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RESUMO/ABSTRACT

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Key words: public employment service, matching, efficiency, DEA

JEL Classification: C14, J68

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The Efficiency of Matching in Portuguese Public Employment Service

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Abstract

This paper assesses the matching efficiency of the Portuguese public employment service (PES), applying data envelopment analysis (DEA) combined with principal component analysis (PCA) to Portuguese administrative data and comparing the situations in June 1998 and June 2001. We find evidence that the Portuguese public employment service increased its efficiency potential from 0.54 (June 1998) to 0.65 (June 2001), becoming more efficient and more homogenous. However, employment-centres differ in efficiency and factors affecting efficiency diverge among employment-centres. Policies aimed at improving the efficiency of the matching process should be employment-centre specific. Indeed, we find that some employment-centres could benefit from investing in labour market policies, some from investing in social policies, and others from investing in income support policies. Finally, some employment-centres could benefit from a mix of these socio-economic policies.

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1 Introduction

Labour market performance is a determinant of living standards, economic growth and public balances, and its improvement has been one of the main goals among developed countries in the last decades. With this aim, the OECD's Jobs Strategy recommendations included five main issues: a) the reform of employment protection legislation; b) working hours negotiation between employers and employees; c) the reduction of the cost of unskilled and part-time labour; d) the reduction of inactivity traps; and e) the improvement of the efficiency of the public employment service (OECD, 1998; Brandt et al., 2005).

According to the OECD's recommendations, the improvement of the functioning of the PES requires the integration of three basic PES functions (placement and counselling services, the payment of unemployment benefits and management of labour market programmes), the support of regular contact between claimants and PES to support job-search efforts, and the elimination of the monopoly position of the PES to increase the flow of vacancies through the promotion of private placement agencies (Jamet, 2006).

An efficient functioning PES, besides playing a role in the management of active and passive labour market policies, is essential to assure a rapid matching between workers and jobs. As a result, inefficiency is likely to be associated with a longer vacancy duration and unemployment duration, which may produce negative effects such as discouragement and the loss of skills.

From this perspective, the Portuguese labour market represents an interesting case to be investigated. According to some economists, Portugal may be seen as an extreme case of "eurosclerosis". The Portuguese labour market is characterised by low flow-rates between employment and unemployment and *vice versa*, resulting in an extremely high mean duration of unemployment (Portugal, 2008). According to the literature, many factors may explain the bad performance of the Portuguese labour market, including high employment protection legislation and the unemployment benefit system. However, the functioning of the Portuguese PES represents a key-determinant in improving labour market performance, and its efficiency may depend on employment-centre characteristics, including local labour demand and supply and mismatches between unemployed workers and vacant jobs' characteristics, as well as other environmental factors.

Many studies have been implemented to assess the efficiency of PES, or more generally, the effectiveness of search or recruitment. Petrongolo and Pissarides (2001) provide a detailed review of studies focusing on matching functions, mismatch and both macro and micro approaches to matching. Among micro-studies, Van Ours (1991) evaluates the effectiveness of the public employment office in the Netherlands using information about vacancy duration, while Lindeboom, Van Ours and Renes (1994) use Dutch micro-data to study the effectiveness of searches comparing different recruitment channels, including PES. Among macro-studies, Sheldon (2003) uses the data envelopment analysis approach to provide evidence about the efficiency of PES in Switzerland, showing that in 1997-1998 the Swiss PES reached roughly two thirds of its efficiency potential.

In this paper, we assess the efficiency of the Portuguese PES using an approach close to Sheldon (2003). Indeed, while we similarly adopt Data Envelopment Analysis, we combine it with Principal Component Analysis with the aim of reducing the problem of multidimensionality (Adler and Golany, 2001). DEA-PCA

methodology is applied to administrative information provided by the Instituto do Emprego e Formação Profissional, the Portuguese PES. Efficiency is measured with respect to the number of matches taking place in a specific time-interval at employment-centre level. Finally, with the aim of evaluating the evolution of matching efficiency, we compare the situations in June 1998 and June 2001.

