or simply Pareto-efficiency, is attained when an increase in any output (or a decrease in any input) requires a decrease in at least another output (or an increase in at least another input; e.g., Lovell, 1993).

In DEA, the empirical reference technology $T$, is constructed according to the minimal extrapolation principle: $T^*$ is the smallest subset of $\mathbb{R}^M_+ \times \mathbb{R}^N_+$ that contains the observed data and satisfies certain technological assumptions specific to the given approach; for instance, free disposability and some form of convexity. By constructing the smallest set containing the actual observations, the method extrapolates the least. Here we formalise the basic assumptions made in Charnes et al. (1978), the seminal paper on DEA.

Inclusion of observations:
Each observed DMU $(x_o, y_o) \in T$

Monotonicity or strong (free) disposability of inputs and outputs:
If $(x, y) \in T$ and $x' > x$ then $(x', y) \in T$
If $(x, y) \in T$ and $y' < y$ then $(x, y') \in T$

Convexity:
If $(x, y) \in T$ and $(x', y') \in T$ then $(\lambda(x, y) + (1-\lambda)(x', y')) \in T$
for any $\lambda \in [0, 1]$

No output can be produced without some input:
If $y > 0$ and $y \neq 0$ then $(0, y) \notin T$

Minimum extrapolation:
$T$ is the intersection of all sets satisfying the above assumptions

Constant returns to scale:
If $(x, y) \in T$ then $(kx, ky) \in T$ for any $k > 0$

The free disposability assumption stipulates that we can freely discard unnecessary inputs and unwanted outputs. Thus, if we can produce a certain quantity of outputs with a given quantity of input, then we can also produce the same quantity of outputs with more inputs.
One way to interpret this assumption is to say that we can freely dispose of surplus inputs. We call this assumption the free disposability of input.

Likewise, if a given quantity of inputs can produce a given quantity of outputs, then the same input can also be used to produce less output—we can dispose of surplus output for free. We call this assumption the free disposability of output.

The convexity assumption states that any weighted average (convex combination) of feasible production possibilities is feasible as well. Convexity is a common assumption in production economics. A mixture of two input–output combinations is called a convex combination, and we therefore talk about this as the convexity assumption, or we say that the technology set is convex. Since it allows us to interpolate from observed units to units with input-output profiles between the observations, it extends the technology, which in turn enables us to rely on fewer observations and still attain interesting results.

Based on the observed input–output data and under the foregoing assumptions, DEA empirically constructs a production possibility set as follows:

\[ T^{\text{CRS}} = \{(X,Y) / \sum_{j=1}^{n} X_j \lambda_j, Y \leq \sum_{j=1}^{n} Y_j \lambda_j, \lambda_j > 0, j = 1,\ldots,n \}. \]

Here the superscript CRS indicates that the technology is characterized by constant returns to scale. CRS implies that scaling up or down efficient input–output correspondences is valid. This is a rather restrictive assumption and not always valid in real life.

4.3.2 Variable returns to scale technology

The most relaxed form of returns to scale that we can assume, is that returns to scale are variable (see Banker et al., 1984). This permits not only constant but also increasing returns to scale (IRS) and decreasing returns to scale (DRS) in the sense that, respectively, outputs rise more than or less than proportionately with inputs.

The piecewise mathematical representation of the Technology under variable returns to scale \( T^{\text{VRS}} \) is

\[ T^{\text{VRS}} = \{(X,Y) / \sum_{j=1}^{n} X_j \lambda_j, Y \leq \sum_{j=1}^{n} Y_j \lambda_j, \sum_{j=1}^{n} \lambda_j = 1, \lambda_j > 0, j = 1,\ldots,n \}. \]
Note that this differs from the PPS under CRS noted above. In \( T^{VRS} \) we have the convexity constraint \( \sum_{j=1}^{N} \lambda_j = 1 \). This constraint is in line with the convexity of the PPS assumed but is invalid under CRS since any feasible and efficient \((x,y)\) production possibility under CRS can be scaled up or down.

There are also specifications of the PPS that imply other types of returns to scale, such as nonincreasing returns to scale (NIRS) and nondecreasing returns to scale (NDRS). We address such technologies later.

### 4.4 Farrell Efficiency Measurement

There are many measures of efficiency used in DEA models, though the most traditional are the radial measures of efficiency. Farrell (1957) defined a radial distance function that is the basis of the DEA measures of efficiency. The Farrell measure of efficiency is usually defined either in the input space or in the output space.

The Farrell input measure is illustrated in Figure 4.6, where it is assumed that four DMUs (A–D) are observed producing the same output vector \( Y \) using two inputs \( x1 \) and \( x2 \).

**Figure 4.6: Farrell Input oriented efficiency measurement**

DMUs C and D have technical input efficiency in the Farrell sense of 100%. That is their observed input levels cannot jointly or radially be contracted to lower levels. In contrast, DMUs A and B are away from \( I(y) \) and have efficiency below 100%. Their efficiency is
the fraction to which their observed input levels can be radially contracted to reach $I(y)$. For example, DMU B is inefficient because it could produce the same amount of output using lower levels in both of its inputs. The radial distance of this DMU to the input isoquant $I(y)$ is given by $\theta_B^* = \frac{\|OB\|}{\|OB\|} \leq 1$.

Note that DMU A΄ in Figure 4.6 the radial projection of A, lying on the isoquant, has efficiency of 100% (or 1) but is not Pareto-efficient because it is able to reduce the usage of input $x_2$ without changing the usage of input $x_1$. Therefore efficiency of 100% for a DMU does not necessarily mean it is Pareto-efficient, but the converse is true.

**Figure 4.7: Farrell Output oriented efficiency measurement**

![Farrell Output oriented efficiency measurement](image)

Figure 4.7 illustrates the Farrell measure of efficiency in output space, using a two-output example. DMUs C and D have technical output efficiency in the Farrell sense of 100%. That is their observed output levels cannot jointly or radially be expanded to higher levels. In contrast, DMUs A and B are away from $I(x)$ and have efficiency above 100%. Their efficiency is the fraction to which their observed output levels can be radially expanded to reach $I(x)$. For example, DMU B is inefficient because given input it could produce higher levels in both of its outputs. The radial distance of this DMU to the output isoquant $I(x)$ is given by $\theta_B^* = \frac{\|OB\|}{\|OB\|} \geq 1$.

Note that the observations lie below this curve, and that the sections of the curve that are at right angles to the axes result in output slack being calculated when a production point
is projected onto those parts of the curve by a radial expansion in outputs. For example, the point A is projected to the point A’ which is on the frontier but not on the efficient frontier. This is because the production of $y_1$ could be increased by the amount AC’ without using any more inputs. Thus there is output slack in this case of A’C in output $y_1$.

### 4.5 CCR (Charnes, Cooper, Rhodes, 1978) DEA Models

Efficiency involves a comparison of the actual location of a DMU within the PPS with the optimal input and output levels corresponding to the points located on the production frontier. The first measure of technical efficiency dates back to the work of Debreu (1951) and Farrell (1957). The Debreu's measure of efficiency was called the “coefficient of resource utilisation”. Farrell extended this previous work by proposing the measurement of efficiency using empirical observations, i.e. by comparing a DMU to the best actually achieved by its peers.

The DMUs’ efficiency measure can be obtained from two perspectives, corresponding to an input-reduction or output-expansion orientation. Assuming an input orientation, the Debreu-Farrell technical efficiency measure is defined as the maximum radial (proportional) reduction to all inputs that is feasible to achieve whilst securing a certain output level, within a given technology. On the other hand, assuming an output orientation, this measure is defined as the maximum radial (proportional) expansion to all outputs that is feasible to achieve with a certain input level, within a given technology (Fried et al., 2008).

#### 4.5.1 CRS envelopment formulations

We start our discussion in DEA by assuming that we have observations on the $i = 1,..., m$ inputs that are used and the $r = 1,...,s$ outputs that are produced by each of $j = 1,..., n$ decision making units (DMUs) which all use the same (or similar) inputs and produce the same (or similar) outputs. Given these data the following model is the one that we focus on. For this purpose we designate one of the $DMU_j$, say the $k^{\text{th}}$, as $DMU_{o}$ and evaluate its performance relative to the observed values of the performances of all the $DMU_j$, including $DMU_{o} = DMU_k$, by means of the following model:
\[
\min \theta_o
\]
subject to
\[
\sum_{j=1}^{n} x_{ij} \lambda_j + s_i^- = \theta_o x_{io}, \quad i = 1, 2, ..., m
\]
\[
\sum_{j=1}^{n} y_{jr} \lambda_j - s_r^+ = y_{ro}, \quad r = 1, 2, ..., s
\]
\[
\lambda_j, s_i^-, s_r^+ \geq 0; \forall i, j, r.
\]

where \( y_{ro} \) is output \( r \) for DMU \( o \), \( y_{ro} \) and \( x_{io} \) are the observed inputs and outputs for DMU \( o \), the DMU \( j \) that is to be evaluated. The \( \lambda_j \) -coefficients are called 'structural variables'. The \( s_i^- \), \( s_r^+ \) \( \geq 0 \), which are called 'slack variables', are used to convert inequalities to equivalent equations.

Finally, letting \( j_o \) for each of the \( j = 1, ..., n \) DMUs, in turn, we obtain an efficiency evaluation in the form of \( \min(\theta) = \theta^* \) for the performances of each DMU.

The above model shows that the performance of DMU \( o \) is to be evaluated relatively to the performances of all the \( n \) DMUs, including DMU \( o \). Hence \( \theta = 1 \) is a solution with \( \lambda_j = \lambda_o = 1 \) and all other \( \lambda_j = 0 \). Therefore, \( 0 \leq \theta^* \leq 1 \), where the asterisk designates an optimal value.

As can be gathered from model (4.8), if the optimum value of \( \theta_o \) is \( \theta_o^* < 1 \) then DMU \( o \) is not efficient, because the model will have identified another production possibility that secures at least the output vector \( y_o \) of DMU \( o \) but using no more than the reduced input vector \( \theta_o^* x_o \). Thus, \( \theta_o^* \) is a measure of the radial input efficiency of DMU \( o \) in that it reflects the proportion to which all of its observed inputs can be reduced pro rata, without detriment to its output levels.

The DEA solution methods that are used in most computer codes - e.g. the simplex method of linear programming - utilize only basis sets of linearly independent vectors. See Charnes and Cooper (1961). An optimal solution utilizes efficient DMU \( j \) as the only ones that can have \( \lambda_j^* > 0 \) in an optimal solution. See Cooper et al. (2007) for a proof. The values of these structural variables then generate \( x_{io}, y_{io} \) as a point on the efficiency
frontier that is closest to DMU\(_o\). Reference to expression (4.8) shows that this solution provides both a measure of performance and the sources and amounts of each inefficiency for every DMU\(_o\). In addition the \( \lambda_j \geq 0 \) identify a subset of the efficient DMU\(_j\) that serve as 'benchmarks' to suggest improvements in the practices of the thus evaluated DMU\(_o\).

Model (4.8) is generally referred to as the constant returns to scale model. It is also referred to it as the 'Farrell model' or the 'Debreu-Farrell' model since Debreu (1951) is referenced by Farrell (1957), the originator of DEA, as a source of his ideas.

Similarly, the overall output efficiency of DMU\(_o\) is \( \hat{\phi}_o \), the optimal value of \( \phi_o \) in model (4.9):

\[
\begin{align*}
\text{max } & \phi \\
\text{subject to } & \sum_{j=1}^n x_i \lambda_j + s_i^- = x_{i_o}, \quad i = 1, 2, ..., m \\
& \sum_{j=1}^n y_i \lambda_j - s_i^+ = \phi y_{r_o}, \quad r = 1, 2, ..., s \\
& \lambda_j \geq 0, \quad j = 1, 2, ..., n.
\end{align*}
\]  

(4.9)

\( s_i^+ \), \( s_i^- \) are the output and input slacks, respectively. Whenever, at the optimal solution, any output slack is strictly positive, it is possible to expand that particular output by the amount of the output slack even after it has been expanded by a factor \( \phi^* (\geq 1) \). Suppose that in a particular application we get \( \phi^* = 1.25 \). This means that we can increase all outputs by 25%. In this case, technical efficiency of the firm is 0.80. Now suppose that \( s_I^{+*} > 0 \). This implies that we can further increase output 1 by \( s_I^{+*} \) units. Hence, 0.80 does not fully reflect the extent of its inefficiency. Moreover, if any one of the input slacks is strictly positive, the implication is that above expansion of the output bundle can be achieved while reducing individual inputs at the same time (Ray, 2004).

In a similar manner, if the optimum value of \( \phi_o \) in (4.9) is \( \phi_o^* > 1 \), then DMU\(_o\) is not efficient in that the model in (4.9) will have identified another production possibility that secures at least the augmented output vector \( \hat{\phi}_o y_{r_o} \) using no more than the input vector \( x_o \) of DMU\(_o\). Thus, \( \hat{\phi}_o^* \) is a measure of the radial output efficiency of DMU\(_o\) in that it reflects the largest proportion that any one of its output levels is of the maximum level...
that output could take given the input vector of $\text{DMU}_o$. When $\theta_o^* = 1$ or $\phi_o^* = 1$ at the optimal solution to (4.8) or (4.9), respectively, then $\text{DMU}_o$ lies on the frontier of the referent production possibilities set and it is deemed to be 100% efficient. That is, all its inputs collectively cannot be reduced pro rata without detriment to its outputs, nor can its outputs be raised pro rata without more inputs.

However, when $\text{DMU}_o$ is 100% efficient in this sense it is not necessarily Pareto-efficient because the pro rata improvements to inputs or alternatively to outputs may not be possible but improvements to the individual levels of some inputs or outputs may be possible. Such improvements are captured in the slacks in the input and output constraints of models (4.8) and (4.9). Therefore, models (4.8) and (4.9) do not necessarily identify Pareto-efficiency.

In order to guarantee Pareto-efficiency, Charnes et al. (1978) show that models (4.8) or (4.9) can be solved in a first stage, and then in a second-stage model (4.10), maximizing slacks, should also be solved:

\[
\max \sum_{i=1}^{m} s_i^- + \sum_{r=1}^{s} s_r^+ \\
\text{subject to} \\
\sum_{j=1}^{n} x_{ij} \lambda_j + s_i^- = x_i^- \quad i = 1, 2, \ldots, m \\
\sum_{j=1}^{n} y_{rj} \lambda_j - s_r^+ = y_r^- \quad r = 1, 2, \ldots, s \\
\lambda_j \geq 0 \quad \quad j = 1, 2, \ldots, n.
\]

(4.10)

In this model, the input–output levels located on the input or output isoquant (obtained from a radial expansion or contraction of outputs or inputs) are used on the right-hand side of the constraints. If the optimum sum of slacks in (4.10) is zero, then the point $(x_o^*, y_o^*)$ on the isoquant is Pareto-efficient.

As an alternative to this two-stage approach, there is a single-stage formulation that guarantees Pareto-efficiency by subtracting from the objective function in (4.9) or adding to the objective function in (4.10) the sum of slacks multiplied by a very small factor $(\varepsilon)$. This single-stage formulation was first proposed by Charnes et al. (1978). It means that,
first, pre-emptive priority is given to the minimization of $\theta_o$, or to the maximization of $\phi_o$, and second, the maximization of slacks is sought. Because slacks are multiplied by a very small value (identified by $\varepsilon$), the resulting objective function is in fact virtually equal to the optimal value of $\theta_o$ or $\phi_o$, respectively. This is what is known as a single-stage approach to arrive at once at the radial efficiency measure and at a Pareto-efficient referent point.

Here we give this single-stage theoretical formulation of both an input- and an output-oriented CCR model in its envelopment form:

DEA input oriented model under CRS (envelopment formulation):

$$\min \theta - \varepsilon \left( \sum_{i=1}^{m} s_i^- + \sum_{r=1}^{s} s_r^+ \right)$$
subject to
$$\sum_{j=1}^{n} x_j \lambda_j + s_i^- = \theta x_{i_0} \quad i = 1, 2, \ldots, m;$$
$$\sum_{j=1}^{n} y_j \lambda_j - s_r^+ = y_{r_0} \quad r = 1, 2, \ldots, s;$$
$$\lambda_j, s_i^-, s_r^+ \geq 0 \quad j = 1, 2, \ldots, n.$$

DEA output oriented model under CRS (envelopment formulation):

$$\max \phi + \varepsilon \left( \sum_{i=1}^{m} s_i^- + \sum_{r=1}^{s} s_r^+ \right)$$
subject to
$$\sum_{j=1}^{n} x_j \lambda_j + s_i^- = x_{i_0} \quad i = 1, 2, \ldots, m;$$
$$\sum_{j=1}^{n} y_j \lambda_j - s_r^+ = \phi y_{r_0} \quad r = 1, 2, \ldots, s;$$
$$\lambda_j \geq 0 \quad j = 1, 2, \ldots, n.$$

Note that when model (4.11) or (4.12) is used on a PPS specified under CRS, then we have $\theta_o^* = 1/\phi_o^*$, and so the input efficiency of $\text{DMU}_o$ equals its output efficiency. This is true only under CRS. Note, however, that whether or not a DMU is classified as boundary will depend on the PPS and not on the orientation in which efficiency is
measured. (E.g., under VRS, if a DMU is Pareto-efficient in the input orientation, it will also be so in the output orientation.)

We illustrate input and output oriented CRS DEA efficiency measurement using a simple example involving observations on seven firms that use a single input to produce a single output in Figure 4.8. The full circles symbols correspond to observations.

**Figure 4.8: Input and Output oriented efficiency under CRS**

![Diagram](image)

The slope of the line connecting each point to the origin corresponds to the output per input and the highest such slope is attained by the line from the origin through B. This line is called the "efficient frontier." Notice that this frontier touches at least one point and all points are therefore on or below this line. The name Data Envelopment Analysis, as used in DEA, comes from this property because in mathematical parlance, such a frontier is said to "envelop" these points.

The CRS frontier is given by the ray starting in the origin and passing through DMU B. Note that DMU B corresponds to the maximum productivity level of the sample. Assuming CRS, a change in the input level results in an equally proportionate change in the output level, and so, in this case, the frontier is spanned by the ray OB.

Compared with the best DMU B, the others are inefficient. As can be seen from the points designated by the arrow head, an inefficient DMU may be projected to different points on the frontier under the two orientations. For example, efficiency for E is achieved by
reducing the input until the point K on the efficient frontier while efficiency for D is achieved by raising the output until the point I. Assuming constant returns to scale, the benchmark for E is K in an input orientation while the benchmark for D is point I for an output orientation.

4.5.2 CRS multiplier formulations

We now introduce the following models, which are dual to models (4.11) and (4.12), respectively.

DEA input oriented model under CRS (multiplier formulation):

\[
\begin{align*}
\text{max } & \quad h_j = \sum_{r=1}^{s} u_r y_{ro} \\
\text{subject to } & \quad \sum_{r=1}^{s} u_r y_{ij} - \sum_{i=1}^{m} v_i x_{ij} \leq 0 \\
& \quad \sum_{i=1}^{m} v_i x_{io} = 1 \\
& \quad u_r, v_i \geq 0
\end{align*}
\]

(4.13)

DEA output oriented model under CRS (multiplier formulation):

\[
\begin{align*}
\text{min } & \quad g_o = \sum_{i=1}^{m} v_i x_{io} \\
\text{subject to } & \quad \sum_{i=1}^{m} v_i x_{ij} - \sum_{r=1}^{s} \mu_r y_{ij} \geq 0 \\
& \quad \sum_{r=1}^{s} \mu_r y_{ro} = 1 \\
& \quad \mu_r, v_i \geq 0
\end{align*}
\]

(4.14)

In models (4.13) and (4.14), the variables \( u_r \) and \( v_i \) represent the weights that \( DMU_o \) "assigns" to each one of its inputs and outputs so that its efficiency will be maximized. \( DMU_o \) is free to choose these weights, and as such, the efficiency measure will show it in the best possible light.

Models (4.11) and (4.12), are generally referred to as the Charnes-Cooper-Rhodes models (Charnes et al., 1978). However, both these and the Debreu-Farrell model are referred to as 'envelopment models' because of the way that the frontier envelops the constraints.
Models (4.13) and (4.14) are then referred to as the 'multiplier models' to emphasize that the \(u_r\)- and \(v_i\)-variables that are associated with the respective outputs and inputs are not pre-assigned weights but are to be solved for by reference to the data that are generated by the DMU\(_j\) performances.

The models in (4.13) and (4.14) can be presented as linear fractional models in which the objective function is the ratio of the sum of the weighted outputs to the sum of the weighted inputs of DMU\(_o\). The fractional form of model (4.13) is reproduced in (4.15).

\[
\max h_o(u, v) = \frac{\sum_r u_r y_m}{\sum_i v_i x_i} \\
\text{Subject to} \\
\sum_r u_r y_j / \sum_i v_i x_j \leq 1, \\
\text{for} \quad j = 1, 2, ..., n, \\
u_r, v_i \geq 0. \tag{4.15}
\]

The equivalence between (4.13) and (4.15) can be readily seen (Charnes and Cooper, 1962). Model (4.15) simply reflects scaling the optimal values of \((u, v)\) in (4.13) so that the denominator of the objective function is 1.

In (4.15), the DEA efficiency model maximizes for DMU\(_o\) the ratio of the sum of its weighted outputs to the sum of its weighted inputs, subject to the constraint that at no DMU does this ratio exceed some subjective upper bound. The upper bound is simply the maximum value we set for the relative efficiency index, normally 1 or 100. The model in (4.15) allows one to interpret efficiency in the usual “engineering” sense as a ratio of output to input, the inputs and outputs being aggregated through the use of weights.

The interesting feature of model (4.15) is that the weights are not specified a priori but flow out of the solution of the model. So, in fact, this model gives total freedom to DMUs to choose the optimal set of weights that maximize their efficiency. This, in turn, means that DEA is a powerful tool for identifying inefficiency in that if a DMU can choose the weights that show it in the best possible light and even so, other DMUs using this same set of weights appear with higher efficiency, then clearly there is strong evidence of inefficiency at the DMU concerned. By the same token, the efficiency rating of a DMU may be higher than the DMU merits, most notably, the rating may be raised through the use of counterintuitive weights for some of the inputs and outputs. This is one of the reasons behind many developments in the DEA literature, namely, those related with the
imposition of weight restrictions, to restrict the flexibility of DMUs in assigning weights to inputs and outputs. In related developments, no radial measures of efficiency are used, as we show later, to account for all sources of inefficiency.

4.6 BCC (Banker, Charnes, Cooper, 1984) DEA Models

4.6.1 VRS envelopment formulations

While Farrell (1957) introduced the model for efficiency analysis, the model was restrictive with the assumption of constant returns to scale. Farrell and Fieldhouse (1962) extended this model to allow non-decreasing returns to scale. Afriat (1972) provides the variable returns to scale model that was popularized in the operations research literature by Banker et al. (1984). Banker et al. (1984) (BCC) show that the addition of a convexity constraint to the CCR model results in a DEA model that allows increasing, constant, and decreasing returns to scale. In addition, BCC provides a decomposition of CCR Farrell efficiency into scale and technical parts. The CRS assumption is appropriate when all DMUs are operating at an optimal scale. However, imperfect competition, government regulations, constraints on finance, etc., may cause a DMU to be not operating at optimal scale. BCC model can be used in variable returns to scale (VRS) situations.

If the constraint \( \sum_{j=1}^{n} \lambda_j = 1 \) is adjoined into either of the CCR envelopment forms, they are known as BCC (Banker, Charnes, Cooper, 1984) models. These models are variable returns to scale models.

The input-oriented VRS model (envelopment form) for assessing \( DMU_o \) is shown in equation (4.16):

\[
\begin{align*}
\min & \quad \theta - \varepsilon \left( \sum_{i=1}^{m} s_i^- + \sum_{r=1}^{s} s_r^+ \right) \\
\text{subject to} & \\
\sum_{j=1}^{n} x_{ij} \lambda_j + s_i^- = \theta x_{io} & \quad i = 1, 2, \ldots, m; \\
\sum_{j=1}^{n} y_{ij} \lambda_j - s_r^+ = y_{io} & \quad r = 1, 2, \ldots, s; \\
\sum_{j=1}^{n} \lambda_j = 1, \quad \lambda_j \geq 0
\end{align*}
\]
Model (4.16) differs from the CCR model for assessing input efficiency under CRS only in that it includes the convexity constraint $\lambda_j = 1$. This constraint is invalid when the DMUs operate under CRS because contraction or expansion of scale size is permissible under efficient operation. The convexity constraint is, however, necessary under VRS, to prevent any interpolation point constructed from the observed DMUs from being scaled up or down to form a referent point for efficiency measurement.

We refer to $\theta^*_o$ yielded by model (4.16) as the pure technical input efficiency of $DMU_o$ because it is the net of any impact of scale size. $DMU_o$ is Pareto-efficient if and only if $\theta^*_o = 1$ and all slacks are equal to zero.

The PPS under VRS is a subset of that under CRS. This can be seen from the fact that model (4.16) incorporates the additional convexity constraint compared to the corresponding model under CRS. Thus, the efficiency of a DMU under CRS can never exceed its efficiency under VRS.

We can readily modify the BCC model (4.16) for assessing pure technical output efficiency. The VRS output efficiency model (envelopment form) is

$$\max \phi + \epsilon \left( \sum_{i=1}^{m} s_i^- + \sum_{r=1}^{s} s_r^+ \right)$$

subject to

$$\sum_{j=1}^{n} x_{ij} \lambda_j + s_i^- = x_{io}, \quad i = 1, 2, ..., m;$$

$$\sum_{j=1}^{n} y_{oj} \lambda_j - s_r^+ = \phi y_{ro}, \quad r = 1, 2, ..., s;$$

$$\sum_{j=1}^{n} \lambda_j = 1, \quad \lambda_j \geq 0$$

(4.17)

The optimal value $\phi^*_o$ in (4.17) is the maximum factor by which the output levels of $DMU_o$ can be radially expanded without raising any one of its input levels. Thus, $\phi^*_o$ is a measure of output efficiency of $DMU_o$. We refer to $\phi^*_o$ as the pure technical output efficiency of $DMU_o$. Sometimes, this value is displayed by its inverse as $1/\phi^*_o (< 1)$, for facilitating comparisons of scores between the input-oriented and the output oriented
models or other practical purposes. In the CCR model, both models have the same efficiency value.

Similarly to the input-oriented model, a $DMU_o$ is Pareto-efficient if and only if $\phi_o^* = 1$ and all slacks are zero.

As we have already noted, adding the constraint $\sum_{i=1}^n \lambda_i = 1$ converts CCR model to a variable returns to scale model. This is shown in Figure 4.9 by the curve with segments A-B and B-C. Note that the line connecting A to B represents the region of increasing returns to scale, the point B represents constant returns to scale and the segment from B to C represents the region of decreasing returns to scale. Note also that in all cases the frontiers are derived from observations for $DMU_j$ that have evaluations of $\theta = 1$. The VRS model makes it possible to extend the analysis from only 'technical' to 'returns to scale' inefficiencies.

**Figure 4.9: Input oriented efficiency under VRS**

DMUs A, B and C are technically efficient, producing on the production frontier, it is not possible for any of these DMUs to reduce input levels while simultaneously producing at least as much output. DMUs E and D, on the other hand, are observed producing in the
interior of the technology T. DMU E is observed producing 30 units of output while using 30 units of the input. However, a convex combination of DMUs A and B produces the same output using less units of the input.

Considering points E and D, in Figure 4.9 and Figure 4.10, the arrows show how we can either increase the output co-ordinate without increasing the input coordinate for DMU D by moving vertically to the technical efficiency frontier point H or, we can decrease the input co-ordinate without decreasing the observed output by moving horizontally from E to J. Thus, we can move horizontally (vertically) to the line segment representing the region of increasing (decreasing) returns to scale with no trade-off between output and input. By definition, the performance of E (D) is not technically efficient, i.e. its input (output) performance may be improved without worsening the output (input) as shown by the point J (H) on the line segment that reflects the region of increasing (decreasing) returns to scale.

**Figure 4.10: Output oriented efficiency under VRS**

4.6.2 VRS multiplier formulations

The constraint $\sum_{j=1}^{n} \lambda_j = 1$, which is added into either of the CCR envelopment forms, introduces an additional variable, $w$, into the multiplier problems. This extra variable
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makes it possible to effect returns-to-scale evaluations (increasing, constant and decreasing). So the BCC model is also referred to as the VRS (Variable Returns to Scale) model and distinguished form the CCR model which is referred to as the CRS (Constant Returns to Scale) model.

The dual models (multiplier forms) to (4.16) and (4.17) can also be used to assess efficiencies under VRS. Thus, the duals to (4.16) and (4.17) are (4.18) and (4.19), respectively, where $w, u_r,$ and $v_i$ are variables:

$$\text{max } h_o = \sum_{r=1}^{s} u_r y_{ro} + w$$

subject to

$$\sum_{r=1}^{s} u_r y_{ro} - \sum_{i=1}^{m} v_i x_{io} + w \leq 0 \quad (4.18)$$

$$\sum_{i=1}^{m} v_i x_{io} = 1$$

$$u_r, v_i \geq \varepsilon, \text{ w is free}$$

Let the superscript $^*$ denote the optimal value of the corresponding variable in (4.18). The pure technical input efficiency of $DMU_o$ as yielded by model (4.18) is $h^*_o$. $DMU_o$ is Pareto-efficient if and only if $h^*_o = 1$ and all optimal weights $u_r$ and $v_i$ are basic variables (corresponding to the zero slacks in the envelopment model):

$$\text{min } g_o = \sum_{i=1}^{m} v_i x_{io} + w$$

subject to

$$\sum_{i=1}^{m} v_i x_{io} - \sum_{r=1}^{s} u_r y_{ro} + w \geq 0 \quad (4.19)$$

$$\sum_{r=1}^{s} u_r y_{ro} = 1$$

$$u_r, v_i \geq 0, \text{ w is free.}$$

The pure technical output efficiency of $DMU_o$ is $g^*_o$. $DMU_o$ is Pareto-efficient if and only if $g^*_o = 1$ and all optimal weights are basic variables.
The values of \( u_i \) and \( v_j \), in (4.18) and (4.19), when not infinitesimal (or zero), can be used to arrive at marginal rates of substitution between inputs or outputs, or marginal rates of transformation between inputs and outputs. The value of the variable \( w \), which is dual (in linear programming terms) to the convexity constraint in the envelopment models (4.16) and (4.17), reflects the impact of scale size on the productivity of a DMU. If this variable is zero at an optimal solution, the corresponding model collapses to its CRS equivalent. In such a case, \( DMU^o_i \) lies on or is projected at a point on the Pareto-efficient boundary where locally CRS holds. If the optimal value of \( w \) is not zero at any optimal solution to the corresponding model, then its sign indicates the type of returns to scale holding locally where \( DMU^o_i \) lies or is projected on the efficient boundary.

4.7 Scale Efficiency and Returns to Scale

4.7.1 The concept of returns to scale

In the literature of classical economics, returns to scale (RTS) have typically been defined only for single-output situations. Banker (1984), Banker, Charnes and Cooper (1984) and Banker and Thrall (1992) extend the RTS concept from the single output case to multiple output cases using DEA.

Returns to scale are related to average product. In a single-input/single-output case, let a production unit have input level \( x \) and output \( y \). Then its average product is \( y/x \). Returns to scale relate to how, under efficient operation, average product would be affected by scale size. If operation is not efficient, then changes in average product as scale size changes can be due both to changes in efficiency, and changes in scale size and it would not be possible to differentiate between the two.

Let us now assume that in the case of a Pareto-efficient unit operating in a single-input / single-output context, with current input \( x \) and output \( y \), we scale its input level \( x \) by a marginal change \( \alpha \neq 1 \), \( \alpha \rightarrow 1 \) to \( \alpha x \). Let the unit remain Pareto-efficient by changing its output level to \( \beta y \). Its average product has now become \( (\beta y/\alpha x) = (\beta/\alpha) \times (y/x) \). Thus, average product has been scaled by the ratio \( (\beta/\alpha) \).

If \( (\beta/\alpha) > 1 \), the unit’s average product has risen since \( (\beta y/\alpha x) > (\beta/\alpha) \times (y/x) \). In such a case, we have local IRS because the proportional rise in output \( (\beta) \) is larger than the proportional rise of the input by \( (\alpha) \). The characterization IRS is local because we
considered only a marginal change in the scale of the unit \((\alpha \to 1)\). If \((\beta/\alpha) < 1\), we have local DRS, and if \((\beta/\alpha) = 1\), we have CRS locally.

This makes clear the practical significance of identifying and exploiting returns to scale at an operating unit. Where the unit is not operating under CRS, in principle, there would be advantage to changing scale size so as to exploit returns to scale. However, this may not always be feasible in practice because scale size may not be under the control of an operating unit.

In the multiple input–output case, the definitions of IRS, CRS, and DRS above in terms of the relationship between the percentage radial changes in input and output levels can be generalized. For a detailed analysis, see Thanassoulis et al., (2008).

4.7.2 CRS vs. VRS DEA models

In constructing the PPS in a DEA framework, we need to first decide what assumptions are most plausible to maintain in terms of the type of returns to scale, characterizing the technology under which the units being assessed operate. At a most basic level, this means deciding whether it is sensible to adopt the notion that CRS or non-CRS (or, as normally known, VRS) holds.

Note that the convexity constraint \(\sum_{j=1}^{n} \lambda_j = 1\) essentially ensures that an inefficient DMU is only "benchmarked" against DMUs of a similar size. That is, the projected point (for that DMU) on the DEA frontier is a convex combination of observed DMUs. This convexity restriction is not imposed in the CRS case. Hence, in a CRS DEA, a firm may be benchmarked against firms that are substantially larger (smaller) than it. In this instance, the \(\lambda\)-weights sum to a value less than (greater than) one.

The differences between an assessment under CRS and under VRS are illustrated in Figure 4.11 and Figure 4.12. They illustrate, for a single input-output case, the CRS and VRS boundaries for input and output orientations, respectively.

DMU E is inefficient both under CRS and VRS. The measure of its input technical efficiency calculated in relation to the VRS frontier is \(E_{VRS} = OJ'/OE'\), while the measure of technical efficiency calculated in relation to the CRS frontier is \(E_{CRS} = OK'/OE'\). The difference arises because under VRS, DMU E can be compared to virtual DMU J, which
represents a convex combination of two observed DMUs so that it offers the same scale size as E on the output. No contraction or expansion of E is permitted. Under CRS, however, we can extrapolate from observed DMUs A and B (or some convex combination of theirs), because they offer the largest average product, by raising or lowering their scale size (output) while maintaining their average product (the slope of OB) to create the boundary of CRS. In this case, we assess the efficiency of E relative to K, which is feasible in principle under CRS as a contraction of either B or E. This leads to the derived efficiency rating of E, $E_{CRS} = OK' / OE'$.

Figure 4.11: Input Efficiency Measures under CRS and VRS

The output efficiency assessment is illustrated in Figure 4.12. DMU D is inefficient both under CRS and VRS. The measure of its output technical efficiency calculated in relation to the VRS frontier is $D_{VRS} = OH'/OD'$, while the measure of technical efficiency calculated in relation to the CRS frontier is $D_{CRS} = OI'/OD'$. The difference arises because under VRS, DMU D can be compared to virtual DMU H, which represents a convex combination of two observed efficient DMUs so that it offers the same scale size as D on the input. No contraction or expansion of D is permitted. Under CRS, however, we can extrapolate from observed DMUs B and C (or some convex combination of theirs), because they offer the largest average product, by raising or lowering their scale size.
(input) while maintaining their average product (the slope of OB) to create the boundary of CRS. In this case, we assess the efficiency of D relative to I, which is feasible in principle under CRS as a contraction of either B or C. This leads to the derived efficiency rating of D, $D_{\text{CRS}} = \frac{OI}{OD}$.

**Figure 4.12: Output Efficiency Measures under CRS and VRS**

Based on above considerations we conclude that the sole difference between CRS and the VRS boundary is that the latter does not permit extrapolation of scale size from observed DMUs or their convex combination.

### 4.7.3 NIRS and NDRS DEA models

Apart from CRS and VRS, we can also make assumption for other types of returns to scale in DEA. A less extreme assumption is that of non-increasing returns to scale (NIRS) or, slightly less precise, decreasing returns to scale. This situation prevails if for any possible production process, we can arbitrarily decrease the scale of the operation. Decreasing returns to scale mean that the output will tend to increase less than the input such that it will be possible to scale down but not up. Reasons to expect decreasing returns to scale include whether a producer can run a process at reduced speed, reduce capacity utilization or reduce the amount of time that the process takes. Graphically, this means...
that for a given production observation, all combinations on the line between zero (i.e., the origin) and this observation are also feasible.

Instead of assuming that we can scale down but not up, we might assume that we can scale up but not down. This leads to what we naturally might call non-decreasing returns to scale (NDRS) or, slightly less precise, increasing returns to scale (IRS). This situation prevails if for any possible production process we can arbitrarily increase the scale of the operation. Increasing returns to scale mean that the output will tend to grow faster than the input. One reason for this is that a larger scale implies more experience, more efficient processes and a better ability to utilize specialization possibilities. Graphically, this means that for a given production point, all points on the line extending from the observation but on the same ray compared to zero as the point are also feasible.