The empirical results of our analysis originate from the implementation of five DEA-PCA nested models (cascade analysis): the first one is the benchmark model, which includes labour demand, supply and mismatch variables (Model I), while the remaining models add, in turn, local labour market variables (Model II), a social integration variable (Model III), social shock absorber variables (Model IV) and, finally, environmental variables all together (Model V). According to results from the full model (Model V), the Portuguese PES reached approximately 0.54 of its efficiency potential in 1998 and 0.65 in 2001. Moreover, our procedure allows us to identify eight groups of PES offices to highlight the differences between them.

Because there are no DEA-PCA studies for the Portuguese labour market, this paper contributes to the literature in a novel and meaningful way. Portugal has been dealing with low job-flow rates that, as mentioned above, are associated with mismatches in a sclerotic labour market, as in Blanchard and Portugal (2001). Even during the late 90s and early 00s when Portugal experienced relatively low unemployment, it was well documented that unemployment duration was relatively high, which was associated with low job turnover and workers staying at jobs with low productivity and low quality of job match. Hence, analysing and understanding the matching process in Portugal is paramount to making the Portuguese labour market and its economy more efficient and productive.

In addition, the Portuguese PES has been a central part of implementing different labour market policies in the Portuguese labour market. Hence, analysing the efficiency of the Portuguese PES is critical to understanding the inner functioning of the Portuguese labour market and the efficacy of labour market policies in Portugal.

In particular, the use of a cascade analysis shows that environmental variables are very important to the efficiency of many employment-centres' matching processes between labour demand and supply, with different weights for each unit evaluated. Hence, our results note substantial differences in the Portuguese employment-centres, as the efficiency of some employment-centres depends on some factors that appear to be irrelevant to other employment-centres. This study may thus be source of useful information for improving the efficiency of the matching process: environmental variables highlight the need for targeted and different interventions depending on the context. In terms of policy, an efficient matching process may be reached adopting different interventions across employment-centres. In some cases, it is required to invest more in labour market policies, other employment-centres require new social policies, while still others require income support policies. Finally, some employment-centres require a mix of these interventions with the aim of reaching an efficient matching.

2 Methodology: DEA-PCA

As anticipated above, the efficiency of the Portuguese PES is investigated at employment-centre level by terms of the number of matches in a specific month. Following Petrongolo and Pissarides (2001), the simplest form of the matching function is:

$$M = m(U,V)$$

where M is the number of jobs formed during a given time interval for each employment-centre, U is the number of unemployed workers looking for a work at the employment-centre level and V the number of vacant jobs at the employment-centre level. The matching function is assumed to be increasing in both its arguments, concave and, usually, homogeneous of degree one.

The literature concerning the micro-foundations of the aggregate matching function has suggested that the matching rate may be influenced by other variables besides U and V. Some of these variables should proxy the unemployed worker's actions during the search, while other variables include shifts unrelated to individual search decision (Petrongolo and Pissarides, 2001), such as mismatches in terms of skills, industrial sector and location. Controlling for these factors is essential to take into account labour market heterogeneities.

Given these considerations, we want to evaluate the efficiency of the Portuguese PES using a macro-approach, taking into account the number of matches that have taken place both at time and employment-centre levels (output), several inputs that include the number of unemployed workers and vacant jobs and other variables that control for factors shifting the matching rate. With this aim, we apply the DEA-PCA methodology. Data Envelopment Analysis (DEA) is one of the methods we can use to assess the relative efficiency of similar operating units (also called Decision Making Units or DMUs). In particular, DMUs can represent any set of organisations or departments that perform fundamentally the same task with the same set of variables. In our case, DMUs are the employment-centres constituting the Portuguese PES and the concept of efficiency is measured as the total number of matches achieved by employment-centres in a specific time-period.

Unlike parametric techniques, DEA does not require a detailed description of the production process. DEA estimates technical efficiency by first constructing the production possibility set assumed to contain all feasible input-output correspondences and then estimating the maximum feasible expansion of the output (output orientation) or the maximum feasible contraction of the input levels (input orientation) of the units within the set. Since Charnes, Cooper and Rhodes' (1978) seminal paper, numerous DEA models have appeared in the literature as well as many studies employing this technique (Cooper et al., 2000).

Studying employment-centres poses the specific problem of multidimensionality within the DEA models. In short, there are numerous inputs that contribute to the matching process between labour demand and supply, and in this case, we insert into the analysis a significant number of input indicators to minimise the probability of omitting relevant variables.

In addition, DEA has a problem with higher dimensions. Problems related to discrimination arise, for example, when there is a relatively large number of variables versus DMUs, a condition that in extreme cases may cause the majority of observations to be defined as efficient. Consequently, with an increase of size, DEA is always less selective. A way to overcome this problem is the integration of DEA and principal component analysis (PCA) (Ueda and Hoshiai, 1997; Adler and Golany 2001, 2002, 2006). PCA allows us to reduce the size of the problem. In particular, PCA is a multivariate statistical method devised for dimensionality reduction of multivariate data with correlated variables. This technique accounts for the maximum amount of the variance of a data matrix by using a few linear combinations (termed principal components) of the original variables (Cerioli and Zani, 2007)[1]. Consequently, if a portion of the variability is attributable to the first principal components (latent variables), the inclusion of only these, and not others (latent variables), limits the size without losing much of the contribution of the explanatory variables. In general, the rule is to include enough variables to explain at least 70-80% of the overall variability. Usually this allows significant reduction in the number of variables and allows the use of the DEA technique in the presence of a large number of variables (for a discussion of the methodology, see the studies of Adler and Golany, 2001, 2002, 2006; Adler and Yazhemsky, 2010). In addition, to overcome the problem of diversity of size between variables (variables expressed in different units) we employ normalisation of the original variables (division by standard deviation). Specifically, the analysis consists of three phases: after each variable is divided by the corresponding standard deviation, the correlation matrix of standardised inputs and principal components are calculated and, finally, linear programs are used to derive efficiency scores.

Assuming constant returns to scale (CCR)[2] of activities, the PCA-DEA model we use (Charnes et al., 1978), under output orientation[3] is the following:

$$\max_{\sigma_r,\mu} \sigma_r$$

$$-X_{PC}^{T}\mu - Z_{PC} = -X_{PC_R}^{T}$$

$$-Y_{PC}^{T}\mu - S_{PC} = \sigma_r Y_{PC_R}^{T}$$

$$Z_{PC} = L_Y^T z \qquad (r = 1,\ldots,n)$$

$$S_{PC} = L_Y^T s$$

$$s, z, \mu \geq 0$$

[1] The aim of the PCA is to take p variables X_1, X_2,…, X_p and find linear combinations of them to produce principal components X_{PC1}, X_{PC2},…, X_{PCp} that are uncorrelated.

[2] With variable returns to scale (VRS), the frontier band data more closely, so that each DMU is compared with a subset of the DMU of similar scale; in contrast, the frontier with constant returns to scale (CCR) is more external and each DMU is compared with the best DMU regardless of the scale. Therefore, the indicator of efficiency calculated in the first case will always be greater than that one calculated in the second case.

[3] Given the assumption of constant returns to scale (CCR), in our analysis, we will select employment-centres that lead to a greater number of employment matches while using the same amount of input (output orientation).

where: Y_{PC}^{T} and X_{PC}^{T} denote, respectively, the transposed principal components (orthogonal, non-rotated) of the outputs and inputs, μ is the *nx1* vector of multipliers, *s,* e and *z* are the slacks on the original variables, S_{PC} and Z_{PC} are the slacks on the principal components variables and L_Y^T is the matrix of the eigenvectors ordered in descending order of the eigenvalues.

This linear programming problem must be solved n times, once for each unit in the sample, to obtain a value of σ for each DMU. The value of σ_r is termed the technical output efficiency of DMU *r* and is bounded between 0 and 1. An efficient unit will have a score equal to one, while inefficient units will have a score less than one.