The NIRS and NDRS technologies are also useful for identifying the type of returns to scale that apply locally at the efficient frontier.

The envelopment models in (4.16) and (4.17) can be readily modified to assess efficiency under NIRS or NDRS. The modifications needed are as follows:

- To assess pure technical input or output efficiency under NIRS, replace the convexity constraint in model (4.16) or (4.17) by the constraint \( \sum_{j=1}^{n} \lambda_j \leq 1 \). This permits scaling efficient input–output combinations pro rata downward but not upward.

- To assess pure technical input (output) efficiency under NDRS replace the convexity constraint in model (4.16) or (4.17) by the constraint \( \sum_{j=1}^{n} \lambda_j \geq 1 \). This permits scaling efficient input–output combinations pro rata upward but not downward.

For a further elaboration on the rationale of these modifications, see Cooper et al. (2000).

We next consider additional return-to-scale issues of interest in a managerial context.

4.7.4 Scale efficiency measurement

Given that, under VRS, scale size affects the average product of a DMU, one important question is to ascertain how far the scale size of a unit is away from optimal which according to Banker (1984), is the most productive scale size (MPSS). In a single input/single-output context, MPSS (constant returns to scale) is offered by the unit(s)
offering maximum output to input ratio (i.e., maximum average product). Scale efficiency is defined in either an input or an output orientation as the ratio between technical (i.e., CRS) efficiency and pure technical (i.e., VRS) efficiency.

For an input orientation scale efficiency is,

\[
\text{Scale input efficiency of } \text{DMU}_o = \frac{\text{CRS efficiency of } \text{DMU}_o}{\text{VRS input efficiency of } \text{DMU}_o}
\]

Alternatively, we can measure scale efficiency using the output-oriented model

\[
\text{Scale output efficiency of } \text{DMU}_o = \frac{\text{CRS efficiency of } \text{DMU}_o}{\text{VRS output efficiency of } \text{DMU}_o}
\]

Turning to the points E and D, in Figure 4.11 and Figure 4.12, respectively, we have already shown that DMU D (E) could improve moving horizontally (vertically) to the technical efficiency frontier point J (H). However, this does not end the possibilities for improvement since movement from J (H) to K (I) would lead to a further decrease in input ((increase in output) without decreasing output (increasing input). This movement to K (I) then represents what could also have been accomplished if the performance of the DMU that is associated with E (D) had been scale efficient as well as technically efficient.

We can interpret scale efficiency as a measure of the distance between the CRS and VRS boundaries at the scale size of the unit. For example, in Figure 4.11, the scale efficiency of DMU E in the input orientation is OK′/ OJ′, which equals E_{CRS}/E_{VRS} as defined in (4.20) since we have E_{CRS} = OK′/OE′ and E_{VRS} = OJ′/OE′.

The overall measure of efficiency (measured in relation to the CRS frontier) is therefore a composite of pure technical efficiency and scale efficiency. With reference to Figure 4.11, we have E_{CRS} = OK′/OE′ = OJ′/OE′ x OK′/ OJ′, which is equivalent to E_{CRS} = E_{VRS} x scale efficiency. The larger the divergence between VRS and CRS efficiency ratings, the lower the value of scale efficiency and the more adverse the impact of scale size on productivity.

The output efficiency assessment is illustrated in Figure 4.12. DMU D is not technically efficient as it is operating below the efficient frontier. It could become efficient, in a pure technical sense, by increasing its output level until reaching point H. However, at this
Point, DMU D would be considered scale inefficient because it is not possible to achieve the maximum productivity level observed at point I. The scale efficiency measure, given by the ratio \( \frac{\text{OI} / \text{OD}'}{\text{OH} / \text{OD}'} = \text{OI} / \text{OH}' \), evaluates the distance between the CRS and VRS frontiers, and measures the amount of output loss attributable to having a scale size that prevents attaining maximum productivity. Therefore, the overall efficiency measure for DMU D, which incorporates both pure technical and scale efficiencies, is given by the product of the pure technical and scale efficiency scores, i.e., \( (\text{OH} / \text{OD}') \times (\text{OI} / \text{OH}') = (\text{OI} / \text{OD}') \).

Another way to see scale efficiency is that the distance of the scale size of a DMU from MPSS is reflected in its scale efficiency. This is illustrated in Figure 4.13. Consider technically efficient DMU A which is the furthest from the constant returns to scale facet OB along the increasing returns to scale facet AB. Starting at DMU A, as \( x \) increases along the increasing returns to scale facet AB, the input-oriented distance between AB and the constant returns to scale frontier OB decrease. Hence, as a technically efficient benchmark gets closer to the most productive scale size, VRS efficiency approaches CRS efficiency and the scale efficiency approaches unity.

**Figure 4.13: Input Orientation and Scale Efficiency**
The interpretation of the scale from the output oriented model is similar to the one from the input oriented model. In Figure 4.14, we present the output-oriented measure of scale efficiency. In this case, technically efficient DMU A is projected up to the constant returns to scale frontier. As production increases along the increasing returns to scale facet AB, the vertical distance between points on AB and the facet from the origin through the B narrows. As the technically efficient benchmark approaches most productive scale size B, the scale efficiency of the benchmark approaches 1. Likewise, as production increases along the decreasing returns to scale segment BC away from the most productive scale size B, scale inefficiency increases as indicated by the larger arrows as the input level increases.

**Figure 4.14: Output Orientation and Scale Efficiency**

We now note that there will always be at least one DMU (like B) in the frontier which has the 'most productive scale size' where both scale and technical efficiency will have been achieved. Hence evaluation of performances in both technical and returns-to-scale efficiency can always be made. See chapter 2 in Cooper et al. (2004). We also note from Figure 4.13 and Figure 4.14 that technical efficiency is a necessary but not a sufficient condition for scale efficiency.
The necessity of technical efficiency is also true for other inefficiencies such as allocative (i.e. price) efficiency, which is based on pre-assigned weights in the form of unit costs, etc., when such information is available. We therefore continue to focus on technical efficiency since it is the simplest case and requires only minimal information and its attainment is necessary for all other types of efficiency.

The scale inefficiency along with the returns-to-scale nature may indicate whether or not a production unit may improve its productivity by expanding or contracting its operations, after elimination of its pure technical inefficiency.

4.7.5 Identifying local returns to scale
As noted above, if IRS holds at a Pareto-efficient production point, then raising its input levels by a small percentage will lead to an expansion of its output levels by an even larger percentage, assuming the unit remains Pareto-efficient. Thus, knowing the local returns to scale at a DMU is very important for managerial decision making. Obviously, it makes sense for a DMU operating at a point where IRS holds to increase its scale size, if this is under its control, because its additional input requirements may be more than compensated for by a rise in output levels. Similarly, a DMU operating at a point where DRS holds should decrease its scale size. The ideal scale size to operate at is where CRS holds. This scale size, which is input–output mix specific, is what Banker (1984) termed Most Productivity Scale Size (MPSS).

There is a vast literature on the theory and applications of identification of returns to scale (RTS) for DMUs in DEA literature. For a comprehensive survey, see Banker et al (2004). All methods provide well-defined return-to-scale classifications only for production units lying on the efficient frontier. For inefficient units, as Banker and Thrall (1992 p. 82) note, “productivity changes due to returns to scale are confounded with productivity changes due to inefficiency elimination,” and so return-to-scale characterizations are not possible unless inefficient units are projected on the efficient boundary. However, in that case, the characterization of returns to scale of the inefficient unit would depend on the particular location of the efficient boundary where the unit was projected.

A method that can be applied to characterize returns to scale is that of Färe et al. (1985). Their approach requires three efficiency estimates, respectively, in relation to three technological return-to-scale specifications: CRS, VRS, and NIRS. From the efficiency
measures obtained from each of these models, conclusions can be reached concerning returns to scale:

- If the CRS, VRS, and NIRS models yield exactly the same efficiency measure, then the unit lies, or is projected, on a boundary region exhibiting local CRS.

- If the CRS and NIRS efficiency measures are both equal and lower than the VRS efficiency measure, then the unit lies, or is projected, on an IRS region of the boundary.

- If VRS and NIRS efficiency measures are both equal and higher than the CRS efficiency measure, then the unit lies, or is projected, on a DRS region of the boundary.

The Färe et al. (1985) method has the advantage of being unaffected by the existence of multiple optimal solutions. Its main disadvantage seems to be the need to solve three DEA problems (Seiford and Zhu, 1999a).

In this thesis we apply the most recent approach presented in Sherman & Zhu (2006) for identifying RTS. This approach, safely ignoring possible multiple optimal solutions of $\lambda_j$, determines the local RTS status. More precisely:

- $DMU_o$ exhibits CRS if and only if its CRS efficiency score is equal to its VRS efficiency score. Otherwise,

- $DMU_o$ exhibits IRS if and only if $\sum_{j=1}^{n} \lambda_j < 1$ in the solution of the CCR envelopment model

- $DMU_o$ exhibits DRS if and only if $\sum_{j=1}^{n} \lambda_j > 1$ in the solution of the CCR envelopment model

4.8 Target Setting and Benchmarking

One of the key outcomes in an efficiency assessment is the identification of targets and efficient peers. Setting the target input and/or output levels that would render an inefficient DMU efficient is closely connected with benchmarking, which can be defined as the process of comparing the performance of one unit against that of “best practice”
units. Within the DEA framework, where the “best practice” units define the frontier of the PPS $T$, benchmarking is equivalently defined as the process of comparing the performance of a DMU to the frontier of $T$. Since in the very nature of the DEA mechanism is a comparison of observed producers to each other, it seems logical to expect that DEA is particularly suitable for target settings and benchmarking.

Irrespective of whether we use input- or output-oriented DEA models, information about targets and efficient peers can be directly obtained from the envelopment form of the DEA models.

4.8.1 DEA efficient targets

The solution of an envelopment model, such as (4.16) or (4.17), leads to the levels the inputs and outputs of $DMU_o$ need to place it on the boundary of the PPS. Specifically, models (4.16) and (4.17) yield with respect to $DMU_o$, respectively, the boundary input–output levels $(\hat{x}_io, \hat{y}_{ro})$ in (4.33) and (4.34):

$$\begin{align*}
\hat{x}_{io} &= \sum_{j=1}^{n} x_{ij} \lambda_j^* = \theta_o x_{io} - s_i^* \quad i = 1, 2, \ldots, m \\
\hat{y}_{ro} &= \sum_{j=1}^{n} y_{jr} \lambda_j^* = y_{ro} + s_r^* \quad r = 1, 2, \ldots, s
\end{align*}$$

(4.22)

$$\begin{align*}
\hat{x}_{io} &= \sum_{j=1}^{n} x_{ij} \lambda_j^* = x_{io} - s_i^* \quad i = 1, 2, \ldots, m \\
\hat{y}_{ro} &= \sum_{j=1}^{n} y_{jr} \lambda_j^* = \phi_o y_{ro} + s_r^* \quad r = 1, 2, \ldots, s
\end{align*}$$

(4.23)

The input-output levels in (4.22) and (4.23) clearly use a linear combination of a set of DMUs located on the efficient part of the boundary. Such DMUs correspond to $\lambda$ values that are nonzero at the optimal solution to model (4.27) or (4.28), and they are called the peer units or efficient referents of the $DMU_o$.

The boundary levels in (4.22) and (4.23) are used as a basis for going to Pareto-efficient input–output levels for $DMU_o$. The input-output levels that would render a DMU efficient are normally referred to as targets. The determination of targets for DMUs is an important theme in DEA, since in many practical applications one is more interested in
determining targets that render the DMUs efficient rather than in determining their level of inefficiency.

Mathematically, the input–output levels \((\hat{x}_{io}, \hat{y}_{ro})\) are the coordinates of the point on the efficient frontier used as a benchmark for evaluating \(DMU_o\). A practical interpretation of \((\hat{x}_{io}, \hat{y}_{ro})\) is that it constitutes a virtual DMU whose performance \(DMU_o\) should, in principle, be capable of attaining. The proof that the input–output targets would render \(DMU_o\) Pareto-efficient can be found in Cooper et al. (2000). These levels are often referred to as a projection point of \(DMU_o\) on the efficient boundary or simply as targets for \(DMU_o\).

When a DMU is Pareto-inefficient, the input–output levels in (4.22) and (4.23) can be used as the basis for setting its targets so that it can improve its performance. The specific combination in (4.22) corresponds to giving preemptive priority to the radial contraction of the input levels of \(DMU_o\) without lowering any one of its output levels. This means that the targets in (4.23) preserve in large measure the mix of inputs and outputs of \(DMU_o\), though if any slack values are positive, the mix of the target input–output levels differs from that of \(DMU_o\). The preservation of the input–output mix in target setting has some advantages. The mix typically reflects a combination of operating choices and uncontrollable factors. Setting inefficient DMU targets that preserve in large measure their own mix of inputs and outputs makes it easier for the DMU to accept them and attempt to attain them. This is because the targets will reflect in large measure the DMU’s own operating priorities, history, and environment.

The key difference between the target levels in (4.22) and (4.23) is that those in (4.23) are arrived at by giving preemptive priority to the radial expansion of the output levels of \(DMU_o\) without raising any one of its input levels. When radial expansion of outputs is complete, the targets exploit further reductions in individual input and/or rises in individual output levels that are feasible at the radially expanded output levels. Such individual input savings and/or output augmentations are reflected in the slack values \(s_i^-\) and \(s_i^+\).
Clearly, the targets in (4.22) would be more suitable in cases where in the short-term input levels are controllable while output levels are not. The targets in (4.23) are more suitable when the opposite is the case.

4.8.2 DEA efficient peers

We can readily identify the efficient peers to a DMU whether we use envelopment or a multiplier DEA model. Here we consider the envelopment model (4.16). Using $\lambda^*$ again to denote the optimal values of the corresponding variables in that model, the efficient peers or efficient referents to $DMU_o$ are those DMUs that correspond to positive $\lambda$ values.

We can see the practical significance of the efficient peers now if we look again at the targets in (4.22), which model (4.16) yields for $DMU_o$. It is clear that the target level for $DMU_o$ on a given input is a linear combination of the levels of that input at its efficient peers. The same is true of the target level on each output for $DMU_o$. Further, it is easy to deduce from (4.16) that the efficiency rating $\theta^*$ of $DMU_o$ is the maximum of the ratios $(\hat{x}_{io}/x_{io})$ ($i = 1, 2, ..., m$). Thus, the target input–output levels of $DMU_o$ and its efficiency rating are exclusively dependent on the observed input–output levels of its efficient peers and on no other DMUs. Recall that different priorities on input–output improvements will lead generally to different efficient peers.

In sum, the features of efficient peers we have identified make them very useful in practice as role models that $DMU_o$ can emulate so that it may improve its performance. They are efficient, and given that they have a mix of input–output levels similar to that of $DMU_o$, they are likely to operate in similar environments and/or to favor similar operating practices to $DMU_o$.

4.9 Statistical Properties of DEA Estimators

DEA has been criticized for its deterministic nature, which assumes no measurement error and other noisy components. However, a number of examples can be easily found to show that the DEA input and output variables are commonly of a stochastic nature. The original DEA models focused primarily on the estimation of the production frontier...
and relative efficiency and all deviations from the frontier are assumed to be due only to technical inefficiencies.

Recognizing the need for a statistical foundation for DEA, Banker (1993) provided a formal statistical basis by identifying conditions under which DEA estimators are statistically consistent and likelihood maximizing. He also developed hypothesis tests for efficiency comparison when a group of DMUs is compared with another or a group of DMUs is compared between two periods. Furthermore, he also provided both parametric and nonparametric statistical tests regarding the scale of operation of the underlying technology and the investigation of factors causing inefficiency. These tests will be presented and applied in the respective chapters of this study.

4.10 Concluding Remarks
Within this study performance is going to be defined in terms of productive efficiency, and to measure productive efficiency, we will use the efficiency frontier technique Data Envelopment Analysis. As described in this chapter, the information most readily obtainable from a DEA analysis is the following:

- A measure of the efficiency of the DMU
- Where the DMU is Pareto-efficient: getting a view on the scope for the DMU to be a role model for other DMUs
- Where the DMU is Pareto-inefficient: identifying efficient DMUs whose operating practices it may attempt to emulate to improve its performance, and estimating target input–output levels that the DMU should in principle be capable of attaining under efficient operation

Clearly, besides the efficiency score, target settings and peer identification are largely the purpose of the DEA analysis. The identification of efficient peers is especially useful for gaining an intuitive feeling for the comparative efficiency results yielded by DEA.
5. The EU LEADER Program

5.1 Socio-Economic Development in EU Context
Generally speaking, development can be defined as a state in which things are improving. However, it is defined in many different ways regarding the social, political, biological, science and technology contexts. Precisely, in the socio-economic context, development can be interpreted as the improvement of people’s well-being that comes from improved levels on education, incomes, human skills, employment etc. In socio-economic development the policy concern is to enhance the social and economic prospects of individuals, territories or sectors. A socio-economic development intervention or policy has its own specific rationale. Some interventions may emphasise on the development of productivity and innovativeness of small and medium sized enterprises while others on the development of modern transport and environmental infrastructure. Moreover, there are development interventions that may emphasise on the regeneration of inner cities or on the diversification of rural areas while others may focus on the integration of disadvantaged groups. Such interventions are included in European Cohesion Policy programs.

- One of the main characteristics of socio-economic development policies is the way they combine different interventions within a sector or territory. These interventions come from different policy areas: research and technology development; education and training; environment; infrastructure development; etc. Hence, socio-economic development encompasses many possible interventions including enterprise support, infrastructure, education and training, science and technology and active labour market programs in various combinations.

Among the most important characteristics of socio-economic development programs, the following can be highlighted (European Commission. DG Regio, 2008):
• They seek to address persistent and apparently intractable structural problems or fundamental needs for adaptation. So, often firms are not competitive, public administrations have limited capacities, social groups have been excluded for a long time, education and training systems are poorly linked to economic needs and the infrastructure is poor.

• They are made up of multiple interventions, intended to reinforce each other. For example, they may combine infrastructure with training, small firm development and technology transfer programs in a single territory. Even a sectoral or thematic program is likely to include multiple interventions or measures. This follows from an understanding that many structural problems are multi-dimensional and can only be addressed if these various dimensions simultaneously change.

• They are tailored to the needs of their settings. So business start-up programs in the north of Germany or the south of Portugal may have similar goals but are likely to approach what they are doing in different ways reflecting the circumstances, history, resources and broader national or regional strategies in those different territories.

• They are nonetheless planned and funded within a broader national or transnational framework. Thus although tailored to particular settings, socio-economic development programs are often guided by a broader concept, strategy or policy. This is so for European Cohesion Policy, shaped by a general commitment to social, economic and territorial cohesion across the EU.

• They have a strong bottom-up (as well as a top down) characteristic. They are designed to respond to needs and priorities of specific actors and stakeholders who may be based in a territory or sector or otherwise involved in priorities such as environmental protection or equal opportunities. These actors are regarded as partners in the Socio-economic development enterprise.

• In innovative policy areas achieving success cannot be taken for granted and implementation is not always straightforward. There is a need for sophisticated management and planning. Socio-economic development is certainly complex and often faces many uncertainties. Choosing goals and measures, designing programs and policies, implementing and sustaining a development dynamic, all
require analysis, anticipation, establishing feedback systems and mobilizing different institutions, agencies and population groups.

5.1.1 New Rural Development Paradigm

According to endogenous development theorists, improvements in the socio-economic well-being of disadvantaged areas can best be achieved through the recognition and animation of the endogenous resources of the territory itself (Ray 2000). This development approach was proposed as an alternative to isolated sectoral central-formulated policies which assume that socio-economic problems can be solved by standard measures, regardless of location or culture (Nemes, 2005). Endogenous development presents the following three characteristics (Ray, 1997).

- First, it sets development activity within a territorial rather than sectoral framework, with the scale of the territory being smaller than the nation-state.
- Second, economic and other development activities are reoriented to maximise the retention of benefits within the local territory by valorising and exploiting local resources – physical and human.
- Third, development is contextualised by focusing on the needs, capacities and perspectives of local people, meaning that a local area should acquire the capacity to assume some responsibility for bringing about its own socio-economic development.

Partnership working has been increasingly recognised as a mechanism to introduce and manage endogenous development (Ray 2000). The partners pool their resources in the pursuit of a common policy objective, in this case the socioeconomic regeneration of a territory. The network paradigm seeks to establish a synthesis between endogenous (local, bottom-up) and exogenous (extra-local, top-down) links in order to foster learning and innovation processes (OECD 1993 and 1996).

Integration in rural development can be approached in various ways. According to Nemes (2005) it’s most common understanding concerns the integration of various economic sectors - agriculture, industry, services. Another frequently mentioned aspect is the integration of those disadvantaged social groups in the development process (women, elderly people, national and ethnic minorities, etc.), which could suffer even more if left out of improvements.
5.2 The Leader Approach to Rural Development Policy

Rural development policy is an increasingly important component of the Common Agricultural Policy. Since its introduction, LEADER has become the most prominent tool of local development and has been extended to almost all regions of the EU (Oedl-Wieser, Strahl, & Dax, 2010). LEADER assists rural communities in improving the quality of life and economic prosperity in their local area. As it became the most famous tool of local development action it spread to almost all regions of the EU (Oedl-Wieser et al., 2010). Leader+ is designed to help the implementation of innovative and integrated local strategies for sustainable development. The implementation of the LEADER initiative is followed by the decentralization of governing and the increased importance of sub-national actors in Rural Development (Milic B, Bogdanov N, Heijman W, 2011). The “LEADER approach” can be defined as an area-based, bottom-up, multi-sector approach that seeks out innovative actions, and uses local management and financing via the creation of local partnerships (Diaz-Puente J. M. et al., 2009). LEADER has been one of the main examples of a successful European Union initiative that has reached out to local areas and people, as well as ‘joining up’ farming, food, local development, environment, and quality of life (Vidal, 2009).

The Community Initiatives Leader I (1991-94) and Leader II (1994-99) also played an experimental role, which has made it possible to define and implement innovative, integrated and participative local schemes.

In policy terms LEADER was introduced as a ‘Community Initiative’ financed under the EU Structural Funds in order to support rural development projects initiated at the local level. There have been three generations of Leader (Table 5.1). LEADER I ran from 1991–93, LEADER II from 1994–99, and LEADER+ from 2000-2006.

Table 5.1: The significant role of Leader in Common Agriculture Policy

<table>
<thead>
<tr>
<th>Leader Initiatives</th>
<th>Number of Local Action Groups</th>
<th>Area covered</th>
<th>EU Funding</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leader I</td>
<td>217</td>
<td>367 000 km²</td>
<td>EUR 442 million</td>
</tr>
<tr>
<td>Leader II</td>
<td>906</td>
<td>1 375 144 km²</td>
<td>EUR 1.755 million</td>
</tr>
<tr>
<td>Leader +</td>
<td>893</td>
<td>1 577 386 km²</td>
<td>EUR 2.105.1 million</td>
</tr>
</tbody>
</table>
The EU LEADER Program

The Community Initiative Leader+ is part of the Community's rural development policy, the second pillar of the common agricultural policy (CAP). In the period 2000-06, it was geared to the diversification of economic activity in rural areas by applying innovative, integrated and participative territorial development strategies. As the second pillar of the CAP and a major factor in economic and social cohesion, the Community's rural development policy is not restricted to boosting the competitiveness of agriculture. It also encourages the development of new activities and sources of employment.

LEADER+ is designed to help the implementation of innovative and integrated local strategies for sustainable development. LEADER approach has demonstrated its viability over the past twenty years. It has helped rural actors assess the long-term potential of their local regions and proven an effective and efficient tool in the delivery of development policies.

The European Commission has also promoted this partnership-based method of funding projects in the EU initiatives URBAN, URBACT, EQUAL, Local Agenda 21, Transition Towns and Territorial Employment Pacts. From 2007 onwards, the LEADER method is fully integrated (‘mainstreamed’) as a mandatory axis within overall EU rural development policy. This means LEADER is included in national and regional general rural development programs supported by the EU, alongside a range of other rural development axes. LEADER method has been extended to cover not only rural but also coastal (FARNET: European Fisheries Areas Network) and urban areas: Community Led Local Development (CLLD), which is, in a way, a transitional change (European Economic and Social Committee, 2014).

The design and delivery of LEADER is based around implementation bodies called “Local Action Groups’ (LAGs). This is an original feature (European Economic and Social Committee, 2010). The LAGs are based on partnerships involving public, private and third sector bodies. Each LAG proposes an integrated local development strategy and, if approved by the managing authority, is responsible for its implementation. The main responsibility of LAGs involved in the delivery of a program is to offer a variety of highly specialized services such as project generation, appraisal and selection, program progress and control.

Since its launch in 1991, LEADER has provided rural communities in the EU with the tools to play an active role in shaping their own future. It has evolved over time, together
with the rest of the Common Agriculture Policy. Information from evaluations and rural stakeholders indicates that the Leader approach is a tool that works well, in quite different situations and types of areas, thus adapting rural policy-making to the extreme diversity of rural areas’ needs. For these reasons, it has now become an integral part of rural development policy. By encouraging local participation in the drawing up and implementation of sustainable development strategies, the Leader approach may prove to be a precious resource for future rural policy.

LEADER encourages rural territories to explore new ways to become or to remain competitive, to make the most of their assets and to overcome the challenges they may face, such as an ageing population, poor levels of service provision, or a lack of employment opportunities. In this way, LEADER contributes towards improving the quality of life in rural areas both for farm families and the wider rural population. It uses a holistic approach to address rural problems. It recognises, for example, that being competitive in the production of food, having an attractive environment and creating job opportunities for the local population are mutually supportive aspects of rural life, requiring specific skills, appropriate technologies and services that need to be tackled as a coherent package and with tailored policy measures. Leader encourages socioeconomic players to work together, to produce goods and services that generate maximum added value in their local area.

LEADER was launched with the aim of improving the development potential of rural areas by drawing on local initiative and skills, promoting the acquisition of know-how on local integrated development, and disseminating this know-how to other rural areas. The main concept behind the Leader approach is that, given the diversity of European rural areas, development strategies are more effective and efficient if decided and implemented at local level by local actors, accompanied by clear and transparent procedures, the support of the relevant public administrations and the necessary technical assistance for the transfer of good practice.

The local development approach is formalised in a local development strategy document. This includes establishment of the objectives, definition of strategic priorities and ranking of the actions to be undertaken. This local development strategy is the basis of the LAG’s application for support under open calls for proposals organised by the LAGs for
LEADER. Member States or regions select successful LAGs and allocate budgets to them for implementation of their local strategies.

5.2.1 The Seven Key Features of Leader

The difference between Leader and other more traditional rural policy measures is that it indicates ‘how’ to proceed rather than ‘what’ needs to be done. Seven key features discern LEADER approach from classical measures of rural development policy. Maintaining a focus on all of the LEADER method’s seven features could allow for even greater rural development (Thuesen & Nielsen, 2014). Each feature complements and interacts positively with the others throughout the whole implementation process, with lasting effects on the dynamics of rural areas and their capacity to solve their own problems.

5.2.1.1 Area-based local development strategies

An area-based approach takes a small, homogenous, socially cohesive territory, often characterised by common traditions, a local identity, a sense of belonging or common needs and expectations, as the target area for policy implementation. Having such an area as a reference facilitates the recognition of local strengths and weaknesses, threats and opportunities, endogenous potential and the identification of major bottlenecks for sustainable development. Area-based essentially means local (European Commission, 2006).

The New Rural Paradigm, which outlined a need for a change in rural policy focuses on places rather than sectors. This approach concentrates on exploiting the areas' own resources of rural areas and to enhance regional competitiveness (OECD, 2006). Communication is favored and willingness to act collectively is improved when areas smaller than the state or region are taken as point of departure (Furmankiewicz, 2012). LAGs must translate their needs and opportunities into local targets and focus on meeting these targets when implementing their strategies (ECA, 2010, p. 21). This area-based strategy making involving local learning is described by Vidal (2009).

5.2.1.2 Bottom-up approach

The bottom-up approach means that local actors participate in decision-making about the strategy and in the selection of the priorities to be pursued in their local area. Experience has shown that the bottom-up approach should not be considered as alternative or opposed to top-down approaches from national and/or regional authorities, but rather as
combining and interacting with them, in order to achieve better overall results (European Commission, 2006).

Of the seven features of Leader the most distinctive one is the bottom-up approach. Rural policies following this approach should be designed and implemented in the way best adapted to the needs of the communities they serve. Bottom-up approach mobilizes local potential on both the LAG and project levels. The idea is that local groups are optimally situated to identify integrated and innovative solutions to local problems and are more able to act responsively (Thuesen & Nielsen, 2014). From a rational choice perspective, local inhabitants are best informed about local needs and how local system works (Furmankiewicz, 2012). A bottom-up approach increases enthusiasm, commitment, capacity building (ECA, 2010, p. 10) and social capital (Teilmann, 2012).

The involvement of local actors includes the population at large, economic and social interest groups and representative public and private institutions. Capacity building is an essential component of the bottom-up approach, involving (European Commission, 2006): a) awareness raising, training, participation and mobilisation of the local population to identify the strengths and weakness of the area (analysis), b) participation of different interest groups in drawing up a local development strategy, and c) establishment of clear criteria for selection at local level of appropriate actions (projects) to deliver the strategy.

5.2.1.3 Local Action Group (LAG)
One of the more important features of LEADER is local partnership, known as a ‘Local Action Group’ (LAG). LAGs may be set up ad hoc to access Leader support, or may be based on previously existing partnerships. LAG represents a model of organisation that can influence the delivery of policies in a positive way. LAG has the task of identifying and implementing a local development strategy, making decisions about the allocation of its financial resources and managing them. LAGs are likely to be effective in stimulating sustainable development because they (ELARD, 2014):

- aggregate and combine available human and financial resources from the public sector, the private sector, the civil and voluntary sectors;
• associate local players around collective projects and multi-sectoral actions, in order to achieve synergies, joint ownership, and the critical mass needed to improve the area’s economic competitiveness;

• strengthen the dialogue and cooperation between different rural actors, who often have little experience in working together, by reducing potential conflict and facilitating negotiated solutions through consultation and discussion;

• facilitate, through the interaction between different partners, the processes of adaptation and change in the agricultural sector (for example, quality products, and food chains), the integration of environmental concerns, the diversification of the rural economy and quality of life. A LAG should associate public and private partners, and be well-balanced and representative of the existing local interest groups, drawn from the different socioeconomic sectors in the area. At the decision-making level, the private partners and associations must make up at least 50% of the local partnership.

Local action groups are delegated to take up a large proportion of management responsibilities (for example, project selection, payment monitoring, control and evaluation tasks) in relation to individual operations. However, the LAGs’ degree of autonomy may vary considerably depending on Member States’ specific mode of organisation and institutional context. Global grants are the most common form of financing Leader projects and actions. Such grants, co-financed by EU and national public funds, cover a variable portion of a project’s financial requirements, depending on the type of project and the type of area.

Farrel and Thrion (2005) argue that the changes of social attitudes are the main immaterial contributions determined by LEADER or, in other words, the social capital improvement of rural areas. Consequently, the LEADER measures are of economic nature, but the processes or methods utilized to make them effective and sustainable are also of a social nature. Social capital emerges in LEADER because the social relationships have an economic value and they mobilize economic activities (Pisani and Franceschetti, 2011).
5.2.1.4 Innovation

Along with the LEADER development process and its implementation in the field that is innovative in itself, Leader has an important role in stimulating innovative approaches to the development of rural areas. Innovation involves the introduction of a new product, a new process, a new organisation or a new market. This common definition of innovation is valid for rural as well as urban areas. Innovation is encouraged by allowing LAGs to make decisions about the actions they want to support. Innovation in rural areas concerns the transfer and adaptation of innovations developed elsewhere, the modernisation of traditional forms of know-how and production, the finding of new solutions to rural problems (ELARD, 2014).

The concept of innovation is often connected with exogenous expert knowledge, private companies, product development, technology and entrepreneurship (Thuesen & Nielsen, 2014). Innovation might concern a social characteristic, the creation of local connections and a learning culture and cultural innovation (Dargan and Shucksmith, 2008; ENRD, 2010a). Frequently, the innovations that come from LEADER are collaborative and link agriculture with tourism and other services (Dargan and Shucksmith, 2008).

5.2.1.5 Integrated and multi-sectoral actions

Leader is not a sectoral development program; the local development strategy must have a multi-sectoral rationale, integrating several sectors of activity. The actions and projects contained in local strategies should be linked and coordinated as a coherent whole. Integration may concern actions conducted in a single sector, all program actions or specific groups of actions or, most importantly, links between the different economic, social, cultural, environmental players and sectors involved.

OECD’s new rural paradigm (OECD, 2006) is centered on the cross-sectoral or integrated feature, underscoring that future rural development should be conceptualised across sectors, as opposed to the previous sector-based focus on, for instance, agriculture. Attention should be devoted to places within or around which the LAGs can strive for integrated collaboration between different sectors (e.g., rural tourism, manufacture, ICT, retail). The OECD report states as follows: ‘There is recognition that policies for rural areas require a multi-sectoral approach as no one sector is sufficient to bring about rural development’.
According to Nemes (2005) integrated rural development is an ongoing process involving outside intervention and local aspirations; aiming to attain improvements on well-being of rural areas and to sustain and improve rural values; through the redistribution of central resources, reducing comparative disadvantages for competition and finding new ways to reinforce and utilise rural resources. It is integrated in the sense that - as opposed to central development - it is controlled and managed locally; but – opposed to local development – besides local resources it also leans on the professional and financial support of the centre.

5.2.1.6 Networking
Networking includes the exchange of achievements, experiences and know-how between Leader groups, rural areas, administrations and organisations involved in rural development within the EU, whether or not they are direct Leader beneficiaries. Networking is a means of transferring good practice, of disseminating innovation and of building on the lessons learned from local rural development. Networking forges links between people, projects and rural areas and so can help overcome the isolation faced by some rural regions. It can help stimulate cooperation projects by putting Leader groups in touch with each other. Lundvall (1992 & 1993), state that the capacity of local areas to engage in processes of learning and innovation through networks is influenced by the local context. Some areas are more suited to network development and hence will benefit more from endogenous development than other more remote areas.

There are different types of networks. The institutional networks are funded by the European Commission, which defines their role. The EU supports networking structures at both European and national level which bring together Leader groups, administrations, and all other interested partners active in rural development. From 2007, the types of institutional network are: a European network for rural development (run by the Commission) and a national rural network in each Member State. Networking activities have expert support and undertake practical activities such as preparing publications on different aspects of rural development, organising seminars, analysing rural development actions to identify good practice, identifying development trends in rural areas, running websites and helping Leader groups search for potential partners and launch cooperation projects. The European network also acts as a meeting point for national networks and administrations in each Member State in order to share experience at European level.
Participation in networking activities is mandatory for all Leader groups receiving EU financial support. National, regional and local networks or associations of Leader groups have also been set up or have emerged more informally at local, regional or national level in some Member States (for example, the network of Irish and Greek groups) and at European level (for example, the European Leader Association for Rural Development - ELARD).

5.2.1.7 Co-operation
Cooperation involves joint projects among local action groups within the same or different regions. Precisely, the two types of cooperation under Leader are the following: a) inter-territorial cooperation: this means cooperation between different rural areas within a Member State; it may take place between Leader groups, and it is also open to other local groups using a similar participatory approach, and b) transnational cooperation: this means cooperation between Leader groups from at least two Member States, or with groups in third countries following a similar approach.

- Cooperation projects in the LEADER program have their own budget. Collaborative projects produce added value by a) achieving critical mass and synergies; b) improving competitiveness through new business partnerships and markets; c) promoting innovation through new skills and expanded horizons; and d) developing territorial identity and raising awareness (ENRD, 2011; ENRD, 2010b). Cooperation projects are not just simple exchanges of experiences. They must involve a concrete joint project, ideally managed under a common structure.

5.2.2 The Structure of EU LEADER+ Program
LEADER+ has three main areas of activity, as follows:

5.2.2.1 Territorial Rural Development Strategies (Axis 1)
The aim of Axis 1 is to support the economic development of EU’s rural areas. It provides Local Action Groups with funding to implement integrated development strategies that take a global approach to addressing the needs and potential that they have identified in their areas in new and original ways. These strategies are based on support for micro-businesses. The strategies drawn up by Local Action Groups are designed around one or more of the following priority themes set by the European Commission and are considered to be of special interest at Community level.
The EU LEADER Program

These priority themes are the following:

- Theme 1 (Measure 1.1): The use of new know-how and new technologies to make the products and services of rural areas more competitive.
- Theme 2 (Measure 1.2): Improving the quality of life in rural areas.
- Theme 3 (Measure 1.3): Adding value to the local products, by facilitating access to markets for small production units via collective actions.
- Theme 4 (Measure 1.4): Making the best use of natural and cultural resources, including enhancing the value of sites of Community interest selected under NATURA 2000.

The four themes outlined above are essentially four of the measures associated with Axis 1. In total, there are six measures for Axis 1, the other three as follows:

- Administration costs of LAGs, including Training and Skills Development for Groups – Measure 1.5.
- Publicity and Promotion of the Activities of LAGs – Measure 1.6.

To increase the impact that LEADER+ makes on economic and social conditions in rural areas, the strategies drawn up by Local Action Groups were further included a focus on the following target groups: women, young people, farmers and farm families, the long-term unemployed.

5.2.2.2 Co-operation ((Axis 2)
Support from Axis 2 is made available to Local Action Groups that wish to co-operate on joint projects to assist them in achieving the objectives set out in their development strategies. The aim of Axis 2 is to encourage effective co-operation between rural areas in order to achieve the necessary critical mass for a project to be viable; encourage Local Action Groups to undertake complementary actions; and add value to a project through the bringing together of complementary skills, know-how, products and/or measures.

5.2.2.3 Networking (Axis 3)
The aim of Axis 3 is to deepen the developing knowledge on rural development by supporting actions to explore, understand and evaluate the lessons gained from the implementation of LEADER+. Support is provided for the networking of all rural areas, whether funded by LEADER+ or not, and of all organisations involved in rural
development. All LEADER+ Local Action Groups are required to participate actively in the network. In addition, to secure the wider role envisaged for the network in facilitating rural development more generally, all rural areas, whether or not selected under LEADER+, are encouraged to participate in the network.

5.3 Weaknesses in Relation to Official Performance Evaluations

The essence of the LEADER approach is that, given the diversity of European rural areas, territorial development strategies are more effective and efficient if decided and implemented at local level by local actors (European Commission, 2006 p. 8). However, the 2011 report of Focus Group 4 on “Better Local development Strategies” established at the 6th LEADER Sub-Committee meeting of 17 May 2011 highlighted a number of weaknesses in relation to performance evaluation of Leader program.

“Evidence regarding evaluation is sparse. What was evident is that there is an enormous variation in (evaluation) approach between LAGs. Only 72% of LAGs actively monitored performance against the delivery of the strategy but over 50% of LAGs either fail to report active monitoring or do so on a very limited basis.

For those who do there is no common or consistent approach applied, there is a very high degree of variation in terms of what is done, who is involved and the frequency of such activity. No formal process of strategy review is mentioned. This appears to reflect the previously identified issues over the lack of monitoring and evaluation plans and there is a need to examine this further.

This overall deficit and lack of consistency is a cause for concern presenting risks of considerable fragmentation in measuring results and outcomes at an important time for demonstrating the benefits of local development approaches. Addressing this performance monitoring deficit therefore appears to be a priority area in planning for the next program period building monitoring and evaluation into the Local Development Strategies.”

This report suggests that a common core of EU indicators could be structured in such a way as to allow them to be further developed at the local level to shed a more acute light on local effects. Local feedback is essential to the process. There is however a need to be able to balance such specificity with the ability to aggregate these indicators at LAG, regional, national and EU levels.
Typically LAGs consider that they were encouraged to undertake self-evaluation although this was not mandatory. However, the 2011 report of Focus Group 4 (ELARD, 2011) finds that: “Guidance on self-evaluation is often absent and some inconsistency evident. This is a significant gap in guidance and support to LAGs, a critical element of developing and delivering quality local development strategies.”

Furthermore, as far as self-evaluation systems of LAGs are concerned, the Synthesis of all member states’ mid-term evaluations of LEADER+ programs (ÖIR, 2006) reports that their evaluations’ procedures are “…not sufficiently harmonized at national level” and are “not adequate to allow meaningful comparison at program/country level” and also that there is “an unstructured approach to evaluation”. It also reports that there is “insufficient guidance or sense of priority from national authorities on evaluation” although the need for evaluation is recognized and included in the work plans.

Concerning external as well as self- evaluations at LAG level, the synthesis reports that ‘Instances of evaluation activities that informed the mid-term evaluation (MTE) process are not evident. While there is general acknowledgement of the need for evaluation and references to planned activities little of significance is available at the MTE stage’ and concludes that: “… the evaluation activities were largely unstructured; there was surprisingly little co-ordination or co-operation between LAGs in the area of evaluation; national networks did not play a prominent role, except in assisting self-evaluations in some areas”

The report recommended that the use by LAGs of a mix of external evaluation and assisted self-evaluation should be designed and introduced in the program and suggested that national or regional networks may help the managing authority in implementing this accompanying device.

The Synthesis of EU Rural Development update of mid-term evaluations (Agra, 2005), reports that in some cases, “delivery system has some negative effects on efficiency”. In some cases, administrative and bureaucratic burdens were reported to have added significant complexity to the program, for instance, with regard to delays in project approval processes. In other cases, excessive bureaucracy was cited as resulting in program inefficiency and was also found to present a barrier to entry, especially in relation to smaller-scale projects.
Concerning the Greek LEADER+, Papadopoulou et al. (2010), support that a large number of administrative and legal procedures (certificates, permissions, contracts, legal documents, experts’ planners’ and engineers’ consulting, etc.), resulted in serious delays and high project cost for the applicants.

Moreover, the ex-post evaluation of LEADER+ (Metis, 2010) recommends that the European Commission “should put more emphasis on local delivery systems which should be in line with efficiency and accountability requirements.”

Finally, the European Court of Auditors noted in its special report in 2010 that “Compared with traditional methods of funding, the LEADER approach involves higher costs and risks, owing to an additional layer of implementation”. It also concluded that although the mid-term evaluations reported on the excessive bureaucracy of the program, they did not properly assess the operational costs. In order to rectify these deficiencies, the report recommended that “member states should require LAGs to account for achieving their local strategy objectives, for achieving added value through the LEADER approach, and for the efficiency of the grant expenditure and the operating costs”.

5.4 Concluding Remarks

Clearly, the requirement for a proper evaluation scheme addressing delivery efficiency from a bottom-up approach along with its complex/multiple objective character makes LEADER an ideal candidate for empirically assessing our proposed performance measurement framework. A DEA-based framework can be used for a multi-criteria appraisal of LEADER delivery. Since DEA, by construction, can judge the trade-offs between programs’ interventions, it will be used as an operational tool in order to accommodate the perspectives of different priorities, stakeholders and areas.
6. MID-TERM PROGRAM PERFORMANCE EVALUATION

6.1 Introduction
In this chapter we discuss the methodological issues for the evaluation of a program when the focus is on its implementation and we demonstrate the framework in the case of Greek Leader rural development program. The three main phases in carrying out an efficiency study by means of DEA are the following: (i) Definition and selection of DMUs to enter the analysis. (ii) Determination of input and output factors which are relevant and suitable for assessing the relative efficiency of the selected DMUs. (iii) Application of the DEA models and analysis of outcomes. Each of these phases comprises several steps.

6.2 Program Performance Evaluation Approach
There a growing interest in policy evaluation and Pazienza, Caruso & Vecchione (2015) in agreement with Esposti & Sotte (2013), state two reasons which can explain the increasing interest in policy evaluation. The first is associated with the increasing complexity of policy and the second is referred to the way scientists and researchers have approached this growing complexity with the employment of multiple and heterogeneous evaluation methods and toolboxes to adequately deal with the multiple objectives of policies.

Performance evaluation is a fairly inclusive term that may refer to the routine measurement and comparison of program inputs, outputs, results, or outcomes. Decisions about what to measure reflect two key factors: the intended use of the performance indicators and the value priorities of those stakeholders who choose what to measure. According to Sager et al (2010), how best to define performance measures is a much-debated issue. Recent reforms, intended to promote more accountable and responsive government, have increased public attention to performance analysis and accelerated the
production and use of information on agency performance and public program outcomes (Heinrich, 2008). Data on performance can be used to support a variety of decisions. Perceptions about which decisions will be affected are critical to those charged with selecting performance measures (Newcomer, 1997).

Figure 6.1 shows the intervention logic of a typical program by defining the relations of indicators and objectives typically used in program design and evaluation schemas. The governance system prepares an intervention in response to needs, based on certain overall objectives. Specific objectives are formulated by specifying the overall objectives, and by translating them into activities and measures meeting the needs of rural areas. In the course of implementation, the governance-borne input stimulates local input (local finance, voluntary work etc.). Projects are put in place, constituting the direct output of the intervention. The inputs are financial or administrative resources. Through program activities they produce the outputs and achieve the operational objectives. Results and impacts are related to the program’s specific and overall objectives.

Figure 6.1: Scope of the thesis in terms of program objectives

Typically, evaluation of a public spending program is primarily focused on the impacts of its interventions on target areas/populations, which are elements outside the program. In this context the main elements of evaluation are the long term impacts of the program. This macro approach appears to be more relevant to the performance objectives of policy stakeholders and questions about the efficiency, effectiveness, utility and others, regarding results and impacts are considered. For example, in the context of the EU Structural and Cohesion Funds (SFs) various methods have been used to determine the efficiency of their effects in target regions: Moore and Rhodes (1973) in their work proposed a model which determines the accumulative effects of SFs in the UK; Bourguignon et al. (1992) used the CGE model in order to analyze Greek regions; the HERMIN econometric model was applied by Bradley (1997) in order to determine the
impact of the SFs; The European Commission (1997) developed an econometric model called QUEST, in order to assess the effects of SFs in regions; María-Dolores and García Solanes (2001) used convergence and selectivity models in order to find the impact of SFs on Spanish regions; Beutel (2002) applied input–output analysis using matrices developed by EUROSTAT (2006); Treyz and Treyz (2003) used the REMI model for assessing the total socio-economic effects of SFs in Italy; Quindós et al. (2003) evaluated the technical efficiency of the SFs in R&D area; Delgado and Álvarez (2005) determined the efficiency of the SFs in R&D area; Beutel (2002) applied input–output analysis using matrices developed by EUROSTAT (2006); Treyz and Treyz (2003) used the REMI model for assessing the total socio-economic effects of SFs in Italy; Quindós et al. (2003) evaluated the technical efficiency of the SFs in R&D area; Delgado and Álvarez (2005) determined the technical efficiency in EU countries by application of DEA, and the trans-logarithmic production function, a Stochastic frontier model; Kutan and Yigit (2007) used DEA to determine the impact of the structural funds on convergence and growth of productivity in less developed European countries; Dall’erba and Le Gallo (2007) determined the impact of structural funds on the convergence progress between European regions applying econometric methods; Espostí and Bussoletti (2008) investigate the impact of the structural funds using panel data econometric models; Lima and Cardenete (2008) analyse the impact of the ERDF in the regions of the South of Spain applying the Applied General Equilibrium Model (AGEM); Gómez-García et al. (2012) estimated the efficiency of SFs’ by applying a stochastic frontier analysis and DEA over 46 European regions.

The assessment of impacts of a given policy intervention is important for the following reasons (Lukesch, R., & Schuh, B., 2010):

- It provides empirical evidence on whether a specific policy worked or did not work. It also provides information about the sustainability of effects of a given policy intervention;

- By comparing results of a policy intervention with target values it provides information on effectiveness of a given policy intervention and achievability of more general societal goals (e.g. concerning growth or development) using this specific policy instrument;

- It helps to re-design a policy intervention (programme) to make it more effective and efficient (by taking into consideration its intervention costs);

- It provides arguments for continuation or discontinuation of policies/programmes by comparing social benefits with costs of specific policy interventions;
• It helps to learn about functioning of economic, social and environmental processes;
• It improves institutional capacities of organisations involved in impact evaluations;
• It improves decision making at all levels;
• It provides some information regarding accountability of institutions involved in formulation and implementation of policies.

In the field of rural development, the EU common monitoring and evaluation framework (CMEF) (EC DG Agri, 2007a) foresees seven common impact indicators relating to growth, jobs, productivity, biodiversity, high nature value areas, water and climate change which reflect explicitly objectives established by the European Council and the Strategic Guidelines for rural development. The impact of the programme as a whole should be assessed against these seven indicators to take into account the full contribution of all axes of the programme (Lukesch, R., & Schuh, B., 2010).

However, when the focus is on program implementation i.e. within the program, a micro approach might be more appropriate in order to collect evaluation data, as more tactical objectives with operational nature are relevant. To become more specific, we argue that while outputs are realized in the short term, their outcomes are long-lasting. Furthermore, results are often related to the use of outputs by target beneficiaries and are therefore not under full control of a program manager. Moreover outputs may fail to produce concrete results in the presence of adverse circumstances outside managerial control. Moreover, results are in some cases the aggregate effect of more than one type of outputs, even though these outputs are produced from different programs. Finally, the results may be strongly influenced by the specificities of the target area and impacts may be predominantly influenced by local effect chains and a lot of other factors from inside and outside the area. Hence, when the focus is on program execution, the outputs, rather than the associated results or impacts must be the focus of program performance evaluation, since outputs are what the program operators are fully responsible for. In this context, operational effectiveness and operational efficiency should play a major role in program performance evaluation.
Based on this discussion we argue that measuring program performance based on program effects is inappropriate for an interim program performance assessment whose primary purpose is to provide information quickly so that managers may perform the required adjustments in program implementation. Hence, although evaluation in terms of impacts is important, when the evaluation objective is to identify and resolve implementation problems and the information gained is for the support of internal management, the outputs, rather than the associated results or impacts must be the focus of the performance evaluation scheme. As argued by Behn (2003) “organizations don’t produce outcomes; organizations produce outputs”.

For this purpose, the absorption rate (i.e. budgetary funds mobilized in proportion to the funds initially allocated), is traditionally used as a standard measure in spending programs’ performance assessment both in formal evaluations and in related academic research. Absorption, in aggregated or disaggregated form, is monitored on an ongoing basis and can be considered as a control and incentive measure, focused on the delivery volume at program, intervention, local, regional or country level. However absorption measurement has limitations when it is used as the sole performance assessment method. As pointed out by Sherman and Zhu (2006), the use of single measures of performance ignores any interactions, substitutions or trade-offs among inputs and outputs. Smith and Street (2005) argue that there are two major drawbacks to using individual performance indicators. Firstly, they provide only an indirect or partial indication of efficiency. Secondly, they may provide conflicting messages: an organization that appears to do well on one indicator may perform less successfully when considered on another. It is therefore not straightforward to draw conclusions about overall organizational performance from a range of single performance indicators. Indeed, comparisons among implementation bodies or regions, as typically carried out on the basis of aggregated absorption rates, are often being criticized and are not always acceptable by program managers. This is because aggregation implies equal weighting of interventions even though their implementation demands different effort and specifications. On the other hand, interpreting and comparing disaggregated absorption rates simultaneously is not easily achievable as they usually generate contradictory rankings and additionally they are too many to be taken into account simultaneously. More importantly, absorption does not indicate whether the resources used to provide administrative services are being managed efficiently.
Hence, it may be argued that in the evaluation of public spending programs, it is necessary to address their productivity in terms of the resources consumed and services provided by implementation mechanisms. In turn, this requires the availability of a suitable method for the measurement of operational efficiency, since improvements in efficiency constitute a fundamental method of improving productivity. This thesis focuses on the introduction and application of such a method.

6.3 Conceptualizing the Program Implementation Phase

Depending on a program’s arrangements, implementation units (IU) are in general responsible to a different extent for program implementation services such as project generation, appraisal and selection, project progress and control procedures. In order to study the productivity and the technical efficiency of implementation units, program administration can be regarded as an economic production process. Under this approach an IU may be thought of as an entity transforming input resources to comparable administrative services related to the delivery of program outputs. Model inputs should reflect the non-project resources used such as labor and capital and outputs should capture the delivery services provided by the implementation body in the generation of program outputs. In many cases, non-discretionary variables beyond management control, such as the local socioeconomic environment may also influence implementation performance and should also be taken into account in the evaluation activity.

Most socio economic programs adopt integrated and complicated strategies and consisting of multiple sets of interventions funding physical infrastructure, economic infrastructure, business development, human resources, technological development and innovation, environmental improvement, tourism and community development. Such programs build the economic infrastructure, improve the business climate or influence the business development process itself etc. (Blair, 2000). Moreover, the volume and mix of interventions may vary across local areas in order to address effectively the area-specific needs and problems. Hence, any attempts to quantify the local delivery services of a complex program must take into account both its strategy-wide content and also its variability across local circumstances.

In this sense, administrative services may be grouped in categories according to the intervention fields they supported since different types of interventions present different
complexity and require different administrative effort. Moreover, as the program outputs are the immediate result of administrative processes and activities, the quantification of intangible delivery services may be approximated through them.

Having sketched the framework of a spending program delivery system, the next step is to specify the method for measuring the administrative efficiency of implementation units in consuming resource inputs to transfer program outputs during its delivery.

6.4 Efficiency Measurement Approach

As we have already showed, DEA models have two important variations based on the orientation of the applied optimization. An input-oriented model primarily focuses on input reduction while an output-oriented approach primarily focuses on output expansion. Overall, the primary objective of implementation units involved in the delivery of public spending programs is not to reduce the administrative costs while maintaining constant delivery production, but to maximize implementation volume and speed through the efficient utilization of input resources available. Consequently, our analysis is concentrated on a DEA output oriented approach.

This section proceeds in three steps: 1) employs a Charnes, Cooper, and Rhodes (1978) (CCR) model under the constant return to scale (CRS) assumption to calculate measures of overall technical efficiency; 2) employs a Banker, Charnes, and Cooper (1984) (BCC) model under the variable return to scale (VRS) assumption to calculate measures of local pure technical efficiency; and 3) compares CRS and VRS efficiency scores of an implementation unit to check for scale efficiencies. Each stage in the DEA methodology was used to assess resource utilization for program implementation units.
6.5 Basic DEA Empirical Model

The mathematical formulation of basic DEA model applied in this thesis is presented here. In general, assume that \( n \) implementation units (IU) must be evaluated. Each IU consumes varying amounts of \( m \) similar inputs to provide the same set of \( r \) program delivery services in varying amounts. Let \( x_{ij} \) be the amount of input \( i \) consumed by IU \( j \) and \( y_{ij} \) the volume of service \( r \) provided by IU \( j \). It is assumed that these inputs \( x_{ij} \) and services \( y_{ij} \) are nonnegative, and that each IU \( j \) has at least one positive input and service value. Under constant returns-to-scale (CRS), the output-oriented overall or delivery efficiency (OE) of IU \( j_0 \) is given by the following CCR envelopment formulation (Charnes, Cooper & Rhodes, 1978, 1981).

\[
\max \varphi + \varepsilon (\sum_{r=1}^{s} s_r^+ + \sum_{i=1}^{m} s_i^+) \\
\text{s.t.} \\
\sum_{j=1}^{n} y_{ij} \lambda_j - s_i^+ = \varphi y_{i0}, \quad r = 1, ..., s \quad (6.1) \\
\sum_{j=1}^{n} x_{ij} \lambda_j + s_i^- = x_{i0}, \quad i = 1, ..., m \\
\lambda_j \geq 0, \quad s_i^+ \geq 0, \quad s_i^- \geq 0, \quad \forall j, r, i
\]

where \( 1.0 \leq \varphi^* \leq \infty \), \( \lambda_j \) are weighting factors of the referenced units for unit \( j \); \( s_i^- \) and \( s_i^+ \) are slack variables representing the input excesses and output shortfalls, respectively; and \( \varepsilon \) a non-Archimedean infinitesimal defined to be smaller than any positive real number. Note that subscript \( '0' \) refers to the unit under evaluation and this linear programming problem must be solved \( n \) times, once for each implementation unit in the sample. If \( \varphi^* = 1.0 \), production is technically efficient; if \( \varphi^* > 1.0 \), production is inefficient and all output levels could be increased by \( \varphi^* - 1.0 \), with input levels held constant. Overall efficiency indicates the maximum feasible radial expansion in all outputs.

The DEA BCC model by Banker, Charnes, & Cooper (1984) incorporates in the CCR model the convexity constraint

\[
\sum_{j=1}^{n} \lambda_j = 1, \quad \lambda_j \geq 0, \quad \forall j \quad (6.2)
\]
The DEA BCC model allows taking into account non-constant returns-to-scale characteristics of the frontier.

In the next section, we illustrate the proposed DEA framework in the case of Greek LEADER+.

6.6 The Unit of Assessment: Local Action Group

The LEADER+ program in Greece was implemented at the national level and delivered through a national operational program. The selection of forty (40) Local Action Groups (LAGs) was carried out following a call for applications. The 40 LEADER+ local programs are being implemented in mountain regions –so characterized in the approved EU list of mountain, disadvantaged, and with special problems areas – and islands, as well as environmentally sensitive areas (e.g. NATURA 2000). It was approved by EU on 19 November 2001 with a budget, after the 2004 indexation, of EUR 368.7 million, of which EUR186.13 million is the EAGGF Guidance Section contribution.

The LEADER+ program is structured on three levels:

- the overall program level which consists of priority axes (2 axes)
- the measure level corresponding to the basic unit of program management (5 measures)
- the intervention level with specific management needs (9 interventions)

Each axis is divided into measures and each measure is further divided into specific interventions as shown in Figure 6.2.

In 2002, the management authority (MA: Ministry of Rural Development and Food acts as the managing authority) of the program selected 40 Local Action Groups (LAGs) in an open process, based mainly on assessments of the integrative and innovative character of their proposed development strategy.
Figure 6.2: The Structure of Greek Leader+

where the various program development interventions are described as follows:

- **RUR**: facilitating development of rural tourism and recreational capacity
- **SMEs**: facilitating development of small entrepreneurship
- **TECH**: innovation systems of technology and know-how
- **HS**: human resources support
- **NENV**: sustainable natural resource management
- **HENV**: protection and enhancement of local historic environment
- **CULTL**: cultural activities
- **LCOOP**: co-operation between rural territories within Greece
- **COOP**: co-operation between Greece and other member states

Public funds, with minor adjustments due to budget constraints, were allocated to these LAGs in accordance to their development priorities as stated in their proposed plans. Project applications for funding ended on 31 December 2006, although approved projects were allowed to be carried out until the end of 2008. Note that among 40 initially selected LAGs, one did not manage to start operating. Consequently, this LAG was excluded from our analysis. Their activity areas cover almost the entire rural territory of Greece, as shown in Figure 6.3.
According to Leader+ Observatory Contact Point / May 2007 the total area covered by LAGs is 82,668 km², which represents 63% of the whole territory; the population of the LAGs area is 2,212,549, which represents 20% of the whole national population and the average LAG area population density: 25.6 inhabitants/km²

According to its local development plan, each LAG had to implement a mix of rural development interventions in order to fund projects in areas of rural tourism and recreational capacity (RUR), small entrepreneurship (SMES), technological development (TECH), human resources support (HS), sustainable natural resource management (NEV), protection and enhancement of local historic environment (HENV), cultural activities (CULTL) and cooperation between rural territories within Greece (LCOOP) and between Greece and other member states (COOP).

**Figure 6.3: LAGs activity areas**

Source: Greek Leader+ National Network Unit

According to contract agreement, each LAG sets the overall strategy for the local Leader project and is responsible for overseeing the implementation of the local development strategy. The LAG has regular paid staff to take care of the activation, application procedures, public relations, information policy, subsidy payments and secretarial work.
Calls for proposals and the actual selection of projects are carried out at local level, by the LAG, ensuring coherence between the eligibility conditions and the objectives of the strategy. Particular project applications are submitted to the LAG which checks that they comply with local development plans and then makes the selection. The selected projects receive a share of public funding that can vary between 30%-100% depending on the significance of the project. Advising, monitoring and controlling of the projects remain the work of the LAG. In summary, the main responsibilities of each LAG include:

- Controlling relevant on-the-spot checks of funded projects
- Retention of all project documentation with a clear audit trail through to bank statements
- Animation of the LAG area
- Monitoring the progress of projects and collection of indicator information.
- Monitoring progress towards LAG targets and strategy.
- Preparation of regular reports on expenditure and monitoring for the Greek Government.

The funds allocated to each LAG for the remainder of the implementation period (2003-2008), broken down by area of intervention are presented in Figure 6.4. In this figure the funds for program administration (ADMIN) are also presented.

The local budgets range from 3 million Euros to just under 7 million Euros and essentially constitute long term targets for fund absorption during the whole implementation period. On average, 20% of the total budget was devoted to the management of the LAG in order to administrate the program (ADMIN).

Focusing at intervention level, on average, the largest share of the output budget is allocated for funding projects in the areas of rural tourism, entrepreneurship and historic environment with shares around 34%, 27% and 14% respectively. Relatively smaller shares were allocated to “softer” or innovative interventions, such as technology (4%), human resources (6%), cooperation (5%) and environment management (7%).
The analysis of its structure clearly implies that Leader+ is an integrated, multi-sectoral multi objective program involving multiple localities. Hence, any attempt to evaluate its delivery must take into account the complexity arising from the nature of the policies being evaluated. Although Structural and Cohesion programs are implemented under a common regulatory framework, they reflect widely differing national and regional circumstances with varied institutional arrangements for managing and delivering regional development policies. Programs comprise a range of interventions targeting physical infrastructure, economic infrastructure, business development, human resources, research, technological development and innovation, environmental improvement, tourism and community development through a mix of financial instruments and many different types of beneficiaries.

6.7 Selection of DEA Input and Outputs
The variables used for the mid-termed (MT) DEA analysis, along with the aggregated output and the components of the input variable are given in Table 6.1. Only one input was specified, namely the total cost of administration (ADMIN) in 1,000 €, which consists of the management costs (Mgmt) plus the capital equipment costs (Equip). Since
these components are not substitutable, we chose not to use them separately. The management costs were provided in aggregated form including staff, office-running and travel assistance costs. Each LAG had a discrete project team, which ran the local program.

On the output side, the production in LEADER programs is highly heterogeneous with an array of 70 different eligible field codes, describing the funded projects at EU level. Typically in DEA efficiency analysis, variables are specified using output measured in quantities. In our case, the aggregate number of projects financed by the Greek LEADER program in the reference period (2003-05) was 1,885 in total. These projects had to be classified into the nine broad areas of interventions mentioned earlier. Although this categorization may help to sharpen the differences between interventions, it cannot reduce drastically the heterogeneity of project types within each one of the nine interventions. For example, within the intervention entitled ‘support for SMEs’, various funded projects are included, related to physical capital (plant and equipment) as well as intangible business advisory services (information, business planning, consultancy services, marketing, management, design etc.).

Moreover, during program implementation, the monitoring system records the actual number of projects started, independently of the degree of their completeness. With these data constraints, the aggregated number of projects within each intervention area was not judged as adequate for capturing the volume of outputs. Since outputs (and inputs) can be perceived as flows occurring between points in time, the value of outputs, i.e. actual certified payments for projects, aggregated by intervention area, was used as a proxy of their volume. This value-based approach (using monetary values to approximate the volume of outputs) has been used frequently by researchers (see Zelenyuk & Zheka (2006) for a recent example). It is coherent with the main mission of implementing bodies, namely transferring public funds from the European Union and the Greek government to the final beneficiaries. Additionally, this approach allows us to directly contrast absorption and efficiency indicators.

Under this approach the DEA estimated delivery efficiency has a broader sense than the basic technical meaning of Farrell’s efficiency. In particular, it is in accordance with Liebenstein’s concept of x-efficiency (1966) and indeed it captures the overall ability of LAGs in mobilizing funds given their administration costs.
Table 6.1: Summary statistics for the input and output DEA variables (2005)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean (%)</th>
<th>St Dev</th>
<th>Min</th>
<th>Max</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADMIN (I)</td>
<td>619.84 (100.00)</td>
<td>136.61</td>
<td>368.24</td>
<td>966.11</td>
<td>24173.75</td>
</tr>
<tr>
<td>Mgmt.</td>
<td>596.07 (96.17)</td>
<td>131.91</td>
<td>363.58</td>
<td>966.11</td>
<td>23246.85</td>
</tr>
<tr>
<td>Equip</td>
<td>23.77 (3.83)</td>
<td>18.07</td>
<td>0</td>
<td>60.80</td>
<td>926.91</td>
</tr>
<tr>
<td>Aggregated Output</td>
<td>1317.42 (100.00)</td>
<td>689.04</td>
<td>205.56</td>
<td>3409.05</td>
<td>51379.20</td>
</tr>
<tr>
<td>RUR (O)</td>
<td>542.64 (41.19)</td>
<td>367.30</td>
<td>0</td>
<td>1714.26</td>
<td>21163.08</td>
</tr>
<tr>
<td>SMES (O)</td>
<td>619.29 (47.01)</td>
<td>463.19</td>
<td>31.48</td>
<td>2057.06</td>
<td>24152.37</td>
</tr>
<tr>
<td>TECH (O)</td>
<td>6.56 (0.50)</td>
<td>14.25</td>
<td>0</td>
<td>70.73</td>
<td>255.82</td>
</tr>
<tr>
<td>HS (O)</td>
<td>54.97 (4.17)</td>
<td>36.74</td>
<td>6.65</td>
<td>207.51</td>
<td>2143.82</td>
</tr>
<tr>
<td>NENV (O)</td>
<td>22.42 (1.70)</td>
<td>68.09</td>
<td>0</td>
<td>390.84</td>
<td>874.56</td>
</tr>
<tr>
<td>HENV (O)</td>
<td>42.82 (3.25)</td>
<td>83.68</td>
<td>0</td>
<td>350.11</td>
<td>1669.88</td>
</tr>
<tr>
<td>CULT (O)</td>
<td>27.96 (2.12)</td>
<td>58.66</td>
<td>0</td>
<td>337.29</td>
<td>1090.60</td>
</tr>
<tr>
<td>COOP (O)</td>
<td>0.75 (0.06)</td>
<td>2.04</td>
<td>0</td>
<td>9.77</td>
<td>29.08</td>
</tr>
</tbody>
</table>

Note: I / O = Input / Output DEA variable. All variables in monetary value (x 1000€).

The data in Table 6.1 clearly indicate that, at intervention level, almost all outputs display a wide range of values and high values of standard deviation between LAGs. Such high variations may imply that there are wide differences in local delivery priorities. These differences may also be a sign of weak administrative operations and hence a great potential for productivity improvements.

6.8 Data Sources

Financing of the programs is based on a system of budgetary commitments and payments. The commitments actually represent a “financial contract” between the Commission and the Member State, for the allocation of European funds to the programs. At this stage, there is therefore no “physical movement” of funds. The commitments are paid in annual instalments, and the first instalment is made when the Commission approves the
assistance. Subsequent instalments are committed, at the latest, on 30 April of each year. The beneficiaries of assistance receive no funds directly from the Commission. They deal with a Paying Authority designated by the Member State. A three-tier system is therefore established, between the Commission, the paying authority and the beneficiaries. After a program is adopted, the Commission makes a payment on account, of up to 7% of the total contribution from the Funds, to the paying authority. Subsequent payments are made in the form of a reimbursement of actual certified expenditure (European Commission, 2011). In principle, the paying authority sends statements of expenditure to the Commission in batches, three times a year. The Commission makes the corresponding payments within two months of the request being received.

Information on local budgets is based on administrative data published by the Greek Ministry of Rural Development and Foods. Input and output data are based on actual monitoring data in an elementary form provided by the managing authority of LEADER. These data concern the mid-term of program implementation (2005) and a year after that point (2006). The financial data concerning outputs are aggregated at intervention level. More specifically, the expenditure of each intervention is calculated as the simple sum of the activity payments comprising that intervention. The same data were used as inputs for the official mid-term evaluation study of the program. Note that local cooperation (LCOOP) was excluded from Mid Term performance analysis since no relevant project had been implemented in any of the local programs at the mid-term of program implementation (year 2005).
7. MID-TERM EMPIRICAL RESULTS AND ANALYSIS

7.1 Introduction
In order to be comparable and compatible with official midterm program evaluation (MTE), DEA analysis in this chapter is based on 2005 monitoring data. First we conduct the typical program absorption analysis. Then follows the presentation of the empirical results achieved using output oriented DEA models for performance assessment of LEADER delivery and the outline of their potential policy and managerial implications. Finally, we apply preliminary tests in order to examine two critical factors, operational size and regional environmental context, that influence the success of program implementation. These factors are further examined in a second stage regression analysis in a following chapter.

7.2 Mid-Term Absorption Analysis
Due to the wide character of LEADER program – multiple development interventions (outputs), simultaneously comparative absorption analysis by LAG and intervention is difficult if not possible (See Figure 7.1 and Appendix). At this point, it is worth noticing that DEA approach can resolve this difficulty in fair manner as it can incorporate multiple input and outputs into the performance analysis.

In terms of the progress of the program delivery until the chronological reference point of this evaluation (October 2005), the following remarks can be made individually at LAG level or intervention lever as well as for entire national program.

- The average of absorption of program administration (ADMIN) is approximately 57 % and significantly exceeds the average of absorption of program aggregated Output (AggregOutput) (29.5 %). This creates a risk of premature exhaustion of program administration funds with all the adverse consequences that would have for the LAGs’ tasks till the end of the programming period. It is observed that
although the absorption of administration allocations for ZAKYNTHOS and KEFALONIA is 63 % and 45 %, the absorption of their program Aggregated Output is only 5.0 % and 9.6 %, respectively.

- HERAKLION, ANVOPE, DRAMA, ANKO and THESSALONIKI are the top program performers with absorption of their Aggregated Output 62.6 %, 55.5 %, 53.3 %, 51.2 % and 50.0 %, respectively.

- As far as the entire national program is concerned, the best development interventions with respect to the program average, are entrepreneurship (SMES) and rural tourism (RURT). Their absorption are 49.37 % and 35.30 %, respectively.

- Middle program interventions, from best to worst, based on their absorption compared with the program average are Culture activities (CULT) and human resources support (HS). Their absorption are 26.46 % and 22.33 %, respectively.

- The absorption for certain development interventions is extremely low compared with the program average. The weakest are cooperation activities (COOP), technological activities (TECH), historic environment (HENV) and conservation of nature (NENV). Their absorption are 0.00 %, 3.46 %, 7.08 % and 8.84 %, respectively. Midterm official evaluation of LEADER program suggests that Managing Authority LEADER+ will need to re-examine possible re-allocation of funds between Priority Axes or measures. This is in accordance with our results.

With respect to the effectiveness of the program, in terms of achieving the initial LAG and program targets, a basic conclusion is that these targets are, in certain cases, over-estimated, given that they were quantified before the introduction of the local programs. From our results it appears that some of the initial LEADER targets will not be achieved at 100% while others may be exceeded. According to official midterm program evaluation, lower achievement in certain categories of program interventions is due to the relative shortfall of certain local programs - their procedures associated with the inclusion and implementation of individual projects (publication of calls, evaluation, approval, signing of contracts between Local Action Groups and investors).
Moreover, according to midterm official program evaluation, the existence of alternative finance options from other Operational programs in the 3rd CSF, governed by procedures with fewer conditions and requirements for a potential investor, compared with the Leader+ (e.g. with respect to job creation, compliance with certain specifications and inclusion in cluster), as well as the required level of investment (which for modernization investments is lower than for start-up investments and often means that the investor has to implement the investment with their own resources alone), are factors which explain why some LEADER investments are less attractive than investments of other programs.
As for the training actions in human resources (HS) program intervention, the delivery delay is partly due to the reluctance of private individuals to make the payment required for participation in the intervention, and partly to the fact that the thematic areas of training in the context of LEADER+ (e.g. in aspects of rural tourism) are already covered by the training programs being implemented by other agencies in other Operational programs (midterm official evaluation). For example, other Integrated Rural Development programs as LEADER support the development of human resources. Given the above, official midterm evaluation of LEADER program regards that the relevant intervention absorption indicators are not feasible.

Historic environment (HENV) and conservation of nature (NENV) interventions, despite the low level of physical implementation they display, midterm official program evaluation, estimates that their program targets can be achieved in all the individual categories of operation (with targets actually being exceeded in certain categories), with the exception of the category involving the creation / upgrading of museums and cultural centres. The problems are due both to the nature of the projects included and the relatively time-consuming procedures for their technical maturity. They mainly involve small public works projects being implemented by local authorities or other collective agencies where the local authority technical services (where these exist) experience significant difficulty in preparing studies and tender documents. Moreover, additional delays might also be caused due to the recent change in the statutory framework for commissioning studies and constructing public works projects (midterm official evaluation report).

According to midterm official evaluation report, there remains a clear danger of failure to meet the targets in interventions concerning both local and transnational cooperation among rural regions as these interventions show significant shortfall, since the emphasis of the LAGs was laid on implementing ‘pure’ development interventions of Axis 1, while there has been no previous experience in LAGS in implementing cooperation projects in the context of Axis 2.

7.3 Mid-Term DEA Analysis
The output oriented CCR and BCC DEA models were applied in the case of the 39 LAGs implementing local LEADER programs across Greece at the mid-term of its implementation. All DEA models of this study as well as the DEA-related diagrams of
introductory sections were solved using the R package Benchmarking (Bogetoft and Otto, 2012). The basic analysis is following.

The technical and scale output efficiency estimators and their calculated returns to scale status, as well as the absorption rates of their management expenditures (Mgmt.) and aggregated output (AggOutput) are listed by LAG in Table 7.1.