The identification of the input and output variables to be used in an assessment of comparative performance is the first and the most important stage in carrying out the evaluation (Thanassoulis 2001). However, the non-parametric approach to efficiency measurement does not offer any tools that can aid researchers in specifying the most appropriate model. To address this drawback, attention must be paid to the selection of the input-output set, giving emphasis to what is postulated by efficiency theory and what is indicated in the particular context under investigation.

In our analysis we consider the number of matches between demand and supply of employment as output of the production process of the PES. As factors of production (input), we consider different sets of variables, i.e., labour demand and supply, some mismatch variables, and some environmental variables (an indicator of the state of the local labour market, an indicator of openness and social integration and the presence of social shock absorbers).

3 Data

The empirical analysis is based on an administrative dataset provided by the Instituto do Emprego e Formação Profissional (IEFP), which is the Portuguese PES. Data has been collected for mainland Portugal between 1998 and 2002 across 83 PES offices (increased to 86 in the period under investigation). They include information on approximately 3 million registrations by people looking for a job (unemployed workers) and approximately 500,000 registrations of vacant jobs. For each registration (unemployed workers and vacancies), IEFP data provides monthly information including the date that the registration took place and the date that a vacancy is filled or a worker finds a job. This allows us to reconstruct the duration of both unemployed workers and vacancies registered at the Portuguese PES in the period 1998-2002. Moreover, IEFP also provides information about characteristics attached to both the unemployed and vacancies. The macro-analysis of matching efficiency through DEA-PCA requires the identification of the number of matches (the output) in the Portuguese PES. Because of the nature of our data, the identification is monthly and calculated using the number of matched between unemployed workers and vacancies registered at the Portuguese PES[4]. In other words, the number of matches is determined by summing, for each employment-

[4] Unemployed workers finding a job by their own means are not used to determine the number of matches.

centre, the number of unemployed workers filling a vacant job at the employment-centre for each month under analysis.

In principle, information attached to unemployed workers and vacancies are available for each unit of analysis and for each month. However, because of missing data problems at the timing level (for example, educational level attached to vacant jobs in 2002) or at the employment-centre level, we limit our analysis to a sub-sample of employment-centres (55 to be more specific) and to specific months for the period 1998-2001. The efficiency of employment-centres is evaluated by DEA-PCA in a dynamic perspective by comparing their performance for two different years (1998 and 2001) but with the reference to the same month (June)[5]. As anticipated, the production process, in our specific case, involves several inputs, including variables associated with the labour demand, labour supply and mismatches. The final output is the number of matches between labour demand and supply.

The employment-centres - the actors involved in the matching process - have the task of combining, as efficiently as possible, the different factors of production (inputs) involved in the matching process. The agents involved in the process of matching jobs are unemployed workers and potential employees. In particular, the first will be characterised by the presence of variables related to labour demand, i.e., the local wage, the percentage of full-time jobs, and the percentages of jobs by industrial sectors (agriculture, industry and services). The second will be characterised by the presence of variables associated with the labour supply, especially with characteristics of individuals looking for a job, i.e.: gender, marital status, presence of dependent persons, temporary work experiences[6]. In addition, we also consider variables that may create frictions in the production process, i.e., mismatch variables. These include education and profession. Specifically, the education mismatch indicator is defined as the ratio between the (average) maximum schooling required to fill a job and the average schooling of individuals looking for a job in that employment-centre that month. Similarly, we define the professional mismatch indicators according to seven sub-groups (manager-specialists, technicians, administrative workers, service workers, farm workers and fishermen, blue-collars, unskilled workers).