**Table 7.1: Absorption and DEA results by LAG**

<table>
<thead>
<tr>
<th>Local Action Group</th>
<th>Absorption of Mgmt.</th>
<th>Absorption of Aggregated Output</th>
<th>Rank (Absorption)</th>
<th>Overall efficiency (CCR)</th>
<th>Rank (CCR)</th>
<th>Technical efficiency (BCC)</th>
<th>Scale efficiency</th>
<th>RTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACHAIA</td>
<td>0.527</td>
<td>0.154</td>
<td>36</td>
<td>0.680</td>
<td>21</td>
<td>0.934</td>
<td>0.728</td>
<td>IRS</td>
</tr>
<tr>
<td>AITOLIKI</td>
<td>0.453</td>
<td>0.149</td>
<td>37</td>
<td>0.571</td>
<td>29</td>
<td>0.770</td>
<td>0.742</td>
<td>IRS</td>
</tr>
<tr>
<td>AKOMM</td>
<td>0.646</td>
<td>0.371</td>
<td>8</td>
<td>0.852</td>
<td>13</td>
<td>0.874</td>
<td>0.975</td>
<td>IRS</td>
</tr>
<tr>
<td>ANKO</td>
<td>0.614</td>
<td>0.513</td>
<td>4</td>
<td>1.000</td>
<td>1</td>
<td>1.000</td>
<td>1.000</td>
<td>CRS</td>
</tr>
<tr>
<td>ANVOPE</td>
<td>0.507</td>
<td>0.556</td>
<td>2</td>
<td>1.000</td>
<td>1</td>
<td>1.000</td>
<td>1.000</td>
<td>CRS</td>
</tr>
<tr>
<td>CHALKIDIKI</td>
<td>0.608</td>
<td>0.247</td>
<td>25</td>
<td>0.965</td>
<td>10</td>
<td>1.000</td>
<td>0.965</td>
<td>DRS</td>
</tr>
<tr>
<td>DODEKANISSA</td>
<td>0.545</td>
<td>0.327</td>
<td>12</td>
<td>1.000</td>
<td>1</td>
<td>1.000</td>
<td>1.000</td>
<td>CRS</td>
</tr>
<tr>
<td>DRAMA</td>
<td>0.694</td>
<td>0.525</td>
<td>3</td>
<td>0.840</td>
<td>15</td>
<td>0.880</td>
<td>0.955</td>
<td>DRS</td>
</tr>
<tr>
<td>EVROS</td>
<td>0.804</td>
<td>0.306</td>
<td>13</td>
<td>0.500</td>
<td>36</td>
<td>0.504</td>
<td>0.994</td>
<td>DRS</td>
</tr>
<tr>
<td>ELASSONA</td>
<td>0.603</td>
<td>0.206</td>
<td>31</td>
<td>0.510</td>
<td>34</td>
<td>0.586</td>
<td>0.871</td>
<td>IRS</td>
</tr>
<tr>
<td>ELIKONAS</td>
<td>0.579</td>
<td>0.226</td>
<td>30</td>
<td>0.469</td>
<td>38</td>
<td>0.496</td>
<td>0.945</td>
<td>IRS</td>
</tr>
<tr>
<td>ETANAM</td>
<td>0.652</td>
<td>0.291</td>
<td>15</td>
<td>0.571</td>
<td>30</td>
<td>0.760</td>
<td>0.751</td>
<td>DRS</td>
</tr>
<tr>
<td>FLORINA</td>
<td>0.707</td>
<td>0.196</td>
<td>33</td>
<td>0.661</td>
<td>22</td>
<td>0.699</td>
<td>0.946</td>
<td>IRS</td>
</tr>
<tr>
<td>FOKIKI</td>
<td>0.502</td>
<td>0.266</td>
<td>22</td>
<td>0.606</td>
<td>27</td>
<td>1.000</td>
<td>0.606</td>
<td>IRS</td>
</tr>
<tr>
<td>IMATHIA</td>
<td>0.544</td>
<td>0.258</td>
<td>24</td>
<td>0.535</td>
<td>32</td>
<td>0.584</td>
<td>0.917</td>
<td>IRS</td>
</tr>
<tr>
<td>EPIRUS</td>
<td>0.472</td>
<td>0.287</td>
<td>18</td>
<td>0.849</td>
<td>14</td>
<td>0.890</td>
<td>0.955</td>
<td>IRS</td>
</tr>
<tr>
<td>HERAKLION</td>
<td>0.657</td>
<td>0.625</td>
<td>1</td>
<td>1.000</td>
<td>1</td>
<td>1.000</td>
<td>1.000</td>
<td>CRS</td>
</tr>
<tr>
<td>KARDITSA</td>
<td>0.648</td>
<td>0.286</td>
<td>19</td>
<td>0.531</td>
<td>33</td>
<td>0.662</td>
<td>0.801</td>
<td>DRS</td>
</tr>
</tbody>
</table>
## Mid-Term Empirical Results and Analysis

In Table 7.1, we present the aggregated data for each region in terms of management absorption, output absorption, and the CCR and absorption ranks. The data shows the average accumulated LEADER payments to projects.

### Table 7.1: LEADER Payments to Projects

<table>
<thead>
<tr>
<th>Region</th>
<th>Management Absorption</th>
<th>Output Absorption</th>
<th>CCR Rank</th>
<th>Absorption Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>ANKAS</td>
<td>0.481</td>
<td>0.154</td>
<td>35</td>
<td>0.383</td>
</tr>
<tr>
<td>KAVALA</td>
<td>0.644</td>
<td>0.244</td>
<td>26</td>
<td>0.509</td>
</tr>
<tr>
<td>KEFALONIA</td>
<td>0.484</td>
<td>0.053</td>
<td>39</td>
<td>0.490</td>
</tr>
<tr>
<td>KENAKAP</td>
<td>0.692</td>
<td>0.297</td>
<td>14</td>
<td>0.647</td>
</tr>
<tr>
<td>KERKIRA</td>
<td>0.743</td>
<td>0.178</td>
<td>34</td>
<td>0.625</td>
</tr>
<tr>
<td>KILKIS</td>
<td>0.648</td>
<td>0.471</td>
<td>6</td>
<td>0.827</td>
</tr>
<tr>
<td>LASSITHI</td>
<td>0.424</td>
<td>0.381</td>
<td>7</td>
<td>1.000</td>
</tr>
<tr>
<td>ETAL</td>
<td>0.473</td>
<td>0.233</td>
<td>29</td>
<td>0.758</td>
</tr>
<tr>
<td>LIMNOS</td>
<td>0.539</td>
<td>0.347</td>
<td>9</td>
<td>0.917</td>
</tr>
<tr>
<td>OADYK</td>
<td>0.500</td>
<td>0.288</td>
<td>17</td>
<td>0.636</td>
</tr>
<tr>
<td>OLIANIA</td>
<td>0.509</td>
<td>0.239</td>
<td>28</td>
<td>0.601</td>
</tr>
<tr>
<td>PARNONAS</td>
<td>0.600</td>
<td>0.284</td>
<td>20</td>
<td>1.000</td>
</tr>
<tr>
<td>PELLAS</td>
<td>0.536</td>
<td>0.340</td>
<td>11</td>
<td>1.000</td>
</tr>
<tr>
<td>PIERIKI</td>
<td>0.525</td>
<td>0.273</td>
<td>21</td>
<td>1.000</td>
</tr>
<tr>
<td>PILIO</td>
<td>0.576</td>
<td>0.260</td>
<td>23</td>
<td>0.724</td>
</tr>
<tr>
<td>RODOPI</td>
<td>0.814</td>
<td>0.347</td>
<td>10</td>
<td>0.632</td>
</tr>
<tr>
<td>SERRES</td>
<td>0.504</td>
<td>0.289</td>
<td>16</td>
<td>0.696</td>
</tr>
<tr>
<td>TESSALONIKI</td>
<td>0.626</td>
<td>0.501</td>
<td>5</td>
<td>1.000</td>
</tr>
<tr>
<td>TRICHONIDA</td>
<td>0.563</td>
<td>0.200</td>
<td>32</td>
<td>0.563</td>
</tr>
<tr>
<td>XANTHI</td>
<td>0.454</td>
<td>0.242</td>
<td>27</td>
<td>0.877</td>
</tr>
<tr>
<td>ZAKYNTHOS</td>
<td>0.642</td>
<td>0.094</td>
<td>38</td>
<td>0.710</td>
</tr>
</tbody>
</table>

**Average**

<table>
<thead>
<tr>
<th>Management Absorption</th>
<th>Output Absorption</th>
<th>Absorption</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.583</td>
<td>0.685</td>
<td>0.783</td>
</tr>
</tbody>
</table>

**Notes:**
- CRS / IRS / DRS: constant / increasing / decreasing returns to scale.

As far as the absorption (of aggregated output) is concerned, the data in Table 7.1 indicate that at the moment of evaluation, the average accumulated LEADER payments to projects...
since the beginning of the programming period account for 29.5% of the total budget, while DEA results show that the average overall efficiency score is 68.5% and that only 9 out of 39 LAGs are overall efficient (CCR score = 1). This indicates that there is scope for efficiency improvements in 30 LAGs. Note that the relatively large absorption of funds dedicated for management purposes (average value equal to 58.3%) is due to the fact that in LEADER programs the initial period is devoted to the preparation of the local strategy as well as the empowerment and promotion of the program to the local population.

Moreover, the listed indices suggest the existence of quite large differences both in terms of the absorption and the overall efficiency of implementation. Absorption ranges from 5.3% to 55.6% while overall efficiency ranges from 38.1% to 100%. In addition, a closer examination of the results reveals some apparent contradictions. For example, the middle-ranked LAGs by absorption, namely PARNONAS and PIERIKI, are overall efficient (CCR score = 1) while RODOPI is ranked 10th by absorption and only 25th by CCR efficiency score.

Regarding the returns to scale nature (RTS), the results show that among the 39 LAGs, only 9 (23%) are operating under constant returns to scale (CRS), and therefore with optimal scale size. Considering scale inefficiency, the most significant problem is that more than twice as many LAGs (21 or 53%) are operating under increasing returns to scale (IRS) than the ones operating under decreasing returns to scale (DRS) (9 or 23%).

The classification of RTS of individual LAG is important for management reasons since it gives indication on possible actions to be taken on an inefficient unit to make it more efficient. If an inefficient production pair \((x_i, y_i)\) is located in a region of increasing returns the indication is that \(y_i\) is too small for the unit to be efficient. On the other hand, if it is located in a region of decreasing returns \(x_i\) is too large for the unit to be efficient. See Färe, Grosskopf and Lovell (1994).

Turning back to the efficiency and absorption and having detected some contradictions between the two performance indices, it is important to examine their relationship and the information they provide. Although both performance indicators follow the rule “the more the better”, as far as outputs are concerned, a direct comparison between them reveals their different focus, and hence their contribution in decisions related to the management of program delivery. More specifically, the absorption rate of a LAG is not
a relative but a self-reflective measure of performance, since it measures its achievements in relation to its own initial plan. On the other hand, an efficiency score, by construction, portrays the simultaneous comparisons of the unit with all other units in terms of their output achievements while taking into account their utilized resources.

We calculated the Pearson correlation coefficients between the absorption rate and the three types of efficiency scores (overall, technical and scale efficiency). The correlation coefficients are 0.633, 0.382 and 0.531, respectively, and are statistically significant at the 1% level. The correlation of overall efficiency with absorption is not very high, since absorption shows poor capacity to discriminate between good and bad management, i.e. management that delivers administrative services efficiently or not. Hence, we can conclude that the two performance measures capture different aspects of delivery performance. Additionally, scale efficiency is evidently stronger correlated with the absorption rate than technical efficiency.

7.4 The Absorption - Efficiency matrix

The relationship between absorption of aggregated output and overall efficiency may be better explained through the scatter diagram shown in Figure 7.2. Following the approach by Boussofiane, Dyson, & Thanassoulis (1991), the scatter diagram is divided, into 4 quadrants defined by the average values of absorption of aggregate output (29.5%) and of overall efficiency (68.5%) of the 39 LAGs.

Figure 7.2: Absorption-efficiency matrix of 39 LAGs
In the upper-right quadrant there are eleven out of the thirty nine LAGs that display both high (above average) absorption and overall efficiency. These are AKOMM, ANKO, ANVOPE, DODEKANISSA, DRAMA, HERAKLION, KILKIS, LASSITHI, LIMNOS, PELLAS and THESSALONIKI. In general, this group seems to face neither managerial nor scale problems as its technical and scale efficiencies are high, with averages of 97% for both types of efficiency. At the moment of evaluation, this group comprises the leading LAGs in program implementation. Their pace of implementation could be accelerated only through the adoption of technological advances or/and an increase in management resources, since the given production technology does not allow for more interventions to be implemented using the current levels of administrative capacity.

The three LAGs in the upper-left quadrant, namely RODOPI, EVROS and KENAKAP, display high absorption, but present low overall efficiency. This has to be attributed mainly to managerial problems as indicated by their low technical efficiency (average BCC score equals 67.2%). Thus, their high absorption is probably due to a favorable environment rather than good management. These LAGs have high potential to further increase their implementation speed and hence their absorption rate by increasing their overall efficiency through improved management. It is worth noting that their average scale efficiency score (83.9 %) is also low, although not as low as their average technical efficiency score.

The LAGs in the lower-right quadrant display low absorption, but high productivity with an average technical efficiency score equal to 89.7% and an average scale efficiency score equal to 91.8%. Hence, their low absorption may be attributed to an unfavorable environment rather than poor management. In general, only minor increases in their absorption speed could come from improvements in delivery operations since these LAGs are either on or very close to the efficiency frontier on the operational side and also do not need large scale adjustments. This group consists of nine LAGs, namely EPIRUS, ETAL, HALKIDIKI, PARNONAS, PIERIKI, PILIO, SERRES, XANTHI and ZAKYNTHOS.

Sixteen out of thirty nine LAGs are located in the lower-left quadrant, corresponding to the low performing units that display low absorption and low overall efficiency. These LAGs have great potential for improvement and need to be examined on an individual basis. Their low absorption is related to overall inefficiency, which is due to both
management and scale problems, although technical inefficiency (average BCC score 66.7%) seems to play a relatively more important role than scale problems (average scale efficiency score 79.5%) in most cases within this implementation group. In cases where scale problems are evident through low scale efficiencies, it may be quite helpful to consider the returns to scale at individual level in order to provide directions for improvement, after eliminating the technical inefficiencies. Within this sub-group overall inefficiency, attributed mainly to operational aspects, is displayed by ANKAS, ELIKONA, ELASSONA, KAVALA, IMATHIA, KARDITSA, OLIMPIA and FLORINA, whereas overall inefficiency attributed mainly to scale problems is displayed by FOKIKI, KEFALONIA and ACHAIA. Finally, a combination of inefficient administrative operations and disadvantageous scale characterizes AITOLIKI, ETANAM, KERKIRA, OADYK and TRICHONIDA.

7.4.1 Managerial implications of the absorption-efficiency matrix
A closer examination of the absorption-efficiency matrix provides useful insights that may be utilized by the managing authority in order to run the program more effectively. Indeed, the joint use of DEA results and the absorption rates reveals that there are LAGs that were previously thought to be good performers on the basis of their absorption, which were found to be inefficient. Hence, these LAGs evidently have the potential to further increase their administrative services and hence their absorption rate. Moreover, DEA also reveals that there are LAGs that were overall efficient but demonstrated low absorption rates and, consequently, were thought to be bad performers. Finally, there is a group of LAGs, belonging in the upper-right quadrant, that is the best in both performance indicators and as they could not increase their productivity with current resources, reserve funds might be allocated to these LAGs in order to be utilized in the most productive manner.

Furthermore, the results presented in the efficiency-absorption matrix can be used for benchmarking purposes. Benchmarking is first and foremost a tool for improvement, achieved through the comparison of a unit with other units, recognized as the best within the area (Bhutta, & Huq, 1999).

The efficiency-absorption matrix offers an appropriate tool for this purpose since it combines the two major performance indicators namely absorption and efficiency. More specifically, the eleven local programs in the upper-right quadrant of the absorption-
efficiency matrix, with relatively high ranking in both performance indicators, may be considered as models both for their best performance implementers and their good local investment environment. Further DEA results and discussion regarding benchmarking are presented in section 7.10.

7.5 Specialization versus Innovation of a Local Program

In order to characterize the delivery profile of LAGs according both to their contribution to the integrated and the innovative character of the program and also their contribution to the absorption of the entire program, we calculated the average volume of each output delivered from each quadrant of the absorption-efficiency matrix. The results are presented in Table 7.2.

The Table also shows the average input resources consumed (ADMIN) respectively. In general, this average value denotes the size of the LAGs within the group.

Table 7.2: Average volume of outputs delivered by each quadrant of the efficiency–absorption matrix

<table>
<thead>
<tr>
<th>Absorption of aggregated Output (Size)</th>
<th>Overall efficiency (Size)</th>
<th>ADMIN</th>
<th>RUR</th>
<th>SMES</th>
<th>TECH</th>
<th>HS</th>
<th>NENV</th>
<th>HENV</th>
<th>CULT</th>
<th>COOP</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>High</td>
<td>654.8</td>
<td>787.4</td>
<td>1070.1</td>
<td>10.7</td>
<td>59.8</td>
<td>48.7</td>
<td>89.4</td>
<td>55.5</td>
<td>0.9</td>
</tr>
<tr>
<td>Low</td>
<td>805.8</td>
<td>877.3</td>
<td>442.5</td>
<td>1.8</td>
<td>47.6</td>
<td>5.1</td>
<td>31.6</td>
<td>27.0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Low</td>
<td>High</td>
<td>578.4</td>
<td>479.9</td>
<td>422.0</td>
<td>9.7</td>
<td>66.6</td>
<td>11.42</td>
<td>59.4</td>
<td>18.2</td>
<td>1.4</td>
</tr>
<tr>
<td>Low</td>
<td>584.1</td>
<td>346.8</td>
<td>453.4</td>
<td>2.8</td>
<td>46.4</td>
<td>13.8</td>
<td>3.5</td>
<td>14.6</td>
<td>0.3</td>
<td></td>
</tr>
</tbody>
</table>

Note: High (Low) = above (below) average value. All output variables in monetary value (x 1000€).

The LAGs in the upper-right quadrant of Figure 1 (high absorption and high efficiency) are the second largest in terms of size and, in general, deliver significant volumes in all areas of the program. These LAGs deliver, on average, the biggest or the second biggest volume in all interventions. As a result of their wide output mix, they contribute the most in the integrated and innovative character of the program. Besides, as they are, on
average, the best or second best in the delivered volume of the two traditional big interventions namely rural tourism (RUR) and entrepreneurship (SMES), they contribute the most in the absorption of the entire program.

The LAGs in the upper-left quadrant (high absorption and low efficiency) are the largest ones. These LAGs are concentrating mainly on the delivery of two interventions, namely rural tourism and cultural activities (CULT) while presenting serious weaknesses in the administration of the remaining six outputs. Since they provide a narrow intervention mix, they contribute quite little in the integrated and innovative character of the program. However, as they have the best position in delivery of rural tourism and medium position (3rd) in entrepreneurship, they contribute quite a lot in the absorption of the whole program.

In the lower-right quadrant (low absorption and high efficiency) there are nine LAGs, the smallest with respect to average size, that manage to deliver relatively significant volumes in four small interventions of the whole program (TECH, HS, NENV, COOP). These local programs could be characterized as partially integrated and innovative. Since their focus is concentrated only on small interventions, this group does not have a significant contribution to the absorption of the entire program.

In the lower-left quadrant (low absorption and low efficiency), there exist relatively small LAGs (2nd smallest on average size) that are hardly able to administrate their programs. On average, they have delivered quite significant volumes (2nd in volume rank) only in two out of eight interventions of the program, namely entrepreneurship and protection of nature (NENV). In general, at the time of this study, this group did not have a significant contribution either to absorption or the integrated and innovative character of the entire LEADER program.

In order to estimate the relationships of both performance indicators with the delivery profile of LAGs, we calculated the Spearman’s correlations for absorption and efficiency with the eight outputs as well as the aggregated output (Table 7.3).

<p>| Table 7.3: Spearman’s correlations for absorption and efficiency with output mix |
|---------------------------------|---------|---------|--------|--------|--------|--------|--------|</p>
<table>
<thead>
<tr>
<th>AggOUT</th>
<th>RUR</th>
<th>SMES</th>
<th>TECH</th>
<th>HS</th>
<th>NENV</th>
<th>HENV</th>
<th>CULT</th>
<th>COOP</th>
</tr>
</thead>
<tbody>
<tr>
<td>.948**</td>
<td>.562**</td>
<td>.536**</td>
<td>.369*</td>
<td>.165</td>
<td>.125</td>
<td>.346*</td>
<td>.232</td>
<td>.035</td>
</tr>
</tbody>
</table>
As expected, there is very high correlation between absorption and observed aggregated output and also high correlation between absorption and rural tourism and entrepreneurship - both consist the largest share in aggregated output. On the other hand, absorption seems to be uncorrelated with the remaining six smaller interventions. In contrast, the correlation coefficients between efficiency and aggregated output as well as between efficiency and each individual intervention are much more balanced throughout all interventions. In other words, efficiency is closely related to the bigger interventions, without neglecting the smaller ones. These results are due to the fact that equal weighting of interventions in the construction of the aggregated absorption indicator gives maximum importance to the delivery of bigger interventions. In contrast, DEA, without neglecting the size of interventions, evaluates the implementation bodies by allowing them to give top priority even to small interventions.

Based on the delivery profile of the efficiency-absorption matrix quadrants, we conclude that DEA rewards the implementation of differentiated development strategies and innovation of local programs according to their specific priorities and needs while absorption promotes the specialization of the program. Therefore, DEA can be thought of as a necessary complementary performance evaluation tool, capturing management ability and scale of operations but also the complex mix of tasks and interventions carried out by LAGs.

### 7.6 Preliminary tests for Size Effects in Performance

The Synthesis of mid-term evaluations of LEADER+ programs (ÖIR, 2006) reported that concerns were raised by a number of managing authorities (including Bavaria, Luxembourg, Estonia, some Italian regions, Spain) over the adequacy of available
resources for LAGs. These concerns highlighted high administrative and bureaucratic demands placed on these LAGs with respect to their available levels of staff.

In order to explore the relationship between LAG size and absorption or efficiency, the LAGs were divided into two groups based on the national average LAG size, as approximated by the total cost of administration (ADMIN). Large (small) sized LAGs are the ones with size larger (smaller) than the national average. Table 7.4 shows the relation between absorption of aggregated output and the three types of efficiency with LAG size.

**Table 7.4: Average Absorption of aggregated Output and delivery efficiency**

<table>
<thead>
<tr>
<th>LAG Size (ADMIN)</th>
<th># Lags</th>
<th>Absorption of Aggregated Output</th>
<th>Overall efficiency</th>
<th>Technical Efficiency</th>
<th>Scale Efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Large</td>
<td>18</td>
<td>0.356</td>
<td>0.734</td>
<td>0.800</td>
<td>0.918</td>
</tr>
<tr>
<td>Small</td>
<td>21</td>
<td>0.240</td>
<td>0.644</td>
<td>0.766</td>
<td>0.828</td>
</tr>
</tbody>
</table>

Note: Large (Small) = above (below) average.

The results show that LAG size has an obvious influence on absorption and efficiency and that larger LAGs are performing better than smaller ones in both indices of delivery performance. In order to check if the differences between the absorption of the aggregated output and efficiencies of the two sizes are statistically significant, we employed the non-parametric Mann–Whitney test. This test was used as the efficiency scores do not fit within a standard normal distribution. The results of this test are presented in Table 7.5

**Table 7.5: Results of Mann–Whitney test**

<table>
<thead>
<tr>
<th></th>
<th>Absorption of Aggregated Output</th>
<th>Overall efficiency</th>
<th>Technical Efficiency</th>
<th>Scale Efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mann-Whitney U</td>
<td>92</td>
<td>139</td>
<td>167</td>
<td>115.5</td>
</tr>
<tr>
<td>Z</td>
<td>-2.754</td>
<td>-1.442</td>
<td>-0.658</td>
<td>-2.106</td>
</tr>
<tr>
<td>Asymp. Sig. (2-tailed)</td>
<td>0.006</td>
<td>0.149</td>
<td>0.510</td>
<td>0.035</td>
</tr>
</tbody>
</table>
According to the results of the test, only the absorption and scale efficiency scores among the two sizes are significantly different, at a 5% significance level. Clearly, these results appear to be consistent with the findings of the Synthesis Report which concluded that larger LAGs, with more staff, processed applications faster than smaller LAGs. However, in contrast to absorption performance indicators, both large and small LAGs show the same low overall efficiency at a 5% statistical level. This occurs because technical inefficiencies, which are a much more serious problem than scale inefficiencies in both size groups, are also not significantly different at a 5% statistical level. This indicates that while organizational resources are a necessary condition for an effective formulation and implementation of programs of this nature, they are not a sufficient one. As argued by Boyne (2003), “the resources must (also) be effectively managed in order to deliver the maximum potential benefits.

**Table 7.6: Returns to scale by LAG size**

<table>
<thead>
<tr>
<th>LAG Size (ADMIN)</th>
<th>CRS</th>
<th>IRS</th>
<th>DRS</th>
</tr>
</thead>
<tbody>
<tr>
<td>large</td>
<td>7</td>
<td>3</td>
<td>9</td>
</tr>
<tr>
<td>small</td>
<td>2</td>
<td>18</td>
<td>0</td>
</tr>
</tbody>
</table>

Note: CRS / IRS / DRS: constant / increasing / decreasing returns to scale.

We also analysed the returns to scale results for each size group (see Table 7.6).

Considering LAG size, the results for RTS show that the LAGs with constant returns to scale are predominantly in the large size group. Whilst only increasing returns to scale are presented within the small–sized group, decreasing returns to scale are exhibited only by big-sized LAGs. The presence of IRS in some large LAGs indicates that size might not be the only influential factor of scale inefficiency and this will be further analysed in the following section discussing regional performance.

### 7.6.1 Managerial and Policy implications of LAGs’ size analysis

The returns to scale results indicate that among small size LAGs those facing IRS, have to increase their output scale in order to attain the most productive scale size, after eliminating technical inefficiency. This may be achieved with more intensive promotion of the program and also more intensive effort to support potential applicants for
submitting their project applications. This would increase local demand for investments through the program and would permit the LAG’s expansion in order to exploit existing economies of scale. Unutilized financial resources for management purposes are sufficient for this purpose as their absorption rate is low (average value of absorption of management resources for small LAGs equals 52.91%) in comparison to large LAGs (average value equals 63.99%).

Additionally, this under-utilization might be an indication of weaknesses in their management and particularly in their acquirement of real resources. For instance, this may be reflected in the absence of specialized staff such as engineers or environmental scientists which hinders the delivery of their programs.

On the other hand, large LAGs that face diseconomies of scale need to reduce the absorption rate of their management resources in order to eliminate coordination problems. Finally, in order to overcome the displayed scale inefficiencies, it may be necessary to re-examine the structure of the delivery network (number and localities of LAGs). This may be achieved through consolidation strategies such as mergers or shared management and must be examined at regional level since geographical coexistence of the LAGs involved is a prerequisite for that purpose.

7.7 Ranking of LAGs
The analysis of peer groups allows us to identify truly efficient LAGs and distinguish them from apparently efficient ones for which the choice of an optimal system of weights conceals some abnormal behaviour. In order to draw this distinction, it is necessary to consider the efficient LAGs and to evaluate how often each of them belongs to a peer group. It is reasonable to assume that efficient LAGs that are often included in the peer groups of inefficient ones, have determined a more robust set of weights for their own evaluation. On the other hand, efficient LAGs which rarely represent a term of comparison imply that their system of optimal weights may appear distorted, in the sense that it may implicitly reflect the specialization of these LAGs along a particular dimension of analysis. The frequency of each efficient LAG in the peer groups of inefficient ones for VRS is shown in Table 7.7 while the analytical results are presented in Appendix.
Table 7.7: Efficient lags as peers

<table>
<thead>
<tr>
<th>LAG</th>
<th>Times as peer</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>ANKO</td>
<td>22</td>
<td>1</td>
</tr>
<tr>
<td>ANVOPE</td>
<td>13</td>
<td>2</td>
</tr>
<tr>
<td>DODEKANISSA</td>
<td>8</td>
<td>5</td>
</tr>
<tr>
<td>FOKIKI</td>
<td>4</td>
<td>9</td>
</tr>
<tr>
<td>HALKIDIKI</td>
<td>2</td>
<td>11</td>
</tr>
<tr>
<td>HERAKLION</td>
<td>5</td>
<td>8</td>
</tr>
<tr>
<td>LASSITHI</td>
<td>10</td>
<td>4</td>
</tr>
<tr>
<td>LIMNOS</td>
<td>12</td>
<td>3</td>
</tr>
<tr>
<td>PARNONAS</td>
<td>2</td>
<td>11</td>
</tr>
<tr>
<td>PELLAS</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>PIERIKI</td>
<td>3</td>
<td>10</td>
</tr>
<tr>
<td>THESSALONIKI</td>
<td>4</td>
<td>9</td>
</tr>
<tr>
<td>XANTHI</td>
<td>7</td>
<td>6</td>
</tr>
</tbody>
</table>

7.8 Allocating Reserve Funds

The Structural Funds regulations highlight the principle of efficiency in the management of financial resources. For this purpose they provide for a performance reserve i.e. a certain percentage of the initial resources is held back for allocation at mid-term to the best performing local programs. The Commission report concluded that this reserve acted as an incentive for capacity building and better management practices across the Member States (European Commission, 2004). The performance reserve gives additional resources to the most efficient administrations in terms of using allocated funds. This prompted MAs to invest first in the financially more consistent actions with the aim of increasing expenditure efficiency and thus obtaining further financing. (Lion et al, 2006).

The Greek LEADER managing authority allocated the reserve funds among the better performing LAGs, primarily on the basis of their absorption performance. Some of these funds were consumed by LAGs as input resources. The drawback of this approach is that it does not consider the actual and potential production capacity of LAGs. We argue that
DEA ratings could be employed as an alternative or complementary approach to absorption rates for more effective allocation of these additional funds. In this case, since CCR model estimations include scale effects, they could be used as weights for reserve allocation in order to prevent potential absorption problems due to scale effects. This suggested approach incorporates incentives without hindering the productivity of the program.

Following the mid-term evaluation report of the program, these extra funds which accounted for approximately 10% of the initial LEADER budget, were allocated by the managing authority to 29 out of 39 LAGs as presented in Table 7.8 In the same table two DEA-based alternative scenarios are proposed. In the stricter first scenario, funds are divided equally among the 9 efficient LAGs. In the second scenario, reserve funds are allocated among 17 well performing LAGs whose technical efficiencies are relatively high, namely above the national average. The share of the reserve funds allocated to each of these LAGs was calculated based on its normalized efficiency score i.e. the efficiency score divided by the sum of scores of the 17 well performing LAGs. In the third case, where DEA is employed as a complementary rule, the reserve funds are allocated among the 29 originally selected LAGs, based both on their actual allocation and their efficiency scores. In this case, the share allocated to each LAG was calculated based on the normalized sum of absorption rate plus efficiency score.

**Table 7.8: Absorption and DEA based reserve allocation by LAG (in 1000 €)**

<table>
<thead>
<tr>
<th>Criterion</th>
<th>Initial Budget</th>
<th>Actual* reserve allocation</th>
<th>Alternative scenarios of reserve allocation based on DEA estimations</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Absorption* (mainly)</td>
</tr>
<tr>
<td>LAG-36</td>
<td>6400</td>
<td>1800</td>
<td>2808</td>
</tr>
<tr>
<td>LAG-17</td>
<td>6800</td>
<td>1800</td>
<td>2808</td>
</tr>
<tr>
<td>LAG-05</td>
<td>6300</td>
<td>1700</td>
<td>2808</td>
</tr>
<tr>
<td>LAG-04</td>
<td>6400</td>
<td>1700</td>
<td>2808</td>
</tr>
<tr>
<td>LAG-25</td>
<td>5800</td>
<td>1300</td>
<td>2808</td>
</tr>
<tr>
<td>LAG-32</td>
<td>6100</td>
<td>600</td>
<td>2808</td>
</tr>
<tr>
<td>LAG</td>
<td>6100</td>
<td>0</td>
<td>2808</td>
</tr>
<tr>
<td>-------</td>
<td>-------</td>
<td>-----</td>
<td>------</td>
</tr>
<tr>
<td>LAG-07</td>
<td>5535</td>
<td>0</td>
<td>2808</td>
</tr>
<tr>
<td>LAG-30</td>
<td>5300</td>
<td>0</td>
<td>2808</td>
</tr>
<tr>
<td>LAG-06</td>
<td>6300</td>
<td>0</td>
<td>1354</td>
</tr>
<tr>
<td>LAG-27</td>
<td>4330</td>
<td>500</td>
<td>1287</td>
</tr>
<tr>
<td>LAG-38</td>
<td>5270</td>
<td>580</td>
<td>1231</td>
</tr>
<tr>
<td>LAG-03</td>
<td>5100</td>
<td>750</td>
<td>1195</td>
</tr>
<tr>
<td>LAG-16</td>
<td>6200</td>
<td>0</td>
<td>1191</td>
</tr>
<tr>
<td>LAG-08</td>
<td>5300</td>
<td>1700</td>
<td>1179</td>
</tr>
<tr>
<td>LAG-24</td>
<td>5800</td>
<td>1000</td>
<td>1160</td>
</tr>
<tr>
<td>LAG-26</td>
<td>4400</td>
<td>0</td>
<td>1063</td>
</tr>
<tr>
<td>LAG-33</td>
<td>4450</td>
<td>600</td>
<td>1016</td>
</tr>
<tr>
<td>LAG-39</td>
<td>4300</td>
<td>0</td>
<td>996</td>
</tr>
<tr>
<td>LAG-35</td>
<td>6160</td>
<td>1000</td>
<td>977</td>
</tr>
<tr>
<td>LAG-22</td>
<td>6000</td>
<td>1400</td>
<td>0</td>
</tr>
<tr>
<td>LAG-18</td>
<td>6300</td>
<td>1400</td>
<td>0</td>
</tr>
<tr>
<td>LAG-12</td>
<td>6400</td>
<td>1000</td>
<td>0</td>
</tr>
<tr>
<td>LAG-14</td>
<td>3150</td>
<td>850</td>
<td>0</td>
</tr>
<tr>
<td>LAG-34</td>
<td>5700</td>
<td>750</td>
<td>0</td>
</tr>
<tr>
<td>LAG-28</td>
<td>5200</td>
<td>600</td>
<td>0</td>
</tr>
<tr>
<td>LAG-13</td>
<td>5100</td>
<td>550</td>
<td>0</td>
</tr>
<tr>
<td>LAG-20</td>
<td>5800</td>
<td>700</td>
<td>0</td>
</tr>
<tr>
<td>LAG-23</td>
<td>5200</td>
<td>500</td>
<td>0</td>
</tr>
<tr>
<td>LAG-29</td>
<td>5490</td>
<td>511</td>
<td>0</td>
</tr>
<tr>
<td>LAG-10</td>
<td>4800</td>
<td>600</td>
<td>0</td>
</tr>
<tr>
<td>LAG-37</td>
<td>4800</td>
<td>500</td>
<td>0</td>
</tr>
<tr>
<td>LAG-09</td>
<td>5140</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>LAG-15</td>
<td>5080</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
Clearly, there are significant differences between the actual allocation and the proposed allocations which take into account the DEA efficiency scores. The actual allocation of reserve funds rewards only the absorption of the program and does not always coincide with the delivery of a wide range of interventions that may contribute significantly towards the integrated character of the program. The multi-objective character of EU Leader programs is a major innovation aspect relative to other, sector-based EU programs. Hence, the general purpose of such DEA-based reserve allocation policies is to shift limited resources to units where they would be utilized more effectively in generating desired outputs.

### 7.9 Defining Potential Improvement and Risks

Some circumstances justify adjusting / reallocating funds etc. the program during implementation. Implementing a program can, for instance, reveal certain defects which should be remedied, such as an intervention which is poorly targeted or too restrictive, a financial appropriation which is badly distributed between “successful” interventions and other less popular ones, the omission of some types of beneficiaries, etc.

More simply, it should not be forgotten that EU programs are spread over seven years. During this period, major changes could occur in the social and economic situation or in the labour market. Such situations can make it necessary to amend the program.

Depending on the type of adjustment necessary, the body responsible will be either the managing authority – which will modify the program– or the Commission, which will act in agreement with the Member State. Any adjustment of a program by the managing authority cannot affect the total amount of Structural Fund assistance; any such adjustment, if necessary, must be decided by the Commission in agreement with the Member State. The same is true for the specific targets set for a priority. Decisions on

<table>
<thead>
<tr>
<th>LAG</th>
<th>Allocation</th>
<th>0</th>
<th>0</th>
<th>0</th>
<th>0</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td>LAG-11</td>
<td>5500</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LAG-19</td>
<td>5200</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LAG-01</td>
<td>5000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LAG-02</td>
<td>5200</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LAG-21</td>
<td>5100</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Ministry of Agriculture’s decision
adjustments are generally taken at meetings of the program monitoring committees, which are usually held once or twice a year. While the need for an adjustment can occur at any time, it is particularly likely to arise after the general evaluation of a program. This must be carried out at mid-term of implementation. Likewise, the allocation of the performance reserve to the programs showing the best results will require adjustments to those programs.

Although input and output implementation targets are pre-set in the initial financial plans in cooperation with the implementation bodies themselves, these are often found to be unrealistic in practice, since absorption problems in many member states are not an unusual phenomenon, as stated by Horvat (2005). It is then necessary to set new feasible, resource-adjusted targets so that an inefficient implementation body may become more efficient within the available transformation technology or in order to adjust expectations for delivery potential based on actual administrative capacity.

For each inefficient LAG, DEA provides a set of target inputs and outputs that the inefficient body should be able to achieve if it were to operate on the efficient frontier. In our case, the improvement objective primarily concerns the outputs produced and the projected values take account of both radial inefficiencies and additional input and output slacks. The differences between these targets and the actual performance define potential improvements and also indicate the areas of inefficiency of the LAG relative to the other LAGs. Potential improvements could be aggregated at country, regional, group or aggregated output level according to the scope of the analysis. Moreover, the higher the suggested improvement for an input resource or an intervention, the greater the magnitude of inefficiency and the weaker the delivery of the program. This DEA suggested potential improvement in each intervention essentially reflects the risk of failing to implement the planned projects within that intervention and, ultimately, the risk of losing funds.

Table 7.9 shows the potential improvements for the input, each of the eight outputs as well as the aggregated output, broken down by absorption group, at the time of evaluation.
Table 7.9: Potential improvements (%) by absorption group; VRS

<table>
<thead>
<tr>
<th>Input/Output</th>
<th>High absorption LAGs</th>
<th>Low absorption LAGs</th>
<th>All LAGs</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADMIN</td>
<td>-4.99</td>
<td>-2.73</td>
<td>-3.63</td>
</tr>
<tr>
<td>RURT</td>
<td>11.45</td>
<td>49.52</td>
<td>29.21</td>
</tr>
<tr>
<td>SMES</td>
<td>17.51</td>
<td>77.69</td>
<td>45.05</td>
</tr>
<tr>
<td>TECH</td>
<td>38.89</td>
<td>102.43</td>
<td>71.73</td>
</tr>
<tr>
<td>HS</td>
<td>18.63</td>
<td>32.60</td>
<td>27.38</td>
</tr>
<tr>
<td>NENV</td>
<td>21.91</td>
<td>150.96</td>
<td>69.66</td>
</tr>
<tr>
<td>HENV</td>
<td>52.24</td>
<td>183.64</td>
<td>98.74</td>
</tr>
<tr>
<td>CULT</td>
<td>24.28</td>
<td>159.12</td>
<td>73.61</td>
</tr>
<tr>
<td>COOP</td>
<td>49.11</td>
<td>66.76</td>
<td>60.76</td>
</tr>
<tr>
<td>AggrOUTP</td>
<td>16.79</td>
<td>68.56</td>
<td>40.70</td>
</tr>
</tbody>
</table>

Note: absorption= absorption of aggregated Output

Figure 7.3 improves the readability of Table 7.9 while it shows the potential improvements only for the output side, broken down by absorption group, at the time of evaluation. These outputs are efficient in the sense that they represent the maximum output achievable relative to given sample.

Clearly, low absorbing LAGs face greater risks of fund losses and need to achieve much higher improvements, in terms of the services offered and projects completed, in the whole array of interventions although in the usage of the input they seem to be performing better than high absorbing LAGs. Within the low absorbing group, the best intervention seems to be human support (HS), rural tourism (RURT) and cooperation (CULT) while the weakest are historic environment (HENV), cultural activities (CULT) and conservation of nature (NENV).
On the other hand, the results of the table indicate that high absorbing LAGs perform quite well in *rural tourism* (RURT) whereas the largest improvement is required in *historic environment* (HENV).

**Figure 7.3: Output Targets (%) by absorption group**

At national level, the most problematic areas are *historic environment* (HENV), *cultural activities* (CULT), *technological development* (TECH) and *conservation of nature* (NENV). In contrast, the traditional interventions, namely *rural tourism* (RURT), *entrepreneurship* (SMES) and *human resources* (HS) are the best areas of the program.

Thus in the context of the impending review and amendment of the program, which normally follows the midterm evaluation, the managing authority will need to re-examine possible redistribution of interventions at both local and national program level. For example, funds may need to be reallocated from interventions presenting high risk to interventions with low risk of funds losses at individual LAG or group level.

**7.10 Identifying Good Delivery Practices**

Program implementation constitutes an area where Community resources can add value, throughout the improvement of sub national and national administrative capacities. Adopted from the private sector, benchmarking has become an increasingly popular tool for improving the policy implementation processes of the public sector. It is also relevant in the ongoing evaluation of public interventions.
Benchmarking for performance improving is a major source of knowledge for local capacity building and in the framework of LEADER (Action 3), a National Network Unit was created in each member state in order to collect, analyze and disseminate information at national level on good practice and also to organize the exchange of experience and know-how and provide technical assistance for cooperation. Active participation in the network was mandatory for LAGs. Nevertheless, the LEADER+ ex post evaluation report (Metis, 2010) recommends that “Targeted opportunities for peer learning for LAGs, whether within or between countries should be further developed”. In this sense, it seems a necessity to identify for each poorly performing LAG a set of peers in order to focus for benchmarking processes.

In DEA, the reference set for each inefficient LAG indicates the efficient ones that are most similar to it in their mix of services and resources. The reference sets of inefficient LAGs are shown in Table 7.10 (Analytical results are presented in Appendix). For this purpose, the results of BCC analysis are more appropriate as this model excludes some scale effects. Focusing on the peers that comprise the reference set of an inefficient LAG may provide useful insights and identify good delivery examples that may be imitated by the inefficient LAG.

**Table 7.10: Inefficient LAGs and their Reference Sets (VRS)**

<table>
<thead>
<tr>
<th>Inefficient LAG</th>
<th>Benchmarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACHAIA</td>
<td>FOKIKI, LIMNOS, PARNONAS, XANTHI</td>
</tr>
<tr>
<td>AITOLIKI</td>
<td>ANKO, XANTHI</td>
</tr>
<tr>
<td>AKOMM</td>
<td>ANKO, ANVOPE, DODEKANISSA, LIMNOS, PELLAS,</td>
</tr>
<tr>
<td>DRAMA</td>
<td>ANKO, ANVOPE, HERAKLION, LASSITHI</td>
</tr>
<tr>
<td>EVROS</td>
<td>ANKO, ANVOPE, HERAKLION, LASSITHI</td>
</tr>
<tr>
<td>ELASSONA</td>
<td>ANKO, DODEKANISSA, FOKIKI, LASSITHI, THESSALONIKI</td>
</tr>
<tr>
<td>ELIKONAS</td>
<td>ANKO, HERAKLION, LIMNOS, PIERIKI</td>
</tr>
<tr>
<td>ETANAM</td>
<td>ANKO, ANVOPE, HALKIDIKI</td>
</tr>
<tr>
<td>FLORINA</td>
<td>ANKO, PARNONAS, THESSALONIKI, XANTHI</td>
</tr>
<tr>
<td>IMATHIA</td>
<td>ANKO, ANVOPE, LIMNOS, PELLAS</td>
</tr>
<tr>
<td>EPIRUS</td>
<td>ANKO, LIMNOS, XANTHI</td>
</tr>
</tbody>
</table>
ANKO, followed by ANVOPE are the most frequent referents (times as referents 21 and 12 respectively) among the 13 efficient LAGs. In these two large LAGs there is also a full coincidence of two performance indices since their absorption is also high with rates 51.27% and 55.57%, respectively. It is worth noting that it is widely accepted that ANKO Development Agency is the leader in local development achievements in Greece and the coordinator of LEADER network.

Next follow four small LAGs namely LIMNOS, LASSITHI, DODEKANISSA and XANTHI with times as referents 11, 9, 7 and 6, respectively. Their absorption rate is 34.74%, 38.13%, 32.72% and 24.24%, respectively. It is worth noting that DEA identifies as potential benchmarks LAGs with very low absorption performance such as XANTHI, whose absorption rate ranks as 27th out of 39 LAGs.
7.11 Assessing Regional Performance

It is also interesting to investigate how absorption rate (of aggregated output) as well as efficiency are distributed across the administrative regions of the country, since this administrative division is instrumental in the European Union's Structural Fund delivery mechanisms and is typically used in policy design and performance comparisons in the relevant EU and academic literature. Furthermore, an investigation of geographical performance dispersion is an initial step in order to further search for environmental drivers that might influence the delivery performance.

The 39 LAGs implementing LEADER+ projects are distributed across 12 administrative regions: Peloponnese (PEL); Crete (CRE); Central Macedonia (CMA); East Macedonia and Thrace (EMT); The South Aegean Islands (SAI); The North Aegean Islands (NAI); Epirus (EPI); West Macedonia (WMA); Thessaly (THE); Central Greece (CGR); Western Greece (WGR); Ionian Islands (IIS).

Table 7.11 below shows the relative share of the inputs and outputs among the 12 administrative regions of the Greek state that operate LAGs which implement the LEADER program.

<table>
<thead>
<tr>
<th>Region</th>
<th>Sal</th>
<th>Equip</th>
<th>AGROT</th>
<th>SMES</th>
<th>TECH</th>
<th>HS</th>
<th>NENV</th>
<th>HENV</th>
<th>CULT</th>
<th>COOP</th>
</tr>
</thead>
<tbody>
<tr>
<td>EMT</td>
<td>14.30</td>
<td>11.31</td>
<td>17.42</td>
<td>13.73</td>
<td>2.20</td>
<td>9.40</td>
<td>0</td>
<td>0</td>
<td>6.42</td>
<td>0</td>
</tr>
<tr>
<td>CMA</td>
<td>19.42</td>
<td>26.81</td>
<td>22.02</td>
<td>20.24</td>
<td>28.79</td>
<td>23.22</td>
<td>57.27</td>
<td>38.07</td>
<td>5.08</td>
<td>40.84</td>
</tr>
<tr>
<td>WMA</td>
<td>7.76</td>
<td>5.87</td>
<td>4.03</td>
<td>11.38</td>
<td>3.81</td>
<td>13.61</td>
<td>0.55</td>
<td>3.98</td>
<td>10.49</td>
<td>11.96</td>
</tr>
<tr>
<td>THE</td>
<td>11.16</td>
<td>11.32</td>
<td>11.47</td>
<td>6.59</td>
<td>2.61</td>
<td>8.92</td>
<td>7.91</td>
<td>5.69</td>
<td>13.15</td>
<td>0</td>
</tr>
<tr>
<td>CGR</td>
<td>4.34</td>
<td>1.15</td>
<td>0.76</td>
<td>5.49</td>
<td>0</td>
<td>3.67</td>
<td>0</td>
<td>3.36</td>
<td>1.09</td>
<td>0</td>
</tr>
<tr>
<td>EPI</td>
<td>5.81</td>
<td>5.81</td>
<td>6.19</td>
<td>5.94</td>
<td>9.00</td>
<td>7.02</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>WGR</td>
<td>8.83</td>
<td>11.97</td>
<td>6.87</td>
<td>4.85</td>
<td>0</td>
<td>9.86</td>
<td>19.10</td>
<td>0</td>
<td>0</td>
<td>9.23</td>
</tr>
<tr>
<td>IIS</td>
<td>7.08</td>
<td>4.53</td>
<td>1.24</td>
<td>2.34</td>
<td>0</td>
<td>10.60</td>
<td>0</td>
<td>4.72</td>
<td>12.14</td>
<td>0</td>
</tr>
<tr>
<td>PEL</td>
<td>5.32</td>
<td>6.40</td>
<td>9.57</td>
<td>6.67</td>
<td>15.83</td>
<td>2.64</td>
<td>1.94</td>
<td>10.67</td>
<td>2.50</td>
<td>37.98</td>
</tr>
<tr>
<td>NAI</td>
<td>3.70</td>
<td>1.08</td>
<td>5.05</td>
<td>2.61</td>
<td>2.75</td>
<td>4.16</td>
<td>4.77</td>
<td>4.60</td>
<td>7.59</td>
<td>0</td>
</tr>
<tr>
<td>SAI</td>
<td>2.40</td>
<td>1.05</td>
<td>1.77</td>
<td>2.11</td>
<td>1.47</td>
<td>1.40</td>
<td>8.46</td>
<td>7.95</td>
<td>30.93</td>
<td>0</td>
</tr>
</tbody>
</table>
There are significant variations across all the regions both in the consumption of resources and in the implementation of interventions as denoted by their relative payments shares. For example, it can be seen that the region of Central Macedonia has the most extensive implementation infrastructure among the twelve regions, with the largest share in both labour and other expenses as well as equipment. It also has the largest shares in almost all interventions with the exception of technology, with the second largest, and culture, with the eighth largest share. In contrast, the region of South Aegean Islands has the smallest share in both resources. It also has the smallest shares in five interventions, the second worst in technology and the largest share in culture.

The average regional absorption as well as the average technical and scale efficiency scores for all the regions, as obtained from our basic analysis, is shown in Figure 7.4.

In this figure the regions are sorted in descending order of their absorption values.

**Figure 7.4: Absorption and efficiency across Greek regions**

Figure 7.4 suggests the existence of quite large differences in both types of performance indicators across regions. The ranges of absorption and efficiency values across regions equal approximately 30% and 45%, respectively. Furthermore, as in the analysis at LAG level, an examination of the results across regions reveals some contradictions. For
example, the bottom-ranked regions by absorption, namely Western Greece and Ionian Islands, do not necessarily have bottom-ranked performance measured by DEA.

Overall, technical efficiency is lower than scale efficiency across all inefficient regions apart from the Ionian Islands and North Aegean Islands where disadvantageous regional conditions seem to pertain, as indicated by the high scale inefficiency. These conditions may have resulted in a very low demand for investment from the target population. The Kruskal-Wallis test was carried out for the efficiency scores at region level and presented in Table 7.12.

Table 7.12: Results of Kruskal Wallis test

<table>
<thead>
<tr>
<th>Absorption of Aggregated Output</th>
<th>Overall efficiency</th>
<th>Technical Efficiency</th>
<th>Scale Efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chi-Square</td>
<td>21.083</td>
<td>18.227</td>
<td>11.488</td>
</tr>
<tr>
<td>df</td>
<td>11</td>
<td>11</td>
<td>11</td>
</tr>
<tr>
<td>Asymp. Sig.</td>
<td>.033</td>
<td>.076</td>
<td>.403</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The results of the test presented in Table 7.12 show that there are not statistically significant differences among regions as far as technical efficiency scores are concerned, while significant differences among regions do exist as far as absorption rates and scale efficiency scores are concerned at 5% level of significance. Moreover, the Spearman correlation test reveals that regional average absorption of aggregated output is highly correlated with regional average scale efficiency. In fact, the correlation coefficient is equal to 0.876 and is statistically significant at 5% level of significance. This may denote the high effect on regional performance of the disadvantageous conditions that characterize certain regions and suggest that further research is necessary in order to find local factors that might directly or indirectly influence LAG productivity. Such factors may include the density of the local population, its demographic characteristics etc.

Based on their average regional absorption in relation to the national average, three clusters of regions are distinguished as high, middle and low absorption clusters. Although somewhat arbitrary, this typology is used more for illustrative purposes. Table 7.13 presents the average performance of the three clusters of regions. Although pure technical and scale inefficiency is spread all over the absorption clusters, it is clear that
the high absorption of the regions of the first cluster is due to both high pure technical and high scale efficiencies. In the middle absorption cluster, lower absorption is caused mainly by pure technical inefficiency as the average pure technical efficiency score is below the national average. The majority of LAGs belong to this middle absorption cluster, which should be the primary focus of the managing authority in order to increase delivery productivity and absorption of the national program. In the low absorption cluster, the main problem seems to be scale inefficiency.

**Table 7.13: Absorption and efficiency of clusters of regions**

<table>
<thead>
<tr>
<th>Absorption size</th>
<th>LAGs</th>
<th>Absorption</th>
<th>CRS</th>
<th>VRS</th>
</tr>
</thead>
<tbody>
<tr>
<td>High absorption</td>
<td>6</td>
<td>41.75</td>
<td>0.89</td>
<td>0.916</td>
</tr>
<tr>
<td>Medium absorption</td>
<td>26</td>
<td>30.51</td>
<td>0.676</td>
<td>0.752</td>
</tr>
<tr>
<td>Low absorption</td>
<td>7</td>
<td>15.25</td>
<td>0.598</td>
<td>0.804</td>
</tr>
<tr>
<td>National</td>
<td>39</td>
<td>29.5</td>
<td>0.685</td>
<td>0.783</td>
</tr>
</tbody>
</table>

The first cluster of regions consists of Peloponnese and Crete and includes six LAGs. They are ranked first in absorption with a value around 42%, which is significantly above the national average (29.5%). With respect to efficiency, the LAGs in Peloponnese are efficient probably due to very low average consumption of input (fourth from the last among all regions) and good or very good average performance in the implementation in six out of eight interventions. In contrast, LAGs in Crete have on average the fourth largest share in total management costs although they have better performance than Peloponnese in all interventions apart from cooperation. This relative lower technical inefficiency of Crete (87%) is mainly due to pure technical inefficiency (89.6%) and not to regional inefficiency (96.8%), as shown in Fig. 4. Hence, LAG managers within the Crete region should aim to make their implementation processes faster through better management and operations processes.

The second cluster consists of eight regions with twenty six LAGs; Central Macedonia, East Macedonia and Thrace, The South Aegean Islands, The North Aegean Islands, Epirus, West Macedonia, Thessaly, and Central Greece. The average cluster absorption (30.5%) is very close to the national program average (29.5%) while the average regional absorptions of the cluster are within 5% from this average. In this cluster, the region of The South Aegean Islands is the only fully efficient region while Central Greece is the
highest inefficient region within the whole of the country (average technical efficiency 53.7%). Although the absorption of these regions is around average there is relatively high variability in productivity as indicated by the efficiency scores. The full efficiency of the South Aegean Islands region is obviously due to its use of the smallest average amount of resources. The efficiency performance of Central Greece, which is the lowest in the country, may be attributed both to managerial issues and the disadvantageous regional conditions in the area. Indeed, this technical inefficient region has both a low pure technical efficiency (74.8%) and also very low scale efficiency (86%).

The third cluster consists of two regions with seven LAGs; Western Greece and Ionian Islands. Average absorption of Western Greece is 18.5% which means eleven units below the national average whilst absorption of LAGs in Ionian Islands region (average equals 10.8 %) is by far the worst in entire Greece with a negative divergence from national average around twenty units. Although the average technical efficiency of Western Greece and Ionian Islands is almost identical (60.4 and 60.8, correspondingly) and quite low (ranked 10th and 9th among 12) the source of inefficiency in the former might be attributed both in high pure technical and high scale inefficiency (77.8 and 78.7, correspondingly). In the Ionian Islands' LAGs the high average technical inefficiency has to be attributed mainly in size or/and disadvantageous regional conditions since its scale efficiency (70.3%) is the lowest in entire Greece and actually 20% lower than its pure technical efficiency (88.4%).

The returns to scale of the LAGs of each region, as determined by the basic analysis, are presented in Table 7.14.

7.11.1 Policy Implications of Regional Analysis

Information as to whether a LAG is operating at increasing (IRS) or decreasing (DRS) returns to scale can prove useful in indicating directions for restructuring in the long run, in low performing regions. This initiative could be started both from the managing authority and the local governments. More specifically, merging or sharing management of low performing LAGs, before the next programming period, might be a viable choice for regions in order to gain and implement additional competitive programs since past performance is an important criterion for contracting new programs. For this purpose, LAGs belonging to the same region, which is characterized by high technical
inefficiency, could be examined more thoroughly for consolidation when at least one of them displays IRS and the rest display IRS or DRS characteristics.

On the other hand, the existence of many more LAGs displaying IRS in contrast to DRS indicates that the national program has been divided at the initial stage into too many sub-programs and that this fragmentation negatively influences program productivity. Based on this evidence, it appears that a higher concentration to fewer local programs might be a more productive solution. Hence, the managing authority should place greater emphasis at the beginning of any program in order to more systematically assess the maximum number of sub-programs (and LAGs) that will be charged with its implementation.

**Table 7.14: Distribution of returns to scale by region**

<table>
<thead>
<tr>
<th>Region</th>
<th>CRS</th>
<th>IRS</th>
<th>DRS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peloponnese</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crete</td>
<td>2</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Central Macedonia</td>
<td>3</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>East Macedonia and Thrace</td>
<td></td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>The South Aegean Islands</td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>The North Aegean Islands</td>
<td></td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Epirus</td>
<td></td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>West Macedonia</td>
<td>1</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Thessaly</td>
<td></td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Central Greece</td>
<td></td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Western Greece</td>
<td></td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Ionian Islands</td>
<td>2</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

**7.12 Concluding Remarks**

The efficient and effective delivery of public spending programs is critical for the achievement of their strategic objectives. Performance assessment systems that are mainly based on traditional simple ratio indicators do not provide sufficient feedback to delivery agents as well as management authorities. In order to overcome these deficiencies, Data Envelopment Analysis is proposed as a simple complementary
managerial tool for comparative evaluation of programs and their implementers. In contrast to traditional methods that employ simple or aggregated absorption indicators, the use of DEA provides more detailed information, takes into account economies of scale and allows a more in-depth comparison of the implementation bodies.

The proposed performance evaluation framework incorporates both conceptual and practical considerations and is illustrated in the EU context and specifically in the case of the Greek LEADER+ development program. As evidence of operational and scale inefficiency of its delivery was found, it is recommended to improve first line administrative capacities in Greece and make adjustments in the number of LAGs and localities charged with the implementation of development policy.

The results of this application indicate that DEA is an insightful tool and can help in analysing the sources of administrative inefficiencies, guiding benchmarking and allocating funds appropriately. Using raw data from the monitoring system of a program and free or commercially available specialized software, this framework can be easily integrated into its evaluation system in order to provide useful managerial information regarding performance. Finally, the knowledge gained through the application of DEA would have an important input in the strategic decision making process concerning the structure of the delivery system.

The approach presented in this chapter offers an initial attempt to assess the operational efficiency of a program for mid-point evaluation purposes and in the next chapters it will be extended in several ways.
8. EFFICIENCY AND PRODUCTIVITY CHANGE MEASUREMENT

8.1 Theoretical Considerations

8.1.1 Introduction

There are two basic approaches to the measurement of productivity change: the econometric estimation of a production, cost or some other function, and the construction of index numbers. We adopt the latter because it does not require the imposition of a possibly unwarranted functional form on the structure of production technology, as required by the econometric approach.

We use the Malmquist index approach (Malmquist, 1953) to analyse changes in the productivity of implementation units between two time periods. Färe et al. (1994) developed a DEA-based Malmquist productivity index which measures productivity change over time. The index can be decomposed into two components, with one measuring the change in the technology frontier and the other the change in technical efficiency. It is designed to measure productivity changes in the context of a multi-output production process involving multiple inputs. It is defined as a product of “catch-up” and “frontier-shift” terms. The catch-up (or recovery) term relates to the degree that a DMU attains for improving its efficiency, while the frontier-shift (or innovation) term reflects the change in the efficient frontiers surrounding the DMU between the two time periods (Tone, K. 2004).

There are several other indexes to measure the productivity change of a unit (such as the Fisher index or the Törnqvist index), but the Malmquist index is adopted here because it permits the separation of technical or technological change from efficiency change (Färe et al., 1994) and is consistent with the DEA efficiency estimation methodology.
According to Casu et al. (2004), the Malmquist index is the most commonly used measure of productivity change.

In the next two sections we use the non-parametric approach of Färe et al. (1994) to measure productivity change for different program implementers. DEA and its use in the computation of the required distances are discussed in the following section.

8.1.2 Definitions and Properties

The nonparametric DEA-Malmquist index can be estimated by exploiting the relationship of distance functions to the technical efficiency measures developed by Farrell (1957). It uses the distance function concepts proposed in Malmquist (1953). Distance functions allow one to describe a multi-input, multi-output production technology without the need to specify a behavioural objective (such as cost minimisation or profit maximisation). One may define input distance functions and output distance functions. An input distance function characterises the production technology by looking at a minimal proportional contraction of the input vector, given an output vector. An output distance function considers a maximal proportional expansion of the output vector, given an input vector. For purposes of this study, we need to consider only output distance functions. However, input distance functions can be defined and used in a similar manner.

Since the Malmquist index purports to measure productivity changes, it is based on the existence of a production technology which transforms multi-dimensional input vectors, say \( x \), into multi-output vectors, \( y \). The output possibility set that models the transformation of inputs into outputs at initial time \( t \) is:

\[
S^t = \{ x^t: x^t \text{ can produce } y^t \}.
\]  

We assume that \( S^t \) satisfies certain axioms which suffice to define meaningful output distance functions (see Shephard, 1970; Färe, 1988): These are: (i) possibility of inactivity; (ii) weak or strong disposability of outputs; (iii) weak or strong disposability of inputs; (iv) closed and bounded production possibility sets; (v) closed input sets; and (vi) input and output convexity.

Following Shephard (1970) or Färe (1988), the output distance function is defined at \( t \), the initial period, as:
Efficiency and Productivity Change Measurement

\[
D^t_o(x', y') = \inf \{ \theta : \frac{y'}{\theta} \in S' \} = (\sup \{ \theta : \frac{x'}{\theta} \in S' \})^{-1}
\]  

(8.2)

Note that \(D^t_o(x', y') \leq 1\) if and only if \((x', y') \in S'\). In addition, \(D^t_o(x', y') = 1\) if and only if \((x', y')\) is on the boundary or frontier technology. In the terminology of Farell (1957), that occurs when production is technically efficient. This function is defined as the reciprocal of the “maximum” proportional expansion of the output vector \(y^t\), given inputs \(x^t\). This distance function measures the maximum possible output that a given amount of inputs can produce. It is a measure of output technical efficiency. That is \(TE_0(x, y) = [D^t_o(x', y')]^{-1}\). Similarly, we can define a distance function in relation to the technology in time \(t+1\), the final period, as \(D^{t+1}_o(x^{t+1}, y^{t+1})\).

Defining the Malmquist productivity index requires us to define the distance function with respect to two different time periods, such as:

\[
D^t_o(x^{t+1}, y^{t+1}) = \inf \{ \theta : \frac{y^{t+1}}{\theta} \in S' \}
\]  

(8.3)

and

\[
D^{t+1}_o(x', y') = \inf \{ \theta : \frac{y'}{\theta} \in S' \}
\]  

(8.4)

The first distance function, equation (8.3), measures the maximum proportional change in outputs required to make \((x^{t+1}, y^{t+1})\) feasible in relation to the technology at the previous period \(t\). Similarly, the second mixed-period distance function, equation (8.4), measures the maximum proportional change in output required to make \((x', y')\) feasible in relation to the technology at period \(t+1\).

The idea can be shown graphically by a simplified (one-input and one-output with constant returns to scale (CRS) technology) case. Points \((x', y')\) and \((x^{t+1}, y^{t+1})\), in Figure 8.1, represent the input-output combinations of a delivery unit in periods \(t\) and \(t+1\) respectively. In both cases, it is operating below the production possibility frontier. In period \(t\) (correspondingly, period \(t+1\)), with input \(x' (x^{t+1})\), it should be able to produce \(y^a (y^a)\) if it has full technical efficiency. Then the technical efficiency is measured by \(y^a/y^t (y^a/y^{t+1})\). Two changes have occurred to this unit between time \(t\) and time \(t+1\). First, the
unit is using better technology in period $t+1$ to produce its output. In the figure, this unit’s input-output combination in period $t+1$ would have been infeasible using period $t$ technology. Second, the firm is operating closer to the frontier in period $t+1$ than in period $t$, indicating a technical efficiency gain between the two periods.

**Figure 8.1: The Malmquist Output-Based Productivity Index**

Productivity change can be measured by the part of output growth that is not contributed by input growth. In Figure 8.1, we can calculate a productivity index by $\left( \frac{y^{t+1}}{y^t} \right) / \left( \frac{y^b}{y^a} \right)$, where $\left( \frac{y^{t+1}}{y^t} \right)$ is the output growth and $\left( \frac{y^b}{y^a} \right)$ represents a movement along the production frontier in period $t$. This can be rewritten as $\left( \frac{y^{t+1}}{y^b} \right) / \left( \frac{y^t}{y^a} \right)$, where the numerator is a distance function for output in period $t+1$ ($y^{t+1}$) with reference to the technology of period $t$ and the denominator is the distance function representing technical efficiency in period $t$.

This is precisely the output-oriented Malmquist productivity index defined by Caves, Christensen and Diewert (1982a and 1982b), with reference to the technology at initial period $t$:

$$M_o = \frac{D_s\left(\chi^{t+1}, y^{t+1}\right)}{D_s\left(\chi^t, y^t\right)}$$

(8.5)
However, one can also choose the technology in period \( t + 1 \) as the reference in defining a productivity index. The Malmquist productivity index in relation to the technology at the final period \( t + 1 \) can be defined as:

\[
M_{t+1}^{i} = \frac{D_{t+1}^{i}(\mathbf{x}^{t+1}, \mathbf{y}^{t+1})}{D_{t+1}^{i}(\mathbf{x}', \mathbf{y}')} \tag{8.6}
\]

The two indexes appear to be identical in the simple case represented by Figure 8.1. However, they may or may not be the same in the cases of multiple inputs and varying returns to scale (VRS) technology. To avoid the arbitrariness in choosing the benchmark, Färe et al. (1989 and 1994) specify the output-based Malmquist productivity index as the geometric mean of the above two indexes:

\[
M_{t}^{o}(\mathbf{x}^{t+1}, \mathbf{y}^{t+1}, \mathbf{x}', \mathbf{y}') = \left[ \frac{D_{o}^{i}(\mathbf{x}^{t+1}, \mathbf{y}^{t+1})}{D_{o}^{i}(\mathbf{x}', \mathbf{y}')} \right]^{\frac{1}{2}} \right] \tag{8.7}
\]

This productivity index is the geometric mean of a pair of ratios of output distance functions. The first ratio compares the data from periods \( t \) and \( t + 1 \) relative to production possibilities existing in period \( t \), and the second compares the performance of the same data relative to production possibilities existing in period \( t + 1 \).

8.1.3 Decomposing the Malmquist Productivity Index

Following Färe et al. (1989 and 1994), the above formula can be decomposed into technical efficiency change (EFFCH) and technical change (TECHCH):

\[
M_{t}^{o}(\mathbf{x}^{t+1}, \mathbf{y}^{t+1}, \mathbf{x}', \mathbf{y}') = \left[ \frac{D_{o}^{i}(\mathbf{x}^{t+1}, \mathbf{y}^{t+1})}{D_{o}^{i}(\mathbf{x}', \mathbf{y}')} \right]^{\frac{1}{2}} \tag{8.8}
\]

where the ratio outside the brackets measures the change in relative efficiency (i.e., the change in how far observed production is from maximum potential production) between periods \( t \) and \( t + 1 \). The geometric mean of the two ratios inside the square brackets captures the shift in technology between the two periods evaluated at \( x' \) and \( x^{t+1} \). More specifically,

\[
M_{t}^{o}(\mathbf{x}^{t+1}, \mathbf{y}^{t+1}, \mathbf{x}', \mathbf{y}') = \text{EFFCH} \times \text{TECHCH} \tag{8.9}
\]

where,
Efficiency change (EFFCH) = \( \frac{D'_o(\chi^{t+1}, y^{t+1})}{D'_o(\chi', y')} \)  

Technological change (TECHCH) = \( \left[ \frac{D'_o(\chi^{t+1}, y^{t+1})}{D'_o(\chi^{t+1}, y^{t+1})} \times \frac{D'_o(\chi', y')}{D'_o(\chi', y')} \right]^{\frac{1}{2}} \)

The efficiency change term is equivalent to the ratio of the Farell technical efficiency in period \( t + 1 \) divided by the Farell technical efficiency in period \( t \). The technological change term is the geometric mean of the shift in technology as observed at \( x^{t+1} \) (the first ratio inside the bracket) and the shift in technology observed at \( x' \) (the second ratio inside the bracket).

The efficiency change component is an index of relative technical efficiency change, and shows how much closer (or farther away) a firm gets to the “best practice” frontier. This component is greater than, equal to, or less than unity depending on whether the evaluated firm improves, stagnates, or declines. The technological change component measures how much the frontier shifts, and indicates whether the best practice frontier, against which the evaluated firm is compared is itself improving, stagnating, or deteriorating. Depending on the case, the index will take a value greater than, equal to, or less than unity – hence technological change would be positive, zero, or negative.

In Figure 8.1, the two components of the Malmquist Index as in Equation (8.6) are represented by:

Efficiency change = \( \frac{y^{t+1}/y^c}{y'/y^a} \) and

Technological change = \( \left[ \frac{y^{t+1}/y^c}{y^{t+1}/y^c} \times \frac{y'/y^a}{y'/y^a} \right]^{\frac{1}{2}} \).

Improvements in productivity yield Malmquist indexes greater than unity. Deterioration in performance over time is associated with a Malmquist index less than unity. In addition, improvements in any of the components of the Malmquist index are also associated with values greater than unity of those components, and deterioration is associated with values less than unity. Note that while the product of the efficiency
change and technical-change components must by definition equal the Malmquist index, those components may be moving in opposite directions.

In principle, one may calculate Malmquist productivity indexes relative to any type of technology (i.e., satisfying any type of returns to scale). One might choose to calculate the Malmquist index relative to the constant-returns-to-scale technology and use an enhanced decomposition of the Malmquist index developed in Färe et al. (1994). This enhanced decomposition takes the efficiency-change component calculated relative to the constant-returns-to-scale technology and decomposes it into a pure efficiency-change component (calculated relative to the variable-returns technologies) and a residual scale component which captures changes in the deviation between the variable-returns and constant returns-to-scale technology. Scale efficiency for an observation is the vertical distance between VRS and CRS frontiers evaluated at the corresponding input for that observation. Thus the scale-change component would be the ratio of scale efficiency in period \( t \) and \( t + 1 \). This enhanced decomposition allows one to report compactly results relative to both types of technologies.

The decomposition becomes:

\[
\text{EFFCH} = \frac{D_o^i\left(x^{t+1}, y^{t+1}\right)}{D_o\left(x^t, y^t\right)} = \frac{D_{VRS}^{i+1}\left(x^{t+1}, y^{t+1}\right)}{D_{VRS}^i\left(x^t, y^t\right)} \times \frac{D_{CRS}^{i+1}\left(x^{t+1}, y^{t+1}\right)}{D_{CRS}^i\left(x^t, y^t\right)}
\]

in which pure efficiency change is:

\[
\text{PEFFCH} = \frac{D_{VRS}^{i+1}\left(x^{t+1}, y^{t+1}\right)}{D_{VRS}^i\left(x^t, y^t\right)}
\]

and, scale efficiency change is:

\[
\text{SCH} = \frac{D_{CRS}^{i+1}\left(x^{t+1}, y^{t+1}\right)}{D_{CRS}^i\left(x^t, y^t\right)}
\]

That is,

\[
M_o^i\left(x^{t+1}, y^{t+1}, x^t, y^t\right) = \text{PEFFCH} \times \text{SCH} \times \text{TECHCH}
\]

Thus, Malmquist productivity index is capable not just of quantifying productivity change, but also of quantifying its three principal sources. Furthermore, Malmquist and
Efficiency and Productivity Change Measurement

its components are local indices. Their values may vary across units and between different adjacent time periods. Thus, some units may exhibit an increase and others may exhibit a decrease in efficiency components, and this can change over time. Similarly, some units may exhibit technical progress and others may exhibit technical regress, and this can also change over time. This feature allows considerable flexibility in explaining the observed pattern of productivity change, both across units and over time.

8.1.4 Approximating Malmquist Using DEA Frontiers

In computing the distance functions, we chose the DEA method among competing alternatives, so as to take advantage of the fact that the distance functions are reciprocals of Farrell efficiency measures. Ali and Seiford (1994), Grosskopf (1994) and Rao and Coelli et al. (2005) explain how the estimation can be done.

The distance functions can be estimated by output oriented DEA models. Malmquist productivity index contains four output distance functions which are the reciprocal of the technical efficiency indicators and each defined on a benchmark technology satisfying constant returns to scale: $D_o^\prime (\chi, y), D_o^{x+1} (\chi, y), D_o^\prime (\chi^{x+1}, y^{x+1})$ and $D_o^{x+1} (\chi^{x+1}, y^{x+1})$.

To derive the full decomposition, including the scale-change component, requires calculation of an additional two programming problems: these are $D_{\text{RS}}^\prime (\chi, y)$ and $D_{\text{RS}}^{x+1} (\chi^{x+1}, y^{x+1})$ relative to the variable-returns-to-scale technology.

The estimators of the distance function $D^\prime (x^t, y^t)$ are obtained by

$$
\left[ D_{\text{CRS}}^\prime (x^t, y^t) \right]^{-1} = \max \left\{ \theta \mid x^t \lambda \leq x^t, \ y^t \beta \geq \theta y^t, \ \lambda \geq 0 \right\} \quad (8.16)
$$

$$
\left[ D_{\text{VRS}}^\prime (x^t, y^t) \right]^{-1} = \max \left\{ \theta \mid x^t \lambda \leq x^t, \ y^t \beta \geq \theta y^t, \ \sum \lambda_i = 1, \lambda_i \geq 0 \right\} \quad (8.17)
$$

Similar estimators to those of (1) and (2) with reference to $t+1$ are obtained for $D^{x+1} (x^{x+1}, y^{x+1})$. The remaining estimators are given as:

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The estimators of the distance function $D_{CRS}(x', y')^{-1}$ are obtained from (8.18) and (8.19) by interchanging the time indices, i.e. substituting $t+1$ for $t$ and $t$ for $t+1$, respectively.

Note that in LP’s (8.18) and (8.19), where production points are compared to technologies from different time periods, the $\theta$ parameter needs not to be greater than or equal to one, as it must be when calculating standard output-orientated technical efficiencies. The data point could lie above the production frontier. This will most likely occur in LP (8.18) or/and (8.19) where a production point from period $t+1$ is compared to technology in an earlier period, $t$. If technical progress has occurred, then a value of $\theta<1$ is possible. Note that it could also possibly occur in LP (8.18) or/and (8.19) if technical regress has occurred, but this is less likely (Coelli et al., 2005).

8.2 Empirical Estimation of Efficiency and Productivity Change

In order to be comparable with program midterm evaluation (MTE), DEA analysis of the previous chapter was based on 2005 monitoring data. In the present chapter, for further investigation of program implementation productivity, we use an additional data set considering data of the year 2006. The following analysis is based on the assumption that there is a shift in the program administration production function (e.g., technical progress) with time. The production technology may change over time, resulting in shifts in the best practice technical frontier, because of experience, increased knowledge, better production techniques and new process innovations.

8.2.1 Tests for Productivity Change

Prior studies in production economics have used both parametric and nonparametric methodologies to measure productivity change in various industries, such as railroads, banking, and pharmaceuticals (Caves et al. 1981, Färe et al. 1994, Wheelock and Wilson 1999). Parametric methods accommodate well-specified statistical tests of productivity change but require explicit assumptions on the structure of the production correspondence. Most nonparametric methods measure productivity change under very
general assumptions about the structure of the production correspondence. However, their usefulness is limited because of the lack of statistical foundation. In this study we use the nonparametric estimation procedures based on data envelopment analysis (DEA) to estimate technical change, relative efficiency change, and productivity change.

Following Banker et al. (2005), we adopted a modified version of the Malmquist index to measure productivity change. More specifically, taking logarithms on both sides of Eq. 8.15 has the natural interpretation of a percentage change in productivity and is expressed as follows:

\[
\ln(M) = \ln(\text{PEFFCH}) + \ln(\text{SCH}) + \ln(\text{TECHCH}) \tag{8.20}
\]

where

\[
\ln(M) = \text{the percentage growth in productivity from the pre-MTE to post-MTE period,}
\]

\[
\ln(\text{TECHCH}) = \text{the percentage technical progress taking account of the production frontier,}
\]

\[
\ln(\text{PEFFCH}) = \text{the percentage change in pure efficiency relative to peers on the efficiency frontiers, and}
\]

\[
\ln(\text{SCH}) = \text{the percentage change of scale component.}
\]

The percentage change in pure efficiency reflects movement toward, or away from the production frontier, and referred to as “catching up to the frontier”.

A value greater than zero for \( \ln(M) \), \( \ln(\text{TECHCH}) \), \( \ln(\text{PEFFCH}) \) and/or \( \ln(\text{SCH}) \) represents an improvement in that measure from the pre-MTE to post-MTE period, while a value less than zero indicates the opposite, that is, a deterioration in performance over time.

**Figure 8.2: Productivity change and its components**
This modified DEA approach of Banker et al. (2003) is illustrated in Figure 8.2 and it is appropriate when there is a technical progress from the pre-MTE period to the post-MTE period for LAGs. Furthermore, it has the advantage of providing explicit statistical characterizations of productivity change.

8.2.2 Changes in Efficiency over Time
We first estimate relative efficiencies for the post-MTE period using exactly the same variables and output DEA models of the previous chapter. The technical and scale inefficiencies of the 39 LAGs for 2005 and 2006 as well as their calculated returns to scale (RTS) are estimated from DEA envelopment models. The results are presented in Table 8.1.

**Table 8.1: Relative inefficiencies in the pre- and post-MT implementation periods**

<table>
<thead>
<tr>
<th>LAG name</th>
<th>Pre-MT period</th>
<th>Post-MT period</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CRSE</td>
<td>VRSE</td>
</tr>
<tr>
<td>ACHAIA</td>
<td>1.471</td>
<td>1.071</td>
</tr>
<tr>
<td>AITOLIKI</td>
<td>1.75</td>
<td>1.298</td>
</tr>
<tr>
<td>AKOMM</td>
<td>1.173</td>
<td>1.144</td>
</tr>
<tr>
<td>ANKO</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>ANVOPE</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Region</td>
<td>Efficiency 1</td>
<td>Efficiency 2</td>
</tr>
<tr>
<td>-------------</td>
<td>--------------</td>
<td>--------------</td>
</tr>
<tr>
<td>CHALKIDIKI</td>
<td>1.036</td>
<td>1</td>
</tr>
<tr>
<td>DODEKANISSA</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>DRAMA</td>
<td>1.19</td>
<td>1.137</td>
</tr>
<tr>
<td>EVROS</td>
<td>1.998</td>
<td>1.986</td>
</tr>
<tr>
<td>ELASSONA</td>
<td>1.959</td>
<td>1.707</td>
</tr>
<tr>
<td>ELIKONAS</td>
<td>2.134</td>
<td>2.015</td>
</tr>
<tr>
<td>ETANAM</td>
<td>1.751</td>
<td>1.316</td>
</tr>
<tr>
<td>FLORINA</td>
<td>1.512</td>
<td>1.43</td>
</tr>
<tr>
<td>FOKIKI</td>
<td>1.650</td>
<td>1</td>
</tr>
<tr>
<td>IMATHIA</td>
<td>1.869</td>
<td>1.714</td>
</tr>
<tr>
<td>EPIRUS</td>
<td>1.177</td>
<td>1.124</td>
</tr>
<tr>
<td>HERAKLION</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>KARDITSA</td>
<td>1.884</td>
<td>1.51</td>
</tr>
<tr>
<td>ANKAS</td>
<td>2.610</td>
<td>2.264</td>
</tr>
<tr>
<td>KAVALA</td>
<td>1.963</td>
<td>1.948</td>
</tr>
<tr>
<td>KEFALONIA</td>
<td>2.042</td>
<td>1.042</td>
</tr>
<tr>
<td>KENAKAP</td>
<td>1.546</td>
<td>1.397</td>
</tr>
<tr>
<td>KERKIRA</td>
<td>1.601</td>
<td>1.396</td>
</tr>
<tr>
<td>KILKIS</td>
<td>1.471</td>
<td>1.071</td>
</tr>
<tr>
<td>LASSITHI</td>
<td>1.75</td>
<td>1.298</td>
</tr>
<tr>
<td>ETAL</td>
<td>1.173</td>
<td>1.144</td>
</tr>
<tr>
<td>LIIMNOS</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>OADYK</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>OLIMPIA</td>
<td>1.036</td>
<td>1</td>
</tr>
<tr>
<td>PARNONAS</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>PELLAS</td>
<td>1.19</td>
<td>1.137</td>
</tr>
<tr>
<td>PIERIKI</td>
<td>1.998</td>
<td>1.986</td>
</tr>
<tr>
<td>PILIO</td>
<td>1.959</td>
<td>1.707</td>
</tr>
</tbody>
</table>
A total of 14 LAGs (36 %), are identified as CRS-efficient at least once either in 2005 or 2006. The large majority of efficient LAGs in the 1st period are also efficient in the 2nd period. This may provide an indication that some LAGs are able to deliver services more efficiently than others. On the other hand, there are 23 LAGs (58 %) that are identified as CRS -inefficient in both periods.

In addition, there are 13 and 22 LAGs that are purely technically efficient (VRS efficiency equal to 1) in 2005 and 2006, respectively. Four of them namely, CHALKIDIKI, FOKIKI, LIMNOS and XANTHI are not scale efficient in 2005 while only two of them, namely, FOKIKI, and LIMNOS are still not scale efficient in 2006.

In 2005, twenty-one (21) inefficient LAGs exhibit local increasing returns to scale and nine (9) LAGs have local decreasing returns to scale with varying degrees of scale efficiency. In 2006 only fifteen (15) inefficient LAGs exhibit local increasing returns to scale and ten (10) LAGs have local decreasing returns to scale with varying degrees of scale efficiency.

Table 8.2 reports descriptive statistics of inefficiencies. From Panel A, we observe that average CRS-administration inefficiency decreased from 1.459 to 1.281 in moving from the pre- to post-MTE period. This suggests that LAGs’ efficiencies improved in the post-MTE period.

The same pattern follows pure and scale average efficiencies. More specifically, it is worth noticing that following the official mid-term evaluation of the program, the pure administration efficiency in terms of services delivered increased significantly. Based on the mean level of pure technical inefficiency across the entire sample the 2005 (2006) results suggest that, on average, the whole national program could increase its delivery
speed through improvements of LAGs’ services by at least 27.7% (17.3%) of their current volume level. Similar trend is suggested from panel B of Table 9.2 which presents the number of LAGS defining the frontiers of interest: 9 and 14 LAGs are on the CRS frontiers of the pre- and post-MTE periods, respectively. The same pattern follows pure and scale frontiers.

**Table 8.2: Descriptive statistics of relative inefficiencies in the pre- and post-MT implementation periods**

<table>
<thead>
<tr>
<th></th>
<th>Pre-MT period</th>
<th></th>
<th>Post-MT period</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CRSE</td>
<td>VRSE</td>
<td>SE</td>
<td>CRSE</td>
</tr>
<tr>
<td>Panel A: Descriptive statistics on inefficiencies</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>1.459</td>
<td>1.277</td>
<td>1.149</td>
<td>1.281</td>
</tr>
<tr>
<td>Standard deviation</td>
<td>0.065</td>
<td>0.055</td>
<td>0.033</td>
<td>0.047</td>
</tr>
<tr>
<td>75% (third quartile)</td>
<td>1.750</td>
<td>1.414</td>
<td>1.160</td>
<td>1.441</td>
</tr>
<tr>
<td>Median</td>
<td>1.436</td>
<td>1.137</td>
<td>1.059</td>
<td>1.240</td>
</tr>
<tr>
<td>25% (first quartile)</td>
<td>1.063</td>
<td>1</td>
<td>1.007</td>
<td>1</td>
</tr>
<tr>
<td>Panel A: Number of LAGs defining the frontier</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>13</td>
<td>9</td>
<td>14</td>
</tr>
</tbody>
</table>

Table 8.3 shows the observed number of LAGs that experienced changes over time in overall efficiency and decomposes them into pure efficiency and scale efficiency change components.

**Table 8.3: Number of LAGs that experienced changes in efficiency**

<table>
<thead>
<tr>
<th>Direction of Change</th>
<th>CRSE</th>
<th>VRSE</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increase</td>
<td>24</td>
<td>19</td>
<td>23</td>
</tr>
<tr>
<td>Not change</td>
<td>9</td>
<td>13</td>
<td>10</td>
</tr>
<tr>
<td>Decline</td>
<td>6</td>
<td>7</td>
<td>6</td>
</tr>
</tbody>
</table>
Out of 39 LAGs, the majority, 24 (61%) experienced overall efficiency increases. Substantially fewer LAGs, 6 (15%), are identified as having overall efficiency declines while 9 (23%) kept their efficient status. Out of 39 LAGs, 19 (48%), have significant pure efficiency increases and a smaller number of 13 (33%) kept their pure efficient status, while a minority of LAGs, 7 (18%), are observed to experience pure efficiency losses. Scale efficiency change (i.e. due to increasing or decreasing returns to scale) shows similar patterns as overall efficiency.

Table 8.4 shows the causes of overall efficiency change. We see that out of 24 LAGs experienced an increase in overall efficiency, 14 (58%) experienced this increase due to both pure efficiency and scale efficiency increase while in the case of 5 (20%) LAGs this is attributable only in pure efficiency increase and the remaining 5 (20%) LAGs faced overall efficiency increases attributable to scale efficiency increases.

A smaller number of LAGs are observed to experience overall efficiency decreases, which in two cases are caused by declines in both pure and scale efficiency. Four LAGs shows efficiency declining which is caused by declines only to pure efficiency decrease.

**Table 8.4: Causes of overall efficiency change**

<table>
<thead>
<tr>
<th>Direction of Change</th>
<th>Source</th>
<th>Direction of Change</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Improvement</td>
</tr>
<tr>
<td>Increase</td>
<td>PEC and SEC increase</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>PEC increase</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>SEC increase</td>
<td>5</td>
</tr>
<tr>
<td>Decrease</td>
<td>PEC and SEC decrease</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>PEC decrease</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>SEC decrease</td>
<td>0</td>
</tr>
<tr>
<td>Not change</td>
<td>neither PEC nor SEC change</td>
<td></td>
</tr>
</tbody>
</table>
8.2.3 Productivity Change Estimation
The Malmquist Index can be calculated in several ways. In this section, we estimate an output-oriented Malmquist Productivity Index which is based on DEA. As we have already mentioned we use output-oriented efficiency measurements since these are more appropriate in a program delivery framework. In output-oriented models, such as the one adopted in this study, DEA seeks to identify technical inefficiency as a proportional increase in output production given inputs.

As we have already mentioned, DEA allows for the estimation of total productivity change in the form of a Malmquist index. Malmquist indexes which denote productivity change, are broken down into relative efficiency change and technological efficiency change. Moreover, relative efficiency change is broken down into pure efficiency change and scale-efficiency change.

The original DEA models focused primarily on the estimation of the production frontier and relative efficiency. They did not explicitly consider the statistical properties of the DEA estimators. Subsequently, Banker (1993) showed that while the DEA estimator of the frontier value is biased for finite samples, the bias vanishes for large samples. Thus, the DEA estimator exhibits the desirable asymptotic property of consistency. More recently, Banker et al. (2002) have shown that the sample mean and median of DMU-specific estimators of technical change, relative efficiency change, and productivity change derived from the DEA estimators of the production frontier values in a base period and a subsequent period are consistent estimators of the population mean and median of these change variables. They also prove, that the asymptotic distributions of test statistics derived from the DEA estimators to evaluate hypotheses on population mean and median, are the corresponding distributions of test statistics based on the true frontier outputs and true efficiencies if these are known.

8.2.4 Overall Productivity Change from the pre- to post-MT period
Table 8.5 presents the results of productivity growth (M) and changes in its components from the pre-MT to post-MT evaluation period. The results indicate that LAGs, on average, experienced an approx. 16.9% increase in average productivity between 2005 and 2006. In addition, we found that the productivity gain may be primarily attributed to a change in relative efficiency rather than to technical progress; indeed, average relative
efficiency (EC) increased by 11.7% while average technological progress (TC) slightly increased by 5.3%.

The EC is the result of adding PEC and SEC. On average, improvements in PEC, that is, operations and management activities are the main reason for the improvements in EC.

The average value of PEC, which measures changes in technical efficiency under VRS, indicates that there is an improvement of 7.38% over the examined period. From the five components analysed in Table 8.5, neither component has an average value below 0, which suggests a deterioration of the component efficiency.

Table 8.5: Tests of productivity change between pre- and post-MT periods

<table>
<thead>
<tr>
<th>Change measure</th>
<th>Mean</th>
<th>t-test of mean = 0 (p-value)</th>
<th>Median</th>
<th>Sign test for median = 0 (p-value)</th>
<th>Sign rank test for median = 0 (p-value)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Productivity change (M)</td>
<td>0.1698</td>
<td>0.000</td>
<td>0.1623</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td>Technical change (TC)</td>
<td>0.0530</td>
<td>0.000</td>
<td>0.0354</td>
<td>0.001</td>
<td>0.000</td>
</tr>
<tr>
<td>Relative efficiency change (EC)</td>
<td>0.1168</td>
<td>0.001</td>
<td>0.0688</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td>Pure efficiency change (PEC)</td>
<td>0.0738</td>
<td>0.001</td>
<td>0</td>
<td>0.014</td>
<td>0.001</td>
</tr>
<tr>
<td>Scale efficiency change (SEC)</td>
<td>0.0429</td>
<td>0.003</td>
<td>0.0177</td>
<td>0.000</td>
<td>0.000</td>
</tr>
</tbody>
</table>

Notes: The p values are for testing whether relative change measure is significantly greater than zero. All results are significant at least at the 1% level for one-sided
hypothesis tests. Productivity change = technical change + relative efficiency change. Relative efficiency change = pure efficiency change + scale efficiency change.

8.2.4.1 Individual Productivity Change Estimation

The individual productivity change results for the 39 LAG between pre- (2005) and post- (2006) MT periods are presented on Table 8.6.

Table 8.6: Estimated productivity change between pre- and post-MT periods

<table>
<thead>
<tr>
<th>LAG #</th>
<th>LAG name</th>
<th>PEC</th>
<th>SEC</th>
<th>EC</th>
<th>TC</th>
<th>M</th>
</tr>
</thead>
<tbody>
<tr>
<td>LAG 01</td>
<td>ACHAIA</td>
<td>0.0686</td>
<td>0.0003</td>
<td>0.0688</td>
<td>0.0935</td>
<td>0.1623</td>
</tr>
<tr>
<td>LAG 02</td>
<td>AITOLIKI</td>
<td>0.1777</td>
<td>0.1148</td>
<td>0.2924</td>
<td>0.0423</td>
<td>0.3347</td>
</tr>
<tr>
<td>LAG 03</td>
<td>AKOMM</td>
<td>0.1348</td>
<td>0.0251</td>
<td>0.1599</td>
<td>0.0043</td>
<td>0.1642</td>
</tr>
<tr>
<td>LAG 04</td>
<td>ANKO</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.0103</td>
<td>0.0103</td>
</tr>
<tr>
<td>LAG 05</td>
<td>ANVOPE</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.0753</td>
<td>0.0753</td>
</tr>
<tr>
<td>LAG 06</td>
<td>CHALKIDIKI</td>
<td>0</td>
<td>0.0355</td>
<td>0.0355</td>
<td>0.4014</td>
<td>0.4369</td>
</tr>
<tr>
<td>LAG 07</td>
<td>DODEKANISSA</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>-0.0696</td>
<td>-0.0696</td>
</tr>
<tr>
<td>LAG 08</td>
<td>DRAMA</td>
<td>-0.0499</td>
<td>-0.0258</td>
<td>-0.0757</td>
<td>0.0589</td>
<td>-0.0168</td>
</tr>
<tr>
<td>LAG 09</td>
<td>EVROS</td>
<td>0.3642</td>
<td>0.0031</td>
<td>0.3673</td>
<td>-0.0163</td>
<td>0.3510</td>
</tr>
<tr>
<td>LAG 10</td>
<td>ELASSONA</td>
<td>0.2354</td>
<td>0.1090</td>
<td>0.3445</td>
<td>0.0669</td>
<td>0.4114</td>
</tr>
<tr>
<td>LAG 11</td>
<td>ELIKONAS</td>
<td>0.3719</td>
<td>0.0035</td>
<td>0.3754</td>
<td>0.1059</td>
<td>0.4813</td>
</tr>
<tr>
<td>LAG 12</td>
<td>ETANAM</td>
<td>-0.1988</td>
<td>0.0340</td>
<td>-0.1648</td>
<td>0.0908</td>
<td>-0.0740</td>
</tr>
<tr>
<td>LAG 13</td>
<td>FLORINA</td>
<td>-0.0179</td>
<td>0.0554</td>
<td>0.0375</td>
<td>0.0640</td>
<td>0.1015</td>
</tr>
<tr>
<td>LAG 14</td>
<td>FOKIKI</td>
<td>0</td>
<td>0.2968</td>
<td>0.2968</td>
<td>-0.0485</td>
<td>0.2483</td>
</tr>
<tr>
<td>LAG 15</td>
<td>IMATHIA</td>
<td>0.0994</td>
<td>0.0177</td>
<td>0.1171</td>
<td>-0.0235</td>
<td>0.0936</td>
</tr>
<tr>
<td>LAG 16</td>
<td>EPIRUS</td>
<td>0.0580</td>
<td>0.0331</td>
<td>0.0911</td>
<td>0.0265</td>
<td>0.1177</td>
</tr>
<tr>
<td>LAG 17</td>
<td>HERAKLION</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.0119</td>
<td>0.0119</td>
</tr>
<tr>
<td>LAG 18</td>
<td>KARDITSA</td>
<td>0.2082</td>
<td>-0.0099</td>
<td>0.1983</td>
<td>0.0551</td>
<td>0.2534</td>
</tr>
<tr>
<td>LAG 19</td>
<td>ANKAS</td>
<td>0.3046</td>
<td>0.0504</td>
<td>0.3550</td>
<td>0.0382</td>
<td>0.3933</td>
</tr>
<tr>
<td>LAG 20</td>
<td>KAVALA</td>
<td>0.3750</td>
<td>0.0022</td>
<td>0.3772</td>
<td>-0.0102</td>
<td>0.3670</td>
</tr>
<tr>
<td>LAG 21</td>
<td>KEFALONIA</td>
<td>0.0409</td>
<td>0.3177</td>
<td>0.3587</td>
<td>-0.0476</td>
<td>0.3110</td>
</tr>
</tbody>
</table>
At individual level, regarding the relative efficiency change (EC), we see that most LAGs showed an increase in their technical efficiency. This is specially observed in LAG 20. Precisely, these LAGs are closer to the frontier in 2006 when compared to the frontier of 2005. LAGs 4, 5, 7, 17, 25, 30, 31, 32 and 36 show values of EC which are equal to 0. This means that there are not changes in technical efficiency from 2005 to 2006. On the contrary, LAGs 8, 12, 22, 23, 29, and 37 decreased their relative efficiency between 2005 and 2006. This suggests that in 2006 these LAGs are further away from the efficiency frontier compared to 2005.

Analysing technical change (TC) results, LAGs 7, 9, 14, 15, 20, 21, 23, 29, 30 and 37 have a value lower than 0; hence, they present technological regression. All other LAGs
have technical change values greater than 0. Therefore, between 2005 and 2006, there is a positive change in their technological frontier (technological progress). This means that, for a given level of input, it is possible to obtain a higher level of output in 2006 compared to 2005, because of the expansion of the frontier between the two periods.

Relative to Malmquist index, we can see that the estimation for productivity change is higher than zero for most delivery units, with the exception of seven units, showing that a large proportion of the units experienced gains in total productivity in the examined period. Estimation results suggest that LAGs 7, 8, 12, 23, 29, 30 and 37 decreased their productivity, since they have values lower than 0 for this index. It is worth noticing that from the 6 LAGs (8, 12, 22, 23, 29 and 37) presenting decreases in technical efficiency, only LAG 22, managed to overcome this situation with very positive changes in its technological frontier. This is strongly contributed to the recorded productivity gains.

While EC refers to changes in relative efficiency calculated under CRS, PEC corresponds to changes in pure efficiency with regard to VRS and represents changes resulting from efficiency improvements in operations and management activities. This decomposition allows us to analyse situations in which a DMU may be technically effective - since the volume of production uses the least amount of resources, however is not operating at the optimal scale. SEC shows the movements inside the boundary that are in the right direction to reach the CRS point.

Regarding pure efficiency change estimation results (PEC), PTEC values show that the relationship between inputs and outputs in LAGs 8, 12, 13, 22, 23, 29 and 37 worsened between 2005 and 2006; that is, these LAGs in 2006 are farther away from the VRS frontier formed by the reference LAG compared to the frontiers of 2005. All others LAGs improved or maintained their pure efficiency due to improvements in operations and management activities between 2005 and 2006. The improvement in pure technical efficiency, which means an improvement in managerial skills, shows that there was investment in organisational factors associated with the management of the delivery units, such as a better balance between inputs and outputs, best-practice initiatives and so on.

With respect to scale efficiency change estimations (SEC), we find that LAGs 8, 18, 22, 24, 28 and 35 deteriorated their scale (size) in this period since they have values lower than 0. Nine LAGs (4, 5, 7, 17, 25, 30, 31, 32 and 36) do not present scale issues and are
operating on the frontier of CRS (most productivity scale size) in both periods. Thus, twenty four LAGs improved their scale efficiency.

The breakdown of the change in technical efficiency into pure technical efficiency change and scale efficiency change shows mixed results. Some LAGs obtain gains in one performance dimension but losses in the other. Remaining LAGs obtain simultaneous gains in both performance dimensions. LAGs 12, 13, 18, 23, 28, 29, 35 and 37 present mixed results.

8.3 Concluding Remarks
In this chapter DEA was used a two time period framework to detect trends in relative program delivery productivity change over time which sharpens the managerial assessment exercise. For example, it was possible to identify LAGs that were relatively efficient in the first period while in the second period become relatively inefficient and vice versa. This allowed program assessment to focus on dynamic as well as static sources of inefficiencies.
9. DETERMINANTS OF PROGRAM’S PERFORMANCE

9.1 Introduction
The context might influence the operational performance (Andrews et al. 2005; Pettigrew, Ferlie, and McKee 1992; Thompson 1967). When DEA is used for measuring efficiency, often, in a second stage, a regression model is estimated in order to relate the DEA efficiency scores with exogenous factors (Ray, 1991; McCarty and Yaisawarng, 1993; Duncombe et al., 1997; Chilingerian and Sherman, 2004; Ray, 2004; Ruggiero, 2004). Ray (1988, 1991) was the first to propose and apply this approach, justifying the use of a Tobit model instead of the ordinary square regression. What is missed from this approach is a serious data-generating process (DGP) that would conceptually link the non-parametric deterministic DEA efficiency score with the statistical two-stage regression analysis. Simar and Wilson (2007) defined a DGP that would make the second stage regression analysis more sensitive. They recommended the use of maximum likelihood estimators of truncated regression and smooth bootstrapping for valid inferences in the second stage regression. Banker and Natarajan (2008) have advanced a DGP that has a much less restrictive form than the DGP proposed by Simar and Wilson (2007). Banker and Natarajan (2008) justify the use of simple ordinary least square (OLS) or even Tobit estimation for the second stage parametric regression analysis. In this study we follow the analysis of the Banker and Natarajan (2008) and we apply both an OLS and a Tobit model in order to assess the impact of contextual variables on the efficiency estimates of the LAGs.

9.2 Hypothesis Formulation
In this subsection, we discuss the main hypotheses to be tested in the empirical part and give an overview of existing literature.
9.2.1 Organizational and Program Size

Many scholars have claimed that size matters for organizational performance and it is a very important dimension of organizational structure that has been examined in public services (Child, 1972; Dalton et al. (1980), Hall (1977), O’Toole and Meier (1999). The advantages that come from large or small organizations have been outlined plenty of times. Traditional arguments on public service structure propose that the consolidation of small units improves service coordination and economies of scale. On the other hand, public choice theorists suggest that fragmentation promotes responsiveness and efficiency (Boyne, 1998). No matter which side is right, it is possible that the relationship between size and performance is nonlinear—excessively small or large organizations may be less successful than their medium-sized counterparts (Boyne, 2003).

As far as organizational size is measured by staff, the relationships that have been found are often positive linear relationship (Bradley et al., 2001; Glisson and Martin, 1980; Greid et al., 2006). Negative linear relationship is found also in many other cases (Amirkhanyan et al., 2008; O’Toole and Meier, 2004). Inverted U-shaped relationship is found by Boyne (1996) and U-shaped relationship by Meier and Bohle (2000). Finally, non-significant relationship is found by Duncombe et al. (1997) and Lan & Rainey, (1992). According to Boyne (2003) further research on the relationship between organizational size and performance in a more comprehensive model is needed.

Many explanations and methodological approaches have been used in order to examine size influence on organizational productivity and efficiency. One approach to explain size effect is contingency theory (Zinn & Mor, 1998). According to this theory, organizational performance is depended on the fit between its choice of mechanisms for communication, coordination, and integration of effort across the organization and its operating context. As a unit increases in size, its organizational structure becomes more complex. Consequently, as the number of employees increases, there is a tendency to formalize and standardize work processes as well as increase the levels of management control (Mills, 1986). The larger units also tends to have more specialized staff that develop their specialized managerial roles to make communication and coordination between staff more effective and efficient (Munson & Zuckerman, 1983). These effects can cause changes in the mechanism of communication, coordination, and integration, thus affecting the unit’s efficiency. When the increase in size can both support the unique
nature of the unit’s production process and complement its operating environment, such increase can positively contribute to unit efficiency.

Another explanation of size effect is addressed by economies of scale (Feldstein, 1983). With economies of scale, the larger the firm, the lower its average cost will be. Beyond the cost dimension, economies of scale can also be applied to resource utilization to explain size effect on efficiency improvements (Conway, 1988). From this perspective, larger organizations can afford greater specialization of labour, equipment, and facilities and delegate these operational capacities to their fullest extent. In addition to the advantages from an increase in size, Feldstein (1983) points out that as an organization grows in size, it will experience not only the advantages from economies of scale but also the increasing management challenges due to a more complex organizational structure. Taking into consideration these two points of view, for a unit, efficiency tends to increase with size if the advantages accruing from economies of scale are greater than the proportion of time and effort required to coordinate and control work in the larger unit.

In addition to contingency theory and economies of scale, size effect on organizational efficiency can be explained through its influence on the management’s role (Munson & Zuckerman, 1983).

As described above, organizational size could have a linear, log-linear or squared linear relationship with organizational performance (Dalton et al., 1980). Furthermore, although, due to its importance, numerous empirical studies have considered organizational size for organizational performance in the public service sector, there has been no development of a consistently systematic relationship between program size and program performance. Hence, the need for more research in size is obvious.

According to MT Synthesis Report, the size of the LAG staff varies between member states and depends on the amount of administrative tasks delegated to them, area and/or population covered by program or budget of program. The larger LAGs with the largest budgets have a coordinator working full-time. The functions vary a lot, but all coordinators are responsible for the administration tasks. LAG staff might comprise LAG managers, project advisors and activators. LAG managers are developing project ideas, advising project applicants and project promoters, give out information, supervise the realization of the strategy, act as a secretary of board meetings, and are carrying out financial, reporting and administrative tasks. Duties of the project advisor/activator
include advising project applicants and promoters and office secretarial duties. Most of LAGs have service contracts with staff without fixed working hours. Administrative Manager - to organize and carry out work related to the implementation of the development strategy (preparation of contracts and other related documents, preparation of reports, preparation of publications, provision of advice to potential project applicants and beneficiaries about the implementation of projects, organisation of seminars, communication with the Payment Authority, the Management Authority, the Rural network, the Rural Forum (LAGs network), other LAGs, decision making body of LAG, participation in information seminars about actualities in the implementation of Leader approach. Finance Manager - the accounting records and preparation of reports, provision of advice to potential applicants about project accounting issues, participation in information seminars.

In Greece it is estimated that there are 1 coordinator and 3-4 persons per LAG. The main tasks are coordination & management of the local strategy, information – publicity, project assessment, project monitoring, administrative checks, payment of claims and to provide all relevant information about the projects to the IT system for rural development program. The LAGs with the largest budgets can also have an economist and perhaps someone working more closely with the projects.

A significant number of LAGs, have a very small staff and many face difficulties in performing the multiple tasks required of them, especially if they have responsibility for control tasks. Larger LAGs tend to have a greater range of responsibilities. The prevalence of small LAG teams is a matter requiring further consideration as inadequately equipped LAGs may undermine the viability of Leader. LAGs are meant to be local structures with the capacity to perform the tasks required for the implementation of their local development strategy, including animation, administration, and assessment and, even, control. This requires for a critical mass in the staff complement of the LAG (full-time and/or part-time) and a separation of functions.

The MT Synthesis Report concludes that the 20% running cost ceiling relative to program budget is likely not to be enough in the case of LAGs with a control task or generally with a wide array of administrative tasks in the case of local development programs with very low budgets.
Approximately an average of 13% of the program budget in Europe and 20% in Greece was targeted at LAG administration. A notable problem in implementing the program was the insufficiency of resources for administration. When viewed from the perspective of the budgetary allocations the smallest LAGs are least satisfied. This implies that it is small LAGs with small budgets that are the most challenged. This may reflect the effects of the prorated capping of financial allocations for management and administration.

The perception of LAG managers was that the fund for administrative tasks did not go only to administrative functions but that also activating (animation) activities, maintaining networks and regional, national and international cooperation were part of these administrative actions. Resources for all these administrative actions were far too low. England reports also highlighted that some LAGs were constrained by the budgetary allocation.

Concerns over the adequacy of resources raised by a number of MAs (including Bavaria, Luxembourg, Estonia, some Italian regions, Spain and a number of its regions) highlighted high administrative and bureaucratic demands placed on LAGs under LEADER+ by comparison with previous periods; some indicated that this had been extended into the current program period.

Many of the concerns raised over the adequacy of these resources relate to the levels of staff which LAGs were required to carry in order to cover these tasks and mechanisms. These appear to vary widely from 2 to 5 or more. National or regional systems and requirements may have had a significant effect here and explain some of the differences in perspective. The scale and budget of LAGs is also an issue here as highlighted in England where small budget LAGs were thought to be disadvantaged by the pro-rated basis of funding allocation which meant that a greater proportion of staff resource was necessarily committed to core administrative tasks rather than the strategic and value adding activities of promotion and animation of high quality project activity. In Poland the fact that 50% of staff time was spent on administration was seen as a constraint.

Ex-post evaluation of LEADER+ (Metis, 2010), as far as implementation of program in Extremadura, Spain is concerned, refers to “excessive administrative bureaucracy of the program resulting in the technical team being constantly overloaded and with not enough time to implement its communication and promotion program as planned.” Moreover, the report indicates that, “uncertainties in the face of the numerous procedures in the
management of the program had reduced the motivation and confidence of both the technical team and the board as well as that of the population in general.

Based on above considerations and public services literature review, we expected both Size of LAG staff and Program’ Budget to strongly relate with delivery productivity.

*Hypothesis 1: we expected Size of LAG to relate with delivery productivity although the linearity of their interaction is not clear.*

*Hypothesis 2: we expected Size of local Program Budget to relate with delivery productivity although the linearity of their interaction is not clear.*

9.2.2 Local Area Characteristics

LEADER funds are distributed through Local Action Groups (LAG). The Local Action Groups operate in rural territories of a small size which form a homogeneous unit in physical (geographical), economic and social terms. The population must as a general rule be not more than 100000 in the most densely populated areas (around 120 inhabitants/km²) and in general not less than about 10000. Demography is probably the single most important supply-side determinant of economic activity in rural areas.

The distinctive feature of LEADER is the approach or LEADER method based on small scale, area based and multi-faceted activities. The 40 Greek LEADER+ local programs are being implemented in mountain regions –so characterized in the approved EU list of mountain, disadvantaged, and with special problems areas – and islands, as well as environmentally sensitive areas (e.g. NATURA 2000). These areas represent 63% (82.668 km²) of the country and 20% (2.121.549 inhabitants) of its population.

The relatively limited local area size— which is not too small in terms of achieving critical mass but also not large enough to dissipate the personal interactions between stakeholders – is one of the main advantages of LEADER. NUTS IV (NUTS: Nomenclature of Territorial Units for Statistics) is the level of the area that the local LEADER+ programs are implemented.

LEADER areas played a role of interface between an area based perspective and the global economy. The ex-post evaluation of LEADER+ confirmed that closeness or proximity is a trump card of LEADER. The blessings of proximity accrue from a relatively limited area size which is not too small in terms of achieving a critical mass,
but also not too large as to dissipate the personal interactions between stakeholders, promoters and supporters. LEADER areas ranged between NUTS IV and III. This size range can be related to institutional economies of scale: face-to-face communication and personal networks still play a leading part, whereas the achievable critical mass (concerning the number of people and stakeholders, the territorial scope and diversity, the volume of mobilisable funds) already allows for investing in formal organisations and semi-formalised networks.

Based on the above considerations, we included in the regression, as control variables, the size of LEADER surface and LEADER population in areas served by LEADER in order to check their influence in productivity of LEADER delivery.

\textit{Hypothesis 3a: we expected LEADER surface to positive influence the delivery productivity.}

\textit{Hypothesis 3b: we expected LEADER population to positive influence the delivery productivity.}

9.2.3 Competitive Programs

In the context of the various Common Structural Funds (CSFs), Greece has drawn up several Operational Programs aiming at the sustainable development of the agricultural sector and of rural areas. More specifically, during the 3rd Programming Period 2000-2006, i.e. the 3rd CSF, with regard to agricultural and rural development, priority has been given to the overall rural competitiveness in a sustainable and balanced way, with particular emphasis on the mobilization of private investment, the promotion of quality, improvements in manufacturing and marketing of agricultural products as well as the protection of natural resources and the environment. Based on the above general objectives, during the 3rd Programming Period 2000-2006, the Ministry of Rural Development and Food has been responsible for the drawing up, together with the related CEU Services, and the management of three OPs: i. The Operational Program for the “Agricultural Development and Reform of the Country-side” (OPADRC), ii. The “Agricultural Development Plan Document” (ADPD) as well as iii. The Operational Program of the Community Initiative “LEADER+” (LEADER+).

The aims and objectives of LEADER+ differ from those of the main structural funds. The purpose of the program is to support projects that test and pilot innovative approaches to
rural development; build community capacity to develop local initiatives; promote schemes which learn from other rural areas, and encourage participation in joint activities (LEADER is a funding program in specific sub.doc)

Simultaneous to LEADER+, the sub-program “OPAAX” [7th Priority Axis, titled as “Integrated Rural Development Program”, of OPADRC was introduced at the level of 40 designated territorial units. It had centralised management by the Ministry of Agriculture with a view to the development of the mountainous and disadvantageous rural areas of Greece and represented, in the spirit of LEADER, an innovative but more centralized approach to rural development programming and implementation. It included a series of measures addressing in particular the needs of rural population in mountainous and less-favoured areas of Greece.

Some degree of overlapping appeared between the LEADER+ and Integrated Rural Development Program (OPAAX). Since a number of measures were common among all rural development programs certain rules were issued for the better implementation of the programs. Thus, in the areas where both LEADER+ and the Integrated Rural Development Programs are implemented, at national level, and in the case that the same type of investment was supported under both programs (e.g. agro tourism, handicraft, preservation of the architectural heritage, protection of the environment, promotion of local products, cultural events etc.), those investments are financed and implemented only by the Integrated Rural Development Programs and LEADER+ could only support and implement “soft” type of investments (such as clusters, networking etc.). This arrangement aimed to avoid overlapping with regard to allowable activities among the programs and achieve complementarities between similar activities as well as increased added value (Efstratoglou and Mavridou, 2009).

It seems that together both programs generated a better impact than their respective individual effects due to complementarities and synergies that might arise. However, when similar programs were overlapping in place and time, targeting similar groups of potential beneficiaries, this might have negative influence in the implementation of either program due to over-supply of investment opportunities and to augmentation of relative administrative burden such as information provided to potential investors. Accordingly we expect that this fact, public support in similar scope and target groups as well as territorial and time overlapping might hinder the implementation of LEADER program.
We included in the regression two variables (percent surface and population overlapped by OPAAX) in order to check their influence in productivity of LEADER delivery and we expected them to negatively affect the delivery of LEADER+.

*Hypothesis 4a. Surface overlapped by OPAAX program negatively affect the delivery productivity of LEADER+.*

*Hypothesis 4b. Population overlapped by OPAAX program negatively affect the delivery productivity of LEADER+.*

### 9.2.4 Island located LAG

In relation to mainland, islands suffer from permanent constraints (e.g. accessibility problems due to insularity). The development of an area within the European borders and in the current development model framework depends on its attractiveness. The dominating model relies on economies of scale, accumulation and high accessibility (ESPON and the University of the Aegean, 2009).

The European Union recognises that the islands suffer from disadvantaging external natural and economic circumstances. Economic opportunities exist either related to the sustainable management of their natural and cultural assets or to the exploitation of new technologies, the shift of human preferences towards “healthy” and high quality products, the renewable energy sources. ESPON studies (ESPON and the University of the Aegean, 2009-2011) have documented that areas with “low urban influence and low human footprint” display good socio-economic performances and that regional competitiveness can be achieved through “soft infrastructure” in order to exploit local assets as quality of life, natural and cultural heritage. Therefore, an appropriate policy framework for the European islands has to be elaborated that should pursuit the increase of their attractiveness for sustainable living and entrepreneurship so that they could keep pace (in terms of development) with the continental mainland.

Tsobanoglou and Vlachopoulou (2013), argue that the Greek state should promote participation by supporting collaboration within and among the insular communities. Such an initiative would allow for the development of local structures which would be based upon locality, would exploit the comparative advantages of each community and sustain and enhance cohesion and solidarity, which would in turn contribute to further
development of local structures. It would result in a positive feedback which would accelerate the processes of reaching the local growth potential.

Efficiency of policies and programs mainly depends on national and regional governance giving perhaps the impression that insularity has no impact on the results; the fact is that the efficiency of a policy is lower in an island region in comparison with the efficiency of the same policy on the continental area of the same Member State; this stands for infrastructure construction, for training courses, for environmental management etc. as economies of scale are not possible and the transfer of personnel, resources and machinery on islands costs. At the same time human capital in an island region is lower than at the mainland of the same MS; this fact implies less competences and know-how for effective planning in the islands of a MS than on his mainland (ESPON and the University of the Aegean, 2011). Based on above considerations, we expected a negative correlation if the LAG is operated in an island with its delivery productivity.

_Hypothesis 5: LAGs that operated in an island negatively influence the delivery productivity of LEADER+._

9.2.5 Pre-Selection Ranking of LAG

A Local Action Group (LAG) selection procedure was put in place by the Greek Managing Authority (MA) of LEADER+ program in order to improve the quality and efficiency of Local Development Strategies (LDS). The MA set mandatory and qualitative selection criteria for the LAGs and organized a public call for tenders, with these criteria.

Implementation of LEADER program was through LAGs selected in an open procedure based on the criteria laid down in the program. These included the rural nature of the territories, their homogeneity in physical, economic and social terms, and integrated and innovative development plans. Economic and social partners and associations had to make up at least 50% of the local partnership, and the relevance and effectiveness of this partnership was also taken into account. These criteria were related to the LAG as a legal organisation as well as with the seven specific features of LEADER and the quality of their Local Development Strategies. (bottom up approach, innovative approach, multi-
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sector integration, equity and sustainability, cooperation and complementarity, realistic budgeting, municipal commitment and co-financing).

LAGs submitted a bid, setting out what they aimed to deliver and what level of funding they required to achieve their chosen local development strategy. These bids were assessed by a selection panel approved with Ministerial decision No 509/6.6.2002. Bids were subject to a competitive process based on a set of criteria devised by the Ministry of Agriculture and were included in approved by the EC LEADER+ Greek program. In total 52 proposals were submitted, 10 of which were rejected at the examination of minimal criteria of integration (legal form, local installation, region of intervention, population, determination of level of decision-making, existence of ex-ante evaluation etc.) or because in one or more groups of criteria they assembled grades below 50.

The remainder 42 proposals were ranked in decreasing order. Finally the committee selected the first 40 programs as it was predefined in the approved LEADER+ program.

The final step was the formal approval of the LAG and its Local Development Strategies. At this stage, public funds are allocated to each of the approved LAGs with No 830/1.8.2002 decision of the Minister of Agriculture. If the funding was considerably less than requested, a LAG had a chance to adapt its targets to the available budget. Based on the above considerations, we expected a positive correlation of LAGs’ approval/preselection ranking with its delivery productivity.

Hypothesis 6: LAGs that had higher ranking during LAG selection procedure by Ministry of Agriculture will positively influence the delivery productivity.

9.2.6 LAG’s Management Experience
Another factor considered as being critical for the delivery system of rural development policies is the adequacy of staff members in terms of expertise which, according to Mantino et al. (2009), affects positively the delivery of the measures.

LEADER requires good program management and a bit more. Deficiencies in program management tend to have more detrimental effect on LEADER than other programs simply because of its complexity. The MTE reports repeatedly list these deficiencies: (i) excessive bureaucracy; (ii) difficult relationships between managing and other involved authorities on one side and LAGs and project promoters on the other; (iii) problems with
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rising co-funding; (iv) delays in financing; and (v) insufficient autonomy of the LAG. The consequence of these deficiencies has been a loss of management efficiency (e.g. too much time spent on bureaucracy rather than mobilising and animating) and in due course disappointment of the local actors.

As mentioned in Synthesis of mid-term evaluations of LEADER+ programs the MTE reports confirm a strong relationship between experience in previous LEADER phases and effective program implementation without really defining the nature of the experience and where impact can be anticipated. According to Synthesis the essence of this experience lies in the value of experienced personnel which produces a dividend specifically in program design, the design of local action plans, a quicker start-up, etc. However, there is little data to show if inexperience caused difficulties or indeed if new ideas emerged where new people with little previous experience of LEADER+ were involved. There is no systematic knowledge accumulation and transfer from one LEADER phase to another. It is difficult to identify and describe common patterns of learning between the LEADER phases, either among the programming authorities or between the LAGs: the transfer of lessons seems to be mostly left to chance as very few instruments or tools seem to have been utilised to promote it on purpose. The national networks have developed case studies and established data bases of good practices. However, these are mainly data banks and little work seems to have been done on conceptual and methodological aspects, e.g. on the nature of pilot strategies, on how to involve women and young people in local development etc. All in all, the occasional events and meetings facilitated by the networks have fostered personal exchanges which eventually lead to mutual learning and the transfer of concepts and approaches.

According to ENRD (2010), many LAGs are experienced having operated in previous programming. The percentage of LAGs operating already under the previous programming periods varies from: almost 100% (Finland, Greece, Ireland, Portugal, ES Navarre, ES Basque Country, ES Balearic Isles, ES Cantabria, ES Murcia, ES Valencia) to 40% to 75% (France, Latvia, Poland, DE (Hessen, Bayern, Baden Wurttemberg, Niedersachsen, Nordrhein-Westfalen, Rheinland-Pfalz, Saarland, Sachsen-Anhalt) ES Aragon, ES Canary Isles, ES Madrid ES La Rioja, ES Castla la Mancha and IT) -0% to 25%. (Czech R., Denmark, DE Schleswig-Holstein, ES Catalonia, Slovakia, Slovenia,
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Sweden. Moreover, most of the LAGs in all countries, deliver other EU or national programs or funds.

Based on the above we expect that years of operation of a LAG is a variable that might determine its success or productivity as they can measure any learning or experience effects in the LAG. Delivery is a demanding task and expertise will occur with time and experience and we suppose that the LAG will learn from accumulating experience and specialized know-how.

Hypothesis 7: LAGs that have more years of operation will positively influence the delivery productivity.

9.2.7 Intervention- Mix Differences

Program’s implementation characteristics such as specialization and concentration are described here. These indices are included in the regression equation as explanatory variables to test the hypothesis that diversified program implementers and local size are influence delivery productivity.

The Specialization index; the specialization measure reflects the degree to which a LAG is specialized in certain interventions (or inversely the degree to which a LAG is diversified across interventions). We calculate the specialization index for each LAG (j=1 to 39) in each year (t=2005, 2006) across all its rural development interventions (r=1 to 9) as follows:

\[
SPI_{jt} = \sum_{r=1}^{9} \sum_{j=1}^{39} S_{jr}^2
\]

where \( r \) indexes the 9 interventions of the \( j^{th} \) LAG and \( S_{jr} \) equals the proportion of a LAG's Aggregated Output payments accounted for \( r^{th} \) intervention in each year (t=2005, 2006). The range of this index is \((1/s, 1)\), \( s=9 \) being the number of interventions. We included this variable to control for the effect of service specialization/diversity on LAG productivity. An implementation unit that focuses on delivering only one or a few rural interventions has a higher Specialization index, whereas a unit that offers a wider range of interventions has a lower Specialization index, indicating higher diversification in program interventions.
This Specialization index is closely related to the operational focus construct found within the operations management literature (Anderson, 1995; Bozarth & Edwards, 1997; Brush & Karnani, 1996; Hayes & Wheelwright, 1984; Ketokivi & Jokinen, 2006; Mukherjee et al., 2000; Pesch & Schroeder, 1996; Schmenner & Swink, 1998; Skinner, 1974). It is defined as the range or scope of program administration services offered by the LAG. Individual LAGs often exhibit administration competencies (skill or ability) based either on the local population and investors served or on the specific strategic direction dictated by LAG management and local Program Strategy. Therefore, individual LAGs will often exhibit varying levels of program administration volume. If the range of program administration services is narrowly focused, one would expect higher levels of program delivery efficiency.

*The Concentration index:* To control for the effect of local delivery concentration we include an industry concentration variable measured by the arithmetic sum of rural development intervention-specific Herfindahl Indexes. The Herfindahl-Hirschman index (HHI) is a commonly accepted measure of market concentration. Moreover, a lot of empirical studies employ this index in order to research how specialization and concentration of economic activities influence local and regional economic development (Aiginger & Davies, 2004; Hallet, 2002; Goschin et al., 2015).

The Herfindahl index is used as a measure of the size of local programs in relation to the intervention type. It is defined as the sum of the squares of the intervention shares of a LAG within that intervention, where the intervention shares are expressed as fractions.

We first calculate a Herfindahl concentration index for each intervention \((r=1 \text{ to } 9)\) across all LAGs \((j=1 \text{ to } 39)\) in each year \((t=2005, 2006)\):

\[
HHI_{jrt} = \sum_{j=1}^{39} ps_{jrt}^2
\] (2)

where \(ps_{jrt}\) is the payment share of the \(j^{th}\) LAG in each year in the \(r^{th}\) intervention. The calculation squares each intervention share value, thus it places a higher importance on those LAGs that have larger intervention shares.

We then calculate each LAG’s \((j=1 \text{ to } n)\) concentration index in each year \((t=2005, 2006)\) as follows:
where $r$ indexes the nine interventions examined.

The concentration index is a synthetic measure which permits a distinction among LAGs based on the degree to which interventions are concentrated at the local / individual level. The range of HHI index is (0, 1.0), moving from a huge number of very small LAGs delivering a program to a single central implementation body. Hence the local concentration index range is (0, $s = 9$), $s$ being the number of interventions. We included the variable $CI_{j,t}$ to control for the effect of local concentration on LAG productivity.

Based on the above considerations we expect that both specialization and concentration the indexes are positively related to the productivity.

*Hypothesis 8a:* It is assumed that high output specialisation in production (or inversely low output diversification), increases efficiency/productivity, other factors constant.

*Hypothesis 8b:* It is assumed that local (LAG) concentration in production increases local efficiency/productivity, other factors constant.

To evaluate our hypotheses, we treat each LAG year observation as a decision-making unit (DMU) and model the production function relating the nine outputs (RUR, SMES, TECH, HS, NENV, HENV, CULT, COOP and TCOOP) of each DMU to its input (ADMIN) and contextual variables that may be exogenously fixed as well as others that may be under the control of the DMU.

### 9.3 The DEA Production Function

Consider observations $(j,t)$ on $j=1,\ldots,39$ LAGs (DMUjt) for $t=1,2$ years. Each observation $(j, t)$ comprises a vector of output $Y_{jt} = (y_{1jt}, \ldots, y_{Rjt})$ and a vector of inputs $X_{jt} = (x_{1jt}, \ldots, x_{Ijt})$. The vectors $Y_{jt}$ and $X_{jt}$ are strictly positive in at least one dimension.

Following Banker and Natarajan (2008), we specify the underlying production function $Y = \phi(X)$ and an error term $\varepsilon$. The production function $Y = \phi(.)$ is monotone increasing and concave in $X$, and relates the input vector $X$ to the output vector $Y$ as specified by the following equation:
\[ Y_{jt} = \phi(X_{jt}) \cdot e^{\varepsilon_{jt}} \quad j=1,\ldots,39; \ t=1,2 \]  

(9.1)

The random variable representing the error \( \varepsilon_{jt} \) is itself generated by the process

\[ \varepsilon_{jt} = v_{jt} - u_{jt} - \sum_{s=1}^{S} \beta_{s} z_{jst} \]  

(9.2)

where \( v_{jt} \) represents random noise for observation \((j, t)\) and has a two-sided distribution, \( u_{jt} \) represents technical inefficiency and has a one-sided distribution and the contextual variables \( z_{jst} \) are all non-negative. The error attributable to only noise and technical inefficiency is specified as \( \varepsilon_{jt} = v_{jt} - u_{jt} \).

We impose the following structure on the probability density functions generating the various variables:

\[
\begin{align*}
    f_{x_i}(x_i) &= 0 \text{ for all } x_i < 0 \\
    f_{z_s}(z_s) &= 0 \text{ for all } z_s < 0 \\
    f_u(u) &= 0 \text{ for all } u < 0 \\
    f_v(v) &= 0 \text{ for all } |v| > V^M
\end{align*}
\]

(9.3)

where \( V^M \) is a finite upper bound

Further, the probability density functions \( f_{x_i}(x_i) \), \( f_{z_s}(z_s) \), \( f_u(u) \) and \( f_v(v) \) are all independent of each other. Each stochastic variable has finite variance and the mean of the noise variable, \( E(v) \), is zero.

This representation as in Banker and Natarajan (2008) specifies output as a general nonparametric function of inputs and an error term, and the error term as consisting of three distinct components: a linear function of contextual variables, a one-sided inefficiency term and a two-sided random noise term bounded above. Except for the additional component involving the contextual variables, this specification of the error term is analogous to composed error term formulations in parametric stochastic frontier models. Banker and Natarajan (2008) provide theoretical and simulation-based justification for the use of a two-stage method that uses DEA in the first stage and OLS regression in the second stage to evaluate the impact of contextual variables on productivity.
9.4 Estimation Models

9.4.1 Pooled DEA model

We use the output oriented CCR and BCC DEA models to estimate the efficiency scores of the different observations \((j, t)\) for \(\text{LAG}_j = 1, \ldots, 39\), and year \(t = 1, 2\). More specifically, we use the output-oriented BCC model to evaluate the productivity scores using one input to produce nine outputs. Recall that the nine outputs are RUR, SMES, TECH, HS, NENV, HENV, CULT, COOP and TCOOP, and the input is ADMIN. There are 78 \((= 39 \times 2)\) observations. The pure productivity \(\hat{\varphi}_{jt}\) of an observation \(j\) in period \(t\) is the reciprocal of \(\varphi_{jt}\) which is obtained from the following linear program:

\[
\begin{align*}
\hat{\varphi}_{jt} &= \max \varphi_{jt} \\
\text{subject to} & \\
\sum_{r=1}^{11} \sum_{j=1}^{39} \hat{\lambda}_{jr} x_{ijt} & \leq x_{i'r't'}, \quad i'=1 \\
-\sum_{j=1}^{11} \sum_{r=1}^{14} \hat{\lambda}_{jr} y_{ijt} + \phi_{r't'} y_{r't'} & \leq 0, \quad r=1, \ldots, 9 \\
\sum_{j=1}^{2} \sum_{r=1}^{39} \hat{\lambda}_{jr} & = 1 \\
\hat{\lambda}_{jr}, \phi_{r't'} & \geq 0
\end{align*}
\]

(9.4)

where

- \(x_{ijt}\) : input \(i\) consumed by \(\text{LAG}_j\)
- \(y_{ijt}\) : output \(r\) produced by \(\text{LAG}_j\)
- \(\hat{\lambda}_{jr}\) : weight placed on input/outputs of \(\text{LAG}_j\)
- \(x_{i'r't'}, y_{r't'}\) : input, outputs for \(\text{LAG}_j\) being evaluated \(i'=1; r=1, \ldots, 9; t=1, 2\)

The linear program is solved for each observation \((j, t)\).

This is the pooled output oriented BCC model. We calculated also the overall (relative) productivity with the use of the CCR model which ignores the convexity constrain in above model. The scale productivity is given by the ratio of overall to pure productivity.
9.4.2 Testing Global Returns to Scale

Aside from the economic implications of whether true frontier production function exhibits CRS, there are also statistical issues relating to this question. If frontier production function exhibits CRS everywhere, then both CRS and VRS DEA frontier models are consistent estimators of true frontier. On the other hand, if true frontier production function exhibits non-constant returns to scale at some locations, then DEA CRS will be an inconsistent estimator of the true frontier. Therefore, researchers need to know whether the technology is one of constant returns to scale before estimating technical efficiency. Moreover, even if the true frontier production function is known to exhibit non-constant returns to scale, for policy purposes one might need to know whether a particular region of the technology displays increasing, constant, or decreasing returns to scale.

According to Simar and Wilson (2002) a priori assuming a CRS technology without investigating the possibility that returns to scale are not constant incurs the risk of inconsistently estimating technical efficiency. From the viewpoint of statistical hypothesis testing, the first issue is whether production function represents a CRS technology. If there is no evidence to the contrary, there seems to be little reason to examine scale efficiency.

This section summarizes the tests of returns to scale initially described in Banker and Chang (1993). We proceed assuming that $x_j \geq 0$ and $y_j \geq 0$, $j=1, \ldots, n$, be the observed input and output vectors in a sample of $n$ observations generated from the underlying technology set

$$T = \{(x, y) : y \text{ is producable from } x\}$$

The underlying technology $T$ is convex and satisfies the properties listed in Banker and Chang (1993). The efficiency of a DMU $j$ is defined by

$$\theta(y_j, x_j) = \sup \{\theta : (\theta y_j, x_j) \in T\} \quad (9.5)$$

Banker et al. (2011) assume the following minimal additional probabilistic structure. The quantity $\theta$ is modelled as a random variable with probability density $f(\theta)$ with support in $(0, 1)$. 

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Nikos Pettas - January 2017
It is further assumed that if $\delta \in (0,1)$, then \[ \int^{1+\delta}_1 f(\theta)d\theta > 0. \]

Under the above assumptions the estimates $\hat{\theta}(y_j, x_j)$ are consistent and converge in distribution, where

$$\hat{\theta}(y_j, x_j) = \max_{\lambda \theta} \theta,$$

subject to the conditions

$$Y\lambda \geq \theta y_j, \quad X\lambda \leq x_j, \quad \lambda I = 1 \text{ and } \lambda \geq 0.$$

Here $Y = (y_1, \ldots, y_n)$ is the output matrix and $X = (x_1, \ldots, x_n)$ is the input matrix.

One says that the technology $T$ shows constant returns to scale; If $(x, y) \in T$ implies $(kx, ky) \in T, k > 0$.

In this case, a consistent and asymptotically convergent in distribution estimator is obtained removing the convexity condition $\sum \lambda = 1$.

Banker & Natarajan (2004) suggest three statistical tests to examine the assumption of returns to scale. Two of them are based on specific assumptions on the density function $f(\theta)$ (exponential and half-normal distributions), and the third is a nonparametric test which is based on the Smirnov-Kolmogorov two sample statistics.

The first set of Banker’s statistics is testing the null hypothesis of constant versus variable returns to scale:

1. If the inefficiency variable $\theta$ follows the exponential distribution over the range of values from one to infinity with a parameter $\sigma$, then asymptotically both the sums

$$\sum_{j=1}^{N} 2(\theta_j^{cr} - 1)/\sigma \quad \text{and} \quad \sum_{j=1}^{N} 2(\theta_j^{cr} - 1)/\sigma$$

follow the chi-square distribution with $2N$ degrees of freedom. Therefore, the test statistic for the null hypothesis of constant returns to scale is given by

$$F_1 = \sum_{j=1}^{N} (\theta_j^{cr} - 1)/\sum_{j=1}^{N} (\theta_j^{cr} - 1)$$
which asymptotically obeys the F-distribution with \((2N, 2N)\) degrees of freedom.

2. If the inefficiency variable is distributed half-normally as \(\left| N(1, \sigma^2) \right|\) then both 
\[
\frac{\sum_{j=1}^{N} (\theta_j^{vrs} - 1)}{\sigma^2} \quad \text{and} \quad \frac{\sum_{j=1}^{N} (\theta_j^{crs} - 1)}{\sigma^2}
\]
follow the chi-square distribution with \(N\) degrees of freedom. Therefore, the test statistic for the null hypothesis of constant returns to scale is given by 
\[
F_2 = \frac{\sum_{j=1}^{N} (\theta_j^{crs} - 1)^2}{\sum_{j=1}^{N} (\theta_j^{vrs} - 1)^2}
\]
which follows the F-distribution with \((N, N)\) degrees of freedom.

3. Finally, if no distributional assumptions are maintained, a non-parametric Kolmogorov-Smirnov test is proposed to test the null hypothesis of constant returns to scale. This statistic is the maximum vertical distance between \(F_{crs}^{\theta_j} - F_{vrs}^{\theta_j}\)

\[
K = \max \left[ \left| F_{crs}^{\theta_j} - F_{vrs}^{\theta_j} \right| ; j = 1, \ldots, N \right]
\]
Semiparametric and non-parametric tests resembling those described here are also presented by Banker and Chang to test for increasing or decreasing returns to scale.

9.4.3 Testing Productivity Differences
Since the DEA estimators are consistent (Banker 1993), we follow Banker (1993, 1996) to employ the following three test statistics to test for the productivity difference between two sample time periods.

1. By assuming that \(\phi_j\) is exponentially distributed for LAGs, we test the null hypothesis (that there is no difference in the efficiency of LAGs between year \(t=2005\) and year \(t+1=2006\)) against the alternate hypothesis (that LAGs improve their efficiency in year \(t\) compared to year \(t+1\)). Specifically, we use the test statistic given by

\[
T_{exp} = \frac{\sum_{j=N_1}^{N} (\phi_j - 1)}{\sum_{j=N_2}^{N} (\phi_j - 1)}
\]
which is evaluated by the F-distribution with \((2N_1, 2N_2)\) degrees of freedom, where \(N_1=N_2\) are the number of sample LAGs in the periods \(t\) and \(t+1\), respectively.
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2. Another statistical assumption is that if the $\hat{\varphi}_j$ is assumed to be half-normally distributed for LAGs we can test the null hypothesis against the alternate hypothesis, described above, by employing the test statistic given by

$$T_{hn} = \sum_{j=N1} (\hat{\varphi}_j - 1)^2 / \sum_{j=N2} (\hat{\varphi}_j - 1)^2,$$

which is evaluated by the F-distribution with (N1, N2) degrees of freedom.

3. Finally, if no distributional assumptions are maintained, we can test the null hypothesis against the alternate hypothesis, described above, by employing the test statistic given by

$$K = \max[(F^{11}(\varphi_j) - F^{12}(\varphi_j) | j = 1...N]$$

9.5 The Empirical Model to Evaluate the Impact of Contextual variables on Productivity

To evaluate the impact of contextual variables, we regress the logarithm of the overall / pure / scale productivity estimators $\hat{\vartheta}_{jt}$ on the contextual variables in the second stage, using the full panel of pooled data. Banker and Natarajan (2008) show that this two-stage procedure involving nonparametric estimation of productivity in the first stage followed by OLS regression provides statistically consistent estimates.

Specifically the regression we estimate is represented as:

$$\ln(\text{Eff}_{jt}) = \ln \hat{\vartheta}_{jt} = \beta_0 + \beta_1 \times \text{LEADSURF}_{jt} + \beta_2 \times \text{LEADPOP}_{jt}$$

$$+ \beta_3 \times \text{OPAASURF}_{jt} + \beta_4 \times \text{OPPAPOP}_{jt} + \beta_5 \times \text{ISLAND}_{jt}$$

$$+ \beta_6 \times \text{LAGSELECT}_{jt} + \beta_7 \times \text{YRSOPER}_{jt}$$

$$+ \beta_8 \times \text{SPECIAL}_{jt} + \beta_9 \times \text{CONCENTR}_{jt}$$

$$+ \beta_{10} \times \text{PROGRSIZE}_{jt} + \beta_{11} \times \text{LAGSIZE}_{jt}$$

$$+ \beta_{12} \times \text{SQRPROGRSIZE}_{jt} + \beta_{13} \times \text{SQRLAGSIZE}_{jt} + \epsilon_{jt}$$

where,
\[ \ln(Eff)_{jt} = \ln(\text{the logarithm of overall / pure / scale productivity measure for LAG}\ j\ \text{in year}\ t), \]

\[ \text{LEADSURF}_j = \text{the size of the LEADER area in thousands Km2 for LAG}\ j, \]

\[ \text{LEADPOP}_j = \text{the size of the LEADER population in thousands for LAG}\ j, \]

\[ \text{OPAASURF}_j = \text{the percentage of surface overlapped by Integrated Rural Development Program for LAG}\ j, \]

\[ \text{OPPAPOP}_j = \text{the percentage of population overlapped by Integrated Rural Development Program for LAG}\ j, \]

\[ \text{ISLAND}_j = \text{one if LAG}\ j\ \text{is island, otherwise zero}, \]

\[ \text{LAGSELECT}_j = \text{the approval ranking by Ministry of Agriculture for LAG}\ j, \]

\[ \text{YRSOPER}_{jt} = \text{the number of years passed since constitution for LAG}\ j\ \text{in year}\ t, \]

\[ \text{SPECIAL}_{jt} = \text{the specialization index for LAG}\ j\ \text{in year}\ t, \]

\[ \text{CONCENT}_{jt} = \text{the concentration index for LAG}\ j\ \text{in year}\ t, \]

\[ \text{PROGRSIZE}_{jt} = \text{the logarithm of aggregated output payments expressed in million euro for LAG}\ j\ \text{in year}\ t, \]

\[ \text{LAGSIZE}_{jt} = \text{the logarithm of total costs expressed in million euro for LAG}\ j\ \text{in year}\ t, \]

\[ \text{SQRPROGRSIZE}_{jt} = \text{the squared logarithm of aggregated output payments expressed in million euro for LAG}\ j\ \text{in year}\ t, \]

\[ \text{SQRLAGSIZE}_{jt} = \text{the squared logarithm of total costs expressed in million euro for LAG}\ j\ \text{in year}\ t, \]

\[ \varepsilon_{jt} = \text{random errors}, \]

\[ j = 1 \ldots 39, \text{ and} \]

\[ t = 1, 2. \]
In variables were specified in natural logarithms and where a natural number was reported as zero, its value was set to the natural logarithm of one. All logarithmic variables were mean centred to improve the ease of interpreting the coefficient values. Mean centering is the process of subtracting the mean of a variable from every individual observation of that variable.

9.6 Pooled DEA Empirical Results

In this sub-section the analysis has been done using pooled data. Initially, the estimation of scale for program delivery production function is presented. Then follows the comparison of time-period efficiencies differences and finally the second stage regression results.

9.6.1 Estimation of Global Economies of Scale

In this section, the question of scale for the program implementation production function is considered. Hypothesis tests developed by Banker (1996) for use with data envelopment analysis are performed to test for global returns to scale in the case of LEADER delivery. Table 9.1 shows a parametric and two DEA-based nonparametric tests of the hypothesis of constant returns (vs. variable returns). These, are overall tests on administrative production function and do not regard the scale of operation of individual program implementation units.

Table 9.1: Statistical test results of constant returns to scale

<table>
<thead>
<tr>
<th>Null Hypothesis</th>
<th>Alt. Hypothesis</th>
<th>Distribution of inefficiency</th>
<th>Test statistic value</th>
<th>Critical value (a=.05)</th>
<th>DF1</th>
<th>DF2</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>CRS</td>
<td>VRS</td>
<td>Exponential</td>
<td>1.494</td>
<td>1.302</td>
<td>156</td>
<td>156</td>
<td>Reject Ho</td>
</tr>
<tr>
<td>CRS</td>
<td>VRS</td>
<td>Half-normal</td>
<td>1.775</td>
<td>1.455</td>
<td>78</td>
<td>78</td>
<td>Reject Ho</td>
</tr>
<tr>
<td>CRS</td>
<td>VRS</td>
<td>Free</td>
<td>0.2051</td>
<td>0.0375</td>
<td></td>
<td></td>
<td>Reject Ho</td>
</tr>
</tbody>
</table>

As shown in Table 9.1, the null hypothesis of constant returns to scale is rejected for the sample as a whole at the 5% significance level under all alternative statistical test procedures. The DEA test results indicate that non-linearity characterizes the production function (the function relating inputs to outputs) while the assumption of constant returns to scale is not sustained.
Following these results, statistical tests in DEA are also employed to examine whether the production function can be properly described with just a decreasing returns to scale or with just an increasing returns to scale model, rather than a model that allows for the presence of both increasing and decreasing returns to scale in different data ranges. The results of decreasing and increasing returns are reported in Table 9.2 and Table 9.3, respectively.

### Table 9.2: Statistical test results of decreasing returns to scale

<table>
<thead>
<tr>
<th>Null Hypothesis</th>
<th>Alt. Hypothesis</th>
<th>Distribution of inefficiency</th>
<th>Test statistic value</th>
<th>Critical value (a=.05)</th>
<th>DF1</th>
<th>DF2</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>NDRS</td>
<td>DRS</td>
<td>Exponential</td>
<td>1.149</td>
<td>1.302</td>
<td>156</td>
<td>156</td>
<td>Ho accept</td>
</tr>
<tr>
<td>NDRS</td>
<td>DRS</td>
<td>Half-normal</td>
<td>1.233</td>
<td>1.455</td>
<td>78</td>
<td>78</td>
<td>Ho accept</td>
</tr>
<tr>
<td>NDRS</td>
<td>DRS</td>
<td>Free</td>
<td>0</td>
<td>1</td>
<td></td>
<td></td>
<td>Ho accept</td>
</tr>
</tbody>
</table>

### Table 9.3: Statistical test results of increasing returns to scale

<table>
<thead>
<tr>
<th>Null Hypothesis</th>
<th>Alt. Hypothesis</th>
<th>Distribution of inefficiency</th>
<th>Test statistic value</th>
<th>Critical value (a=.05)</th>
<th>DF1</th>
<th>DF2</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>NIRS</td>
<td>IRS</td>
<td>Exponential</td>
<td>1.345</td>
<td>1.302</td>
<td>156</td>
<td>156</td>
<td>Reject Ho</td>
</tr>
<tr>
<td>NIRS</td>
<td>IRS</td>
<td>Half-normal</td>
<td>1.543</td>
<td>1.455</td>
<td>78</td>
<td>78</td>
<td>Reject Ho</td>
</tr>
<tr>
<td>NIRS</td>
<td>IRS</td>
<td>Free</td>
<td>0</td>
<td>1</td>
<td></td>
<td></td>
<td>Ho accept</td>
</tr>
</tbody>
</table>

The one sided non parametric tests confirm the presence of increasing returns to scale at the 5% level of significance, for this type of service. The finding of increasing returns to scale, on its own, suggests that productivity gains could be achieved by the increase of LAG size. On the basis of scale economies, we conclude that bigger LAGs are more efficient than smaller ones. On the other hand, the result of the Kolmogorof-Smirnoff test does not support the presence of increasing returns to scale. We can resolve this, assuming that delivery of a complex program follows a more general variable returns to scale production function.
The presence of economies of scale in program administration services, might be a justification for bigger target areas, population and programs, since economies of scale may require a larger program area than it is possible within a particular small local area.

9.6.1.1 The Optimal Size

Having evidence for scale inefficiencies it is expected for Management Authority and LAG managers to ask if LAGs themselves or and their Programs have optimal scale size and if not, if they are too small or too large. However, according to Bogetoft (2012), there is no simple method for characterizing optimal scale size. For two LAGs of similar size - in terms of input or output, one may be too small while the other may be too large. Optimal scale depends on the composition of resources, volume delivered, and the areas’ socioeconomic characteristics. Figure 9.1 presents the occurrence of too small and too big LAGs and Programs according to their size as measured by their consumed value of resources and delivered value of investments, respectively.

**Figure 9.1: Returns to Scale vs. Size**

We see first of all that the majority of scale inefficient LAGs and Programs are too small. This means that there are more LAGs and Programs that are too small than LAGs and
Programs that are too large. We also see that for a given LAG size or program size, some LAGs or Programs are too small while others are too large. There is no a single unique value of size, thus it is difficult to suggest an optimal size. In order to resolve this we can search for a size where LAGs or Programs tend to become too large when they grow, and too small when they reduce. LAGs’ administration costs between 0.7 and 0.9 million and Programs’ investments between 0.7 and 2.0 million, define an approximate balance between those that are considered too small or too large. If the respective sizes increase above these levels, a majority of LAGs and Programs become too large, and if the sizes fall below these levels, most LAGs and Programs become too small. Thus it is logical that both efficient LAG and Program sizes lie in these ranges.

9.6.2 Comparison of Time-Period Efficiencies Differences
In this section analysis will be focus on estimation and comparison of LAGs’ (in)efficiencies between two periods. The estimated pooled output delivery CRS, VRS and Scale efficiencies are split into 2005 and 2006 two time-periods. Their boxplots are presented in Figure 9.2 while their cumulative probability distributions and densities graphs are presented in Appendix.

Greater mass near the left edge of the density graphs implies that most observations are on or close to the efficient frontier. The long tail suggests some, but not many, LAGs that are highly inefficient. Based on the boxplots, distributions and densities it seems that 2006 efficiencies have steeper densities and masses closer to 1, compared to 2005, for all DEA specifications. All graphs indicate that 2006 period outperforms 2005 period in terms of delivery efficiency.

The statistical test procedure proposed by Banker (1993) for the comparison of efficiency ratings between the two examined time-periods, is applied. Basically, the statistical procedure involves testing whether the means of the (in)efficiency score probability distributions for different conditions are different. The two nonparametric test statistics proposed by Banker depend on whether inefficiency deviations of the observed data are postulated to be drawn from exponential or half-normal distributions. It is reasonable to assume an exponential distribution for the inefficiency deviations when one has reason to believe that most observations are close to the production frontier. A half-normal distribution should be assumed when few observations are likely to be close to the frontier. The overall test procedure is as follows.
The null hypothesis is that the two examined periods are not different in terms of inefficiency deviations: \( H_0: \sigma_{2005} = \sigma_{2006} \).

The alternative hypothesis is that the program delivery of 2005 period has greater output inefficiency compared to 2006 period i.e., delivery at 2005 period is less efficient than that of 2006 period: \( H_1: \sigma_{2005} > \sigma_{2006} \).

**Figure 9.2: Boxplots for efficiencies between Pre- and Post-MTE periods**

![Boxplots for efficiencies between Pre- and Post-MTE periods](image)

**Table 9.4: Statistical tests of equality of CRS, VRS and Scale efficiencies [Pre- vs. Post-MTE period]**

<table>
<thead>
<tr>
<th>Null Hypothesis</th>
<th>Distribution of inefficiency</th>
<th>Test statistic</th>
<th>Test statistic value</th>
<th>Critical value ((a=.05))</th>
<th>DF1</th>
<th>DF2</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>CRSE05=CRSE06</td>
<td>Exponential</td>
<td>( T_{EX} )</td>
<td>1.740</td>
<td>1.564</td>
<td>78</td>
<td>78</td>
<td>Reject Ho</td>
</tr>
<tr>
<td></td>
<td>Half-normal</td>
<td>( T_{HN} )</td>
<td>2.433</td>
<td>1.891</td>
<td>39</td>
<td>39</td>
<td>Reject Ho</td>
</tr>
<tr>
<td></td>
<td>Free</td>
<td>( F )</td>
<td>0.359</td>
<td>0.013</td>
<td></td>
<td></td>
<td>Reject Ho</td>
</tr>
<tr>
<td>VRSE05=VCRSE06</td>
<td>Exponential</td>
<td>( T_{EX} )</td>
<td>1.634</td>
<td>1.564</td>
<td>78</td>
<td>78</td>
<td>Reject Ho</td>
</tr>
<tr>
<td></td>
<td>Half-normal</td>
<td>( T_{HN} )</td>
<td>2.298</td>
<td>1.891</td>
<td>39</td>
<td>39</td>
<td>Reject Ho</td>
</tr>
</tbody>
</table>
As described earlier, we first use two DEA-based test procedures to test for the null hypothesis that there is no difference in the productivity of LAGs between 2005 and 2006 sample years. We present the statistical test results for the productivity differences in Table 9.4. As can be seen from Table 9.4, the difference in the productivity of LAGs is significant at conventional levels for three pairs of productivities when the inefficiency is assumed to be either exponentially or half-normally distributed. However, according to the results of the Kolmogorov–Smirnov test, we do not reject the null hypothesis, when we test pure or scale productivity time differences.

Most of our tests show that, for all DEA specifications the difference is significant, and what we see in the figures is therefore most likely not a matter of chance. Overall, these results suggest that for 2006 period, average output efficiencies are lower than that for 2005 period; i.e. 2006 is more efficient than 2005.

These results are based on the use of relative efficiencies of LAGs estimated using pooled observations from both the pre- and post-MTE periods. Such a specification is based on the assumption that there is no shift in the production function (e.g., no technical progress) with time. As we assume in a previous chapter, it is possible that time affects LAG production functions. In any case, the results of this section evaluate the robustness of our earlier results. Overall, all results suggest that there are significant changes in the productivity of LAGs between the two examined time periods.

### 9.6.3 Second Stage Regression Results

In the second stage of our empirical analysis, we regress the logarithm of three DEA productivity scores on the contextual variables. Table 9.5 provides the descriptive statistics of input, outputs and contextual variables included in the second stage regression analysis. Results indicate that some degree of variation exists in contextual variables.
among LAGs. The inclusion of these variables in a second stage regression analysis enables us to understand their impact on program productivity.

**Table 9.5: Descriptive Statistics of DEA and Contextual Variables**

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>SD</th>
<th>First Quartile</th>
<th>Median</th>
<th>Third Quartile</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Input</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ADMIN (I)</td>
<td>674.89</td>
<td>158.40</td>
<td>547.25</td>
<td>659.31</td>
<td>772.42</td>
</tr>
<tr>
<td><strong>Outputs</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RUR (O)</td>
<td>674.21</td>
<td>411.44</td>
<td>400.74</td>
<td>601.40</td>
<td>855.11</td>
</tr>
<tr>
<td>SMES (O)</td>
<td>715.60</td>
<td>495.56</td>
<td>387.93</td>
<td>606.63</td>
<td>870.49</td>
</tr>
<tr>
<td>TECH (O)</td>
<td>12.97</td>
<td>22.80</td>
<td>0.00</td>
<td>1.13</td>
<td>14.94</td>
</tr>
<tr>
<td>HS (O)</td>
<td>57.12</td>
<td>36.38</td>
<td>30.16</td>
<td>57.08</td>
<td>70.24</td>
</tr>
<tr>
<td>NENV (O)</td>
<td>32.32</td>
<td>76.93</td>
<td>0.00</td>
<td>0.00</td>
<td>28.13</td>
</tr>
<tr>
<td>HENV (O)</td>
<td>61.50</td>
<td>103.14</td>
<td>0.00</td>
<td>0.00</td>
<td>74.56</td>
</tr>
<tr>
<td>CULT (O)</td>
<td>37.43</td>
<td>60.12</td>
<td>0.00</td>
<td>20.20</td>
<td>52.48</td>
</tr>
<tr>
<td>COOP (O)</td>
<td>0.09</td>
<td>0.40</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>TCOOP (O)</td>
<td>1.29</td>
<td>2.80</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td><strong>Inefficiency</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overall</td>
<td>1.41</td>
<td>0.38</td>
<td>1.02</td>
<td>1.38</td>
<td>1.65</td>
</tr>
<tr>
<td>Pure</td>
<td>1.27</td>
<td>0.32</td>
<td>1.00</td>
<td>1.16</td>
<td>1.43</td>
</tr>
<tr>
<td>Scale</td>
<td>1.11</td>
<td>0.16</td>
<td>1.00</td>
<td>1.05</td>
<td>1.14</td>
</tr>
<tr>
<td><strong>Contextual Variables</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LEADSURF</td>
<td>2.08</td>
<td>1.13</td>
<td>1.29</td>
<td>1.82</td>
<td>2.62</td>
</tr>
<tr>
<td>LEADPOP</td>
<td>54.70</td>
<td>23.46</td>
<td>38.29</td>
<td>47.08</td>
<td>75.74</td>
</tr>
<tr>
<td>OPAASURF</td>
<td>58.91</td>
<td>23.53</td>
<td>37.00</td>
<td>63.80</td>
<td>74.73</td>
</tr>
<tr>
<td>OPPAPOP</td>
<td>42.52</td>
<td>22.73</td>
<td>26.93</td>
<td>40.48</td>
<td>54.87</td>
</tr>
<tr>
<td>YRSOPER</td>
<td>12.90</td>
<td>4.65</td>
<td>9.40</td>
<td>12.90</td>
<td>14.40</td>
</tr>
<tr>
<td>SPECIAL</td>
<td>45.76</td>
<td>12.07</td>
<td>37.19</td>
<td>44.34</td>
<td>51.80</td>
</tr>
</tbody>
</table>
Determinants of Program’s Performance

<table>
<thead>
<tr>
<th>Variable</th>
<th>Value1</th>
<th>Value2</th>
<th>Value3</th>
<th>Value4</th>
<th>Value5</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONCENTR</td>
<td>80.21</td>
<td>199.48</td>
<td>6.35</td>
<td>15.92</td>
<td>46.94</td>
</tr>
<tr>
<td>PROGRSIZE</td>
<td>1592.55</td>
<td>759.41</td>
<td>1060.59</td>
<td>1426.34</td>
<td>2060.03</td>
</tr>
<tr>
<td>LAGSIZE</td>
<td>650.31</td>
<td>152.97</td>
<td>533.99</td>
<td>640.76</td>
<td>748.43</td>
</tr>
</tbody>
</table>

Notes: All monetary variables in 1000 €. I / O = Input / Output DEA variable

Pearson and Spearman correlations between DEA productivity scores and contextual variables used in the regression model presented in appendix. There is a statistically significant positive correlation of each one of the three dependent variables ($\ln \hat{\theta}^{\text{crs}}$, $\ln \hat{\theta}^{\text{vrs}}$, $\ln \hat{\theta}^{\text{scale}}$) with both PROGSIZE and SQRPROGSIZE. However, there is also a statistically significant positive relationship between only scale productivity ($\ln \hat{\theta}^{\text{scale}}$) with both LAGSIZE and SQRLAGSIZE.

These correlations suggest that these variables will be able to explain variation in three specifications of productivity. However, size variables are also highly correlated with each other which may lead to multicollinearity issues. Thus, some care has to be taken in order to remedy these problems, when performing regression analysis.

Independent variables LAGSELECT and CONCENTR are also highly associated with all three productivity variables. Furthermore, variables LEADSURF, LEADPOP, OPAAXSURF, and OPPAXPOP are generally not significantly correlated with any of the three productivity variables. However, they are included in regression analysis as control variables as they typically are included in official program evaluations (ex-ante, mid-term and post-term implementation) as significant covariates of program planning and execution.

Because pooled cross-sectional and times-series information is used to estimate the impact of contextual variables on LAG productivity, there is the potential for serial correlation biasing the standard errors of the coefficients. For this sort panel analysis, the statistical R packages ‘plm’, ‘sandwich’ and ‘lmtest’ were used (R Development Core Team; Croissant and Millo, 2008; Zeileis and Hothorn, 2002; Zeileis, 2004). The tests of homoscedasticity and serial non-correlation have rejected the null hypothesis (See Appendix). For that reason, we use robust estimation of regression coefficients in order to obtain heteroscedasticity and series correlation consistent coefficients.
### Table 9.6: Pooled OLS regressions results

<table>
<thead>
<tr>
<th>Dependent variable</th>
<th>Overall productivity</th>
<th>Pure productivity</th>
<th>Scale productivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Predictor</td>
<td>Estimate</td>
<td>Std. Error</td>
<td>Estimate</td>
</tr>
<tr>
<td>(Intercept)</td>
<td>-0.26837**</td>
<td>0.08359</td>
<td>-0.25541**</td>
</tr>
<tr>
<td>LEADSURF</td>
<td>-0.06301</td>
<td>0.05619</td>
<td>-0.03331</td>
</tr>
<tr>
<td>LEADPOP</td>
<td>-0.05767</td>
<td>0.05416</td>
<td>-0.06660</td>
</tr>
<tr>
<td>OPAASURF</td>
<td>0.00147</td>
<td>0.00183</td>
<td>0.00140</td>
</tr>
<tr>
<td>OPPAPOP</td>
<td>-0.00061</td>
<td>0.00171</td>
<td>-0.00055</td>
</tr>
<tr>
<td>ISLAND</td>
<td>-0.03262</td>
<td>0.06063</td>
<td>-0.02735</td>
</tr>
<tr>
<td>LAGSELECT</td>
<td>-0.00102</td>
<td>0.00217</td>
<td>-0.00152</td>
</tr>
<tr>
<td>YRSOPER</td>
<td>0.00367</td>
<td>0.00441</td>
<td>0.00463</td>
</tr>
<tr>
<td>SPECIAL</td>
<td>0.21162*</td>
<td>0.09517</td>
<td>0.22844*</td>
</tr>
<tr>
<td>CONCENTR</td>
<td>0.11785***</td>
<td>0.02061</td>
<td>0.11352***</td>
</tr>
<tr>
<td>PROGRSIZE</td>
<td>0.34238***</td>
<td>0.06457</td>
<td>0.18811**</td>
</tr>
<tr>
<td>LAGSIZE</td>
<td>-0.59389***</td>
<td>0.10853</td>
<td>-0.48163***</td>
</tr>
<tr>
<td>SQRPROGRSIZE</td>
<td>0.10035**</td>
<td>0.03722</td>
<td>0.16618***</td>
</tr>
<tr>
<td>SQRLAGSIZE</td>
<td>-0.47551</td>
<td>0.35916</td>
<td>0.54291</td>
</tr>
<tr>
<td>R-Squared</td>
<td>0.76064</td>
<td>0.65061</td>
<td>0.84194</td>
</tr>
<tr>
<td>Adj. R-Squared</td>
<td>0.62412</td>
<td>0.53383</td>
<td>0.69082</td>
</tr>
<tr>
<td>F-statistic</td>
<td>15.6449</td>
<td>9.16737</td>
<td>26.224</td>
</tr>
<tr>
<td>p-value</td>
<td>3.52E-15</td>
<td>2.80E-10</td>
<td>&lt; 2.22e-16</td>
</tr>
</tbody>
</table>

Standard errors are robust. Level of significance: * is 10%, ** is 5%, and *** is 1%.

The results of the pooled ordinary least squares regressions can be seen in Table 9.6. The coefficients on most of the control variables (LEADSURF, LEADPOP, OPAASURF, OPPAPOP, ISLAND, LAGSELECT and YRSOPER) are not statistically significant. On the other hand, the specialization (SPECIAL) and concentration (CONCENTR) variables are positively and significantly related to pure and overall productivity suggesting that...
LAGs’ performance tend to benefit from large values of specialization and concentration. LAGs exhibiting narrower operational focus (higher specialization, i.e. fewer interventions types to deliverer) should be in a position to provide faster administration services and therefore to be able to attain higher levels of delivery productivity.

The most apparent outcome in all three specifications of the model is that both coefficients concerning Size and their quadratic terms are statistically significant. However there is an exception regarding the SQRLAG Size which is statistically significant only on scale productivity. The detailed results are presented in Table 9.6.

9.6.3.1 LAG’s Size
Both overall and pure productivity estimators and LAG’s Size - as proxied by administrative costs, are found to have a clearly statistically significant negative linear relationship. Based on this inverse relationship between LAG’s size and productivity, it is concluded that smaller LAGs are significantly more overall and pure productive than larger LAGs. The negative relationship between organizational size and performance may show a bureaucratizing effect, which can weaken organizational performance. In organizations with more employees, the organizational structure might become less flexible, and thus it might be more difficult to coordinate goals, work and relations among different tasks.

On the other hand, considering scale productivity (Figure 9.3), we see that both coefficients of LAG’s size are clearly statistically significant and indicate that the relationship between delivery mechanism and scale productivity is nonlinear. The negative coefficients for both size and size squared indicate a monotonic increasing and concave function of scale productivity with LAG’s size until a turning point is reached, from which point the function starts to decrease. The relationship between scale productivity and LAG’s size follows an inverted-U pattern. Thus, a LAG being either too large or too small may be harmful. A too-small LAG fails to take full advantage of increasing returns. An expansion of its outputs will reduce its unit cost. On the contrary, a too-large LAG experiences decreasing returns as its unit cost rises with an increase in output.

Figure 9.3: Scale productivity as influenced by LAG’s Size
9.6.3.2 Program’s size

The main potential effects of program’s budget size on program delivery productivity emerged from this analysis are illustrated in three diagrams of Figure 9.4.

Considering scale productivity estimator (Figure 9.4; bottom), both coefficients of program’s size - as proxy by aggregated output payments, are clearly statistically significant and indicate that the relationship between program’s volume and scale productivity is not linear. The positive coefficient for volume of program and the negative one for volume squared imply a monotonic increasing and concave function of scale productivity by program’s size.

On the other hand both overall and pure productivity with program’s size (Figure 9.4; top and middle, respectively), are found to have a convex - shaped relationship as both coefficients of program’s size are clearly statistically significant. The positive coefficients for volume of program and volume squared imply a monotonic decreasing function of overall and pure productivity by program’s size.

Most of the coefficient results of Tobit regression (see Appendix), are similar to the ones of pooled-OLS model apart some exceptions. LEADSURF is found significant in scale productivity model, SPECIAL has become insignificant on overall productivity and CONCENTR is found significant on scale productivity. SQRPROGRSIZE has become insignificant on overall and pure productivity and SQRLAGSIZE is found significant except from the scale also on pure productivity.

**Figure 9.4: Productivity as influenced by Program's Size**
9.7 Conclusions
The main purpose of this chapter was to examine whether organizational size or program size make a difference to the local program delivery performance. We address this
question through regression analyses between size of delivery organization and size of program with overall, pure and scale delivery productivities, while holding constant the effects of a range of control variables such as population, area served etc.

The main regression result is that there exists a monotonic increasing and concave function of scale productivity by program’s size which outlined the importance of scaling up program’s budget. Moreover, a non-linear ‘U-shaped’ relationship exists between program’s budget size and delivery pure productivity. This suggests that pure delivery productivity at first decreases as program’s size rises, but then improves again at the top end of the size distribution. In other words, performance of the medium-sized program implementation units is the worst among all sizes. This might be due to higher workload than the smaller ones, but not high enough to gain economies of scale. The policy implication of this might be to either disaggregate such units (to move left to a higher part of the curve) or to amalgamate them (to move right, to an equally high part).

The relationship between organizational size and performance is an ‘inverted U’. This implies that medium-sized program implementation units (LAGs) are the best performers, perhaps because they have acquired economies of scale. However, they are not so large to be burdened by bureaucratic congestion. In this case, the performance of the smallest and largest units could be improved by amalgamation and disaggregation respectively.

The most general policy implication of our findings is that size effects cannot be ignored in decisions regarding regional and local program administrative reorganisation and program budgeting. A change in the size either of administrative mechanism or the program itself is likely to make a significant difference in many aspects of local implementer productivity. However, the direction and strength of that difference is likely to vary between different performances measures of delivery productivity. This suggests that a unique size formula cannot be applied to decisions on reorganisation or public program budgeting. Instead, the implications for performance, along with other considerations, should be evaluated in the context of the reforms proposed for each local area.

Based on the empirical results, the importance of scaling up rural development is outlined. This means, bigger local expenditure programs for rural development, combined with balanced allocations in their administration, permit the implementation of public rural
development programs on a larger scale. This appears to stimulate faster delivery of rural development programs. Operating at medium scale, with substantial resources, is no panacea, but when combined with good administration and bigger program budgets, the experience of LEADER has shown that program’s implementation can exceed the current rural program’s implementation speed.
10. DISCUSSION, CONCLUSIONS AND IMPLICATIONS

10.1 Introduction
This chapter concludes the research work. The objective of the chapter is to provide a summary of the main findings, policy recommendations and managerial implications. In addition, the chapter discusses the limitations of the research and suggests areas of future research.

10.2 Summary of Findings
DEA findings may be summarized as follows:

Using DEA, inefficient LAGs are located, and are found to be inefficient with respect to a narrower set of relatively efficient ones which helps to focus the investigation into the source and nature of the inefficiencies.

DEA identified alternative paths for improving the efficiency of inefficient LAGs up to the level of the relatively efficient ones in the data set. DEA does not, however, identify the one path that will move the inefficient LAG to the underlying efficient production relationship. Hence, managerial judgment is required to assess the improvement paths which are most appropriate for a particular LAG.

In this study, DEA does not concentrate only on a cross-section assessment of program implementers operating in one period. DEA was also used in a two time period framework to detect trends in relative program delivery efficiency and productivity change over time which sharpens the managerial assessment exercise. For example, it was possible to identify LAGs that were relatively efficient in the first period while in the second period become relatively inefficient and vice versa. This allowed program assessment to focus on dynamic as well as static sources of inefficiencies.
The high variability in observed performance across program implementation units provides strong evidence that the implementation system suffers significant absorption problems due to inefficiencies in program administration. This means, that significant increases in program administration services could be achieved within the existing resources. These inefficiencies naturally constrain government ability to speed rural development growth due to operating inefficiencies in existing implementation units.

In addition, a significant proportion of rural development output losses could be traced to or attributed to non-optimal size of the program implementers. Consequently, we can conclude that expansion of rural development output is possible in some implementation units without additional expenditure of administrative resources. Additionally, some resources can be released from implementation units operating under decreasing returns to scale to those operating under increasing returns to scale.

In terms of managerial actions, the magnitude of less outputs and output expansions suggest those local programs where outputs can be better produced. With the current state of technology in the program implementation sector and the output profiles, some program implementers perform efficiently. These implementers qualify to serve as benchmarks or role models for further benchmarking in order to improve delivery efficiency of the network.

With respect to factors affecting program delivery productivity, both sizes of delivery mechanism and program budget are significant variables which have implications of program productivity. Thus, we can reasonably infer that local program implementers with averaged administration resources and larger program budgets have higher likelihood of being efficient.

Evidence from the comparison of efficiency scores across the regions indicates that location of implementers and their programs might have influenced their delivery performance. In addition, the study finds significant time improvements in delivery productivity of these program implementers.

10.3 Recommendations
The main objective of this study is to shed light and fill the knowledge gap on implementation efficiency of a public development program. Generally, efficiency studies are premised on the assumption that more output can be secured from intense use
of the currently available resources. Consequently, the logical recommendation is to enhance the performance of program delivery system through better resource utilisation. Therefore, the following recommendations might be useful in assisting the Ministry of Rural Development and Food in performing its oversight role and improving the efficiency performance of LAGs.

10.3.1 Policy Recommendations

The current economic situation in Greece suggests that it might be more cost-effective to emphasize efficiency as a policy objective. Policy makers, management authorities and program implementation units need to assign significant priority to program delivery system performance assessment. The need to institutionalize efficiency monitoring within the implementation units’ information system is evident. These performance weaknesses seem to be pervasive in the Greek implementation system.

DEA can serve as a useful complement to traditional absorption analysis, and it is proved more powerful than absorption analysis in cases where the simultaneous consideration of multiple outputs and inputs is required for an efficiency assessment.

The wide spread of conventional evaluation of program’s performance with absorption ratios does not adequately consider the use of resources required to produce program outputs. The application discussed in this study is an example of how DEA can focus on delivery efficiency as distinct from aggregated or disaggregated absorption ratios. In contrast to absorption ratios, DEA measures efficiency and indicate operating improvements that may ultimately lead to increased program implementation and program absorption.

The focus in a more comprehensive performance measurement framework for program monitoring and reporting would include consideration of the development and implementation of program delivery efficiency indicators to complement the effectiveness indicator of absorption currently used. This performance measurement and management system contributes to public accountability; provides a better knowledge base to assist program stakeholders and managers; assists government decision making and setting priorities in program budget process. It is also a critical tool in assessing performance and in this way contributes to sound management practice. DEA is an analytical tool that can also assist in the identification of best practices in the use of
resources and the production of outputs among a group of public program implementers. Such identification can highlight possible efficiency improvements that may help program agencies to achieve their potential.

Performance management is now central to public and nonprofit management. However, many organizations collect a vast amount of information, but do not have an effective system for translating this feedback into a strategy for action (Hyland et al., 2009). This study proposes the connection of program evaluation and program performance management information data in an overall program performance framework.

Both program evaluation and performance measurement are increasingly seen as ways of contributing information that helps performance management decisions. Evidence-based decision making depends heavily on both evaluation and performance measurement. Furthermore, evidence of actual accomplishments is central to performance management. Evidence-informed policy making has become an important feature of the public administration of governments (Campbell, Benita, Coates, Davies, & Penn, 2007; Solesbury, 2001). Program evaluation and program efficiency measurement should be seen as complementary approaches creating information for decision makers and stakeholders in public and non-profit organizations by grounding them in the same core monitoring information.

The lack of monitoring the operating inefficiency of program delivery network might be due to the ignorance of efficiency concept of the policy makers, managers and rural development professional. Therefore, it may be necessary to foster linkage with academic institutions that can guide managers and policy makers on efficiency concept. This is because efficiency holds the key to maximization of benefits from the resources invested in a program implementation system. Furthermore, efficiency enhances government ability to expand program delivery services to cover broader policies.

10.3.2 DEA as a Managerial Assessment Tool for Managing Authority

Based on the application described in this study and on the theoretical developments of DEA described in the introductory sections, DEA appears to be a technique that is well suited for efficiency evaluations both for public programs delivery and its managerial assessments. We first summarize where DEA appears to be a useful program and managerial performance assessment tool.
The prevalence of inefficiency in the network of program implementers indicates the need for managerial interventions from the Managing Authority that have oversight of these implementers. A range of options may be considered for program delivery improvement. A restructuring of the implementation system may be required in order to remedy the scale inefficiency problem. A path to tackling the scale inefficiency problem is to consider the option of right sizing the delivery units in line with their output profile. Implementers that are in close geographical proximity could be merged or synchronized. However, this requires careful planning because this option may pose some political and equality challenges. As program specialists may be relatively scarce in some isolated areas it might be useful to consider the resource-sharing among local implementers that are in close geographical proximity.

Furthermore, DEA information may be useful in managerial assessments for many purposes. DEA results can be used as an attention direction tool to allocate the limited management authority resources where program administration inefficiencies are known to exist. DEA results can be used, before benchmarking procedures in order to locate the relatively more and less efficient implementation units. This performance discrimination is the starting point for studying the managerial operations of more efficient units, in order to transfer them to less efficient units.

10.3.3 DEA as a Management Tool for Local Program Implementers
At the LAG level, efforts need to be focused on ensuring better utilization of LAG staff. Furthermore, the problems of scale inefficiencies in the local implementers need to be highly addressed. In the light of the fact that the prevalent scale inefficiency in the delivery system is that of increasing returns to scale, the expansion of output will reduce unit costs in those implementers under increasing returns to scale. Increasing the level of output requires an increase in the demand for rural development investment.

In the wake of the present performance of some of these LAGs which are qualified to serve as benchmarks or role models, it may be profitable for management to consider a detailed analysis of the LAG characteristics, operating environment and other attributes that seem to have prompted the efficiency performance of these LAGs. An investigation of the profile of peer groups vis-a-vis the inefficient LAGs will reveal areas of the operation of the inefficient units that require most attention and adjustment.
10.4 Future Research Directions

The performance evaluation framework presented in this study is a first attempt of assessing the operational efficiency of a program and can be extended in several ways.

Firstly, appropriate weight restrictions may be incorporated in the dual multiplier form of the basic model in order to reflect the particular conditions concerning each local program. Such restrictions may be determined interactively by the decision makers on the basis of their deeper knowledge on the program.

Secondly, the proposed framework relates metrics of outputs and inputs, assuming a constant quality of program administration services. In general, the quality of programs or the perceived quality of a beneficiary may be investigated through the incorporation of quality factors into the DEA models. As quality indices, services mix and absorption indices might be used.

Thirdly, the concept of program efficiency of Charnes, Cooper and Rhodes (1981) can be applied to study managerial inefficiencies between countries delivering similar programs.

Finally, rather than focusing on traditional DEA performance measures we can employ the directional technology distance function introduced by Chambers, Chung, and Färe (1996). Unlike the traditional DEA models that optimize either in the input or the output direction, the directional distance function simultaneously optimize in both directions as much as it is technologically feasible.

10.5 Concluding Remarks

DEA is particularly applicable to public sector and non-profit organizations as they produce multiple outputs and use multiple inputs. This study provides an insight to the efficiency measurement and efficiency management of sub-national implementers of an EU socioeconomic development program. It is admitted that some rural development implementation units are better resourced than similar implementation units. However, it is found that there is prevalence of inefficiency in the entire implementation system. Consequently, the problem of scarcity of resources in the implementation system is also compounded by technical and scale inefficiency that leads to program absorption problems.
DEA program efficiency measurement, as it is demonstrated, brought many positive aspects to performance assessment and drove performance improvement in both public program administration and public policy implementation phase. Conclusively, DEA offers the following advantages:

**Provides clearly communicated expectations:**

With DEA-based targets outlined and communicated, an implementation unit better understands its role in the success of program delivery, and Management Authority has a better grasp on how to gauge performance of units. Using DEA for grading a program implementer against some standard (frontier) which are constructed from similar units means a more objective review.

**Improves accountability:**

Performance measurement also helps with accountability, ensuring that program implementation units are performing as expected and taxpayer’s money is spent responsibly. The management authority may implement DEA performance measurement and use it for cross-agency planning and goal setting to make sure its implementation units tied tightly into the Ministry’s priorities.

**Identifies operational strengths and weaknesses:**

As demonstrated, it is easy for managers to recognize program strengths and weaknesses in implementation. This gives them the way to develop needed skills or redirect them for optimal efficiency.

**Guides the reallocation of program resources:**

Performance measurement with DEA helps Management Authority recognize those program implementers who are succeeding and those who are blundering. By getting a better appreciation for the units’ capabilities, Management Authority becomes able to reallocate resources in the most effective way.

**Provides focus for further benchmarking:**

Formalizing a DEA based performance measurement system means government leaders and auditors are able to compare policy implementation agencies, projects, and budgets. This benchmarking can help increase program network efficiency, increase program
implementation speed and decrease expenses. It creates a broader base of knowledge to use in public policy planning, implementing and budgeting.
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12. APPENDICES

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APPENDIX 1 LEADER+ PROGRAM AXES BROKEN DOWN BY MEASURES, INTERVENTIONS AND RURAL DEVELOPMENT ACTIVITIES

PRIORITY AXIS 1: INTEGRATED PILOT STRATEGIES FOR RURAL DEVELOPMENT

MEASURE 1.1: Technical Support for Implementation Agencies (Local Action Groups)

Beneficiaries: Local Action Groups

1.1.1 Staffing and operations of Local Action Group
1.1.3 Evaluation of program and investment plans
1.1.4 Equipment and computerized processes for Local Action Group

MEASURE 1.2: Investment Subsidies – Support for Entrepreneurship

Beneficiaries: Individuals – Legal Entities, Collective Agencies

1.2.1 Interventions for an integrated approach to rural tourism

1.2.1.1 Creation and improvement of accommodation infrastructures to improve the tourism dynamic of the region
1.2.1.2 Creation and improvement of catering infrastructures to improve the tourism dynamic of the region
1.2.1.3 Development of rural tourism (opening farms for visits, with provision for accommodation infrastructure)
1.2.1.4 Development of alternative and special forms of rural tourism (religious, spa, mountain, educational, camping, etc.)
1.2.1.5 Local centres for organization, provision of information and promotion of rural tourism
1.2.1.6 Businesses to provide rural tourism support services (traditional Greek cafés, visitors’ creative leisure centres, etc.)
1.2.1.7 Improving rural tourism businesses for adaptation to needs of certification or clustering

1.2.2 Small businesses in rural sector and other sectors of the economy
1.2.2.1 Manufacturing facilities (cottage industry, crafts, traditional arts production, etc.)
1.2.2.2 Entrepreneurial exploitation of local natural resources
1.2.2.3 Businesses engaged in processing, packaging of agricultural produce
1.2.2.4 Businesses engaged in processing, packaging of livestock produce
1.2.2.5 Businesses engaged in original uses for herbs and healing plants
1.2.2.6 Businesses engaged in production of foodstuffs post first processing
1.2.2.7 Utilization of traditional techniques and places (treading floors, cellars, opening of wineries to visits)
1.2.2.8 Game farms
1.2.2.9 Businesses exploiting eco-friendly and renewable sources of energy, apart from primary production
1.2.2.10 Improvement of businesses, largely in the direction of environmental protection
1.2.2.11 Businesses providing services to support the social economy and social services
1.2.2.12 Improvement of businesses to adjust to needs of certification or clustering

1.2.3 Investments to strengthen collective, sectoral and inter-sectoral action through use of contemporary technology, know-how and new techniques
1.2.3.1 Installation of quality assurance systems (ISO - HACCP)
1.2.3.2 Clustering of similar or complementary businesses
1.2.3.3 Development of IT services for SMEs (e.g. websites)
1.2.3.4 Development of tele-working, tele-marketing and e-commerce systems
1.2.3.5 Development, certification and control of quality marks (Protected Designation of Origin, Protected Geographical Indication, organic products etc.).

MEASURE 1.3: Support Measures
Appendices

Beneficiaries: Individuals – Legal Entities, Collective Agencies, SMEs, Local Action Groups, Local Authorities, Prefectural Authorities

1.3.1 Upgrading skills and specialist knowledge of human resources - training

1.3.2 Provision of advisory support

1.3.3 Marketing and promotional measures

   1.3.3.1 Awareness-raising and briefing of population on local programme

   1.3.3.2 Marketing – promotion of sectors and regions by collective agencies

MEASURE 1.4: Protection, Promotion and Exploitation of Natural and Cultural Heritage

Beneficiaries: Individuals – Legal Entities, Collective Agencies, Cultural Associations and Societies, Local Action Groups, NGOs

1.4.1 Protection, promotion and exploitation of natural environment

   1.4.1.1 Exploitation, promotion and protection of regions of natural beauty, landscapes and areas in the Natura 2000 network

   1.4.1.2 Environmental protection systems

   1.4.1.3 Improvement of refuges

   1.4.1.4 Access trails, paths, bridges

1.4.2 Actions to upgrade the built environment and to promote the traditional architectural heritage of the rural regions

   1.4.2.1 Upgrading of regions’ built areas (communities, neighborhoods, etc.) of architectural interest, implementing an integrated housing construction development plan

   1.4.2.2 Promotion of monuments and buildings making up the rural heritage

   1.4.2.3 Museums representing the rural, folklore and cultural heritage

   1.4.2.4 Centres for cultural and other activities (arts centres, theatres, etc.)

   1.4.2.5 Signposting of sights, monuments, paths - mapping

1.4.3 Actions to support cultural events and events designed to highlight and preserve the local heritage of rural areas
PRIORITY AXIS 2: SUPPORT FOR COOPERATION AMONG RURAL AREAS

MEASURE 2.1: Cooperation among Regions of Greece: Cooperation on local and regional level

Beneficiaries: Local Action Groups and other collective agencies implementing cooperation plans

2.1.1 Co operations in aspects of rural tourism

2.1.2 Co operations in matters affecting small enterprises in rural sector and other sectors of the economy

2.1.3 Co operations in use of new technologies and know-how

2.1.4 Co operations in action on environment and cultural heritage

MEASURE 2.2: Cooperation among regions from two or more countries: Trans-national cooperation

Beneficiaries: Local Action Groups

2.2.1 Co operations in aspects of rural tourism

2.2.2 Co operations in matters affecting small enterprises in rural sector and other sectors of the economy

2.2.3 Co operations in use of new technologies and know-how

2.2.4 Co operations in action on environment and cultural heritage

PRIORITY AXIS 3: CLUSTERS

MEASURE 3.1: GREEK LEADER+ NETWORK

Beneficiaries: Greek LEADER+ Network

3.1.1 Greek Leader+ Network

3.1.2 Operating costs of clusters

3.1.3 Network meetings

MEASURE 3.2: LEADER + NETWORK NATIONAL UNIT

3.2.1 Dissemination measures
3.2.2 Guidance for Local Action Groups, the Operational Programme Management Service and the Monitoring Committee

3.2.3 Data base and telematics system
## APPENDIX 2 LAGS BY REGION

<table>
<thead>
<tr>
<th>Region</th>
<th>Lag Name</th>
<th>Lag code</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. East Macedonia and Thrace</td>
<td>DRAMA S.A.</td>
<td>LAG-08</td>
</tr>
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<td>LAG-09</td>
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<td>OLMPIA S.A.</td>
<td>LAG-29</td>
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8. Ionian Islands | KERKIRA S.A.  | LAG-23  
8. Ionian Islands | ZAKYNTHOS S.A. | LAG-39  
9. Peloponnese  | ANVOPE S.A.  | LAG-05  
9. Peloponnese  | PARNONAS S.A. | LAG-30  
10. The North Aegean Islands | ETAL S.A. | LAG-26  
10. The North Aegean Islands | LIIMNOS S.A. | LAG-27  
11. The South Aegean Islands | DODEKANISSA S.A. | LAG-07  
12. Crete  | AKOMM S.A.  | LAG-03  
12. Crete  | HERAKLION S.A. | LAG-17  
12. Crete  | LASSITHI | LAG-25  
12. Crete  | OADYK S.A.  | LAG-28  

APPENDIX 3 MIDTERM ANALYSIS OF PROGRAM ABSORPTION (%)

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<th>Mgmt.</th>
<th>Equip</th>
<th>RUR (O)</th>
<th>SMES (O)</th>
<th>TECH (O)</th>
<th>HS (O)</th>
<th>NENV (O)</th>
<th>HENV (O)</th>
<th>CULT (O)</th>
<th>LCOOP (O)</th>
<th>TCOOP (O)</th>
<th>Aggregated Output</th>
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<td>49.72</td>
<td>52.65</td>
<td>4.18</td>
<td>27.53</td>
<td>16.47</td>
<td>0.00</td>
<td>16.66</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>5.16</td>
<td>16.11</td>
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- 32.77
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- 20.24
- 0.00
- 0.00
- 27.57

### PILIO
- 58.42
- 57.61
- 89.65
- 31.60
- 44.59
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- 41.25
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- 0.00
- 99.28
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- 26.15

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### THESSALONIKI
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- 62.64
- 55.78
- 55.21
- 67.23
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- 35.04
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- 5.93
- 50.83

### TRICHONIDA
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- 56.31
- 80.38
- 16.79
- 18.00
- 0.00
- 26.09
- 100.00
- 0.00
- 0.00
- 0.00
- 20.67

### XANTHI
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- 45.39
- 68.35
- 30.86
- 37.42
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- 32.55
- 0.00
- 0.00
- 0.00
- 0.00
- 25.06

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- 43.83
- 10.10
- 11.98
- 0.00
- 25.44
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- 49.37
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- 22.33
- 8.84
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### APPENDIX 4 MIDTERM (2005) DEA RESULTS

Table A2.1 Reference sets of inefficient and frequency of efficient LAGs as Benchmarks; (VRS; 2005)

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APPENDIX 4 COMPARISON OF TIME PERIOD EFFICIENCIES DIFFERENCES

Figure A4.1. Densities of CRS, VRS and Scale efficiencies [pre- and post-MT periods]
Figure A4.2. Probability distributions of CRS, VRS and Scale efficiencies [pre- and post-MT periods]
## APPENDIX 5 POOLED DEA RESULTS

Table A5.1 Pre-MT period (2005) relative efficiencies of LAGs estimated using pooled observations

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Table A5.2 Post-MT period (2006) relative efficiencies of LAGs estimated using pooled observations

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## APPENDIX 6 REGRESSION ANALYSIS

Table A6.1 Correlation matrix for regression analysis

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Nikos Pettas - January 2017 281
### Pearson Correlation Matrix

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<td>0.255*</td>
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<td>(0.000)</td>
</tr>
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</table>

**. Correlation is significant at the 0.01 level (2-tailed). *. Correlation is significant at the 0.05 level (2-tailed). p-values in parenthesis.

Pearson correlations are below the diagonal, and Spearman correlations are above the diagonal.
Table A6.2 Diagnostic Checking in Regression Relationships

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<tr>
<th>Tests</th>
<th>Overall productivity</th>
<th>Pure productivity</th>
<th>Scale-productivity</th>
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<td>Lilliefors (KS) Normality Test</td>
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Table A6.3 Pooled Tobit regressions results

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<th>Overall productivity</th>
<th>Pure productivity</th>
<th>Scale productivity</th>
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<td>Std. Error</td>
<td>Estimate</td>
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The effect at the mean of az.

Standard errors are robust. Signif. codes: ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05