In addition, the second group of inputs includes environmental variables that may have an impact on the transformation of resources into outcomes, and could influence the efficiency of the DMU (Charnes et al. 1981; Thanassoulis 2001). In our specific case, the environmental factors identify the socio-economic context where the employment-centres operate. Among the environmental variables we include:

- an indicator of the health of the labor market, i.e., the vacancy-to-unemployment ratio (a standard measure of labour market tightness);
- an indicator of social integration that captures the effect of social openings on the matching process, i.e., number of disabled people enrolled in employment-centres;

[5] Measuring efficiency for the same month in different years should reduce bias due to seasonality. However, as a robustness check, we also perform our analysis for other months (March and September in 1998 and 2001), and we verify that the results are stable. In particular, the efficiency score of each PES is does not vary much across each year of the analysis, as confirmed by rank analysis. For reasons of space, we do not show these results; interested readers can request them from the authors.

[6] These characteristics are evaluated at the average values determined at time and employment-centre levels.

- an indicator that will allow us to capture the effect of social shock absorbers on the efficiency score. In particular, we consider both the benefits paid to young people and unemployment benefits.

4 Analysis of results

The description of our results is reported in three steps. In the first step, we present a static and comparative analysis; in particular, we perform separate DEA-PCA analysis for June 1998 and June 2001; we then proceed to the comparison of results in terms of the efficiency scores at the district level, similar to Sheldon (2003). In the second step, using the results of DEA-PCA, we identify 8 groups of employment-centres characterised by different socio-economic environments from which we deduce policy implications. Finally, in the third step, we proceed in evaluating the significance of the difference in efficiency scores obtained by employment-centres in the two examined periods. With this aim, we perform both the Wilcoxon signed-rank test and the signed test.

4.1 A static and comparative analysis

In this section we list the results of the DEA-PCA analysis obtained for five different cases (Figure 1): input variables with only the benchmark variables (labour demand, labour supply and mismatch variables) (Model I), input variables with benchmark and state of the local labour market variable (Model II), input variables with benchmark and social integration variable (Model III), input variables with benchmark and social shock absorber variables (Model IV), input variables with both benchmark and all environmental variables (state of the local labour market, social integration and social shock absorber) (Model V). Tables 1a and 1b present the DEA-PCA efficiency scores obtained from CCR model for the 55 employment-offices in our sample averaged at the district level. Presenting the average efficiency-score of 18 districts allows a clearer reading of the results; in the Appendix (table A1a and A1b), we report the results for each of the 55 employment-centres. In particular, the districts with an efficiency score equal to one will be considered efficient; in contrast, districts with a score lower than one are considered inefficient[7].

[Figure 1 about here]

In Tables 1a and 1b, we report the number of PES present within each district (*EC*). In this case, we note a clear unbalance in the distribution of employment-centres within districts; in particular, there are districts that have as few as one PES location (Aveiro, Evora, Porto Alegre and Vila Real) and one district that has eight (Lisboa). We report also the number of efficient employment-centres (those obtaining an efficiency score equal to one) within each district (*Eff. EC*), and the average efficiency score of each district (*Eff-score*). In Table 1a we report the results for June 1998 and we observe the following:

- The evaluation of DMUs by means of the first model shows that the Lisboa and Setubal districts both have two efficient offices.. However, no district's overall score was deemed to be efficient because

[7] In the appendix A1a and A1b, we report the results obtained for each PES.

each one presents an average efficiency score less than one. Castelo Branco is the most efficient with an efficiency score of 0.885, while district 17 is the less efficient with an efficiency score of 0.001.

- According to the second model, the two top performing PES locations are in the districts of Coimbra and Lieira; moreover, the average efficiency score of 14 districts increases[8]. These results show that the introduction of the state of the local labour market variable provides several benefits, including more information, a more realistic picture of the different socio-economic contexts and highlighting the employment-centres with a healthier labour market (both those that achieve efficiency, and that that increase their efficiency score but do not become technically efficient).
- In the third model, one employment-centre in the district of Setubal is considered efficient, while the average efficiency score of just 10 of the 18 districts increase. This suggests that the social integration variable has little relevance in improving the matching process of employment-centres. However, two employment-centres in the districts, Coimbra and Lieira, return to being inefficient against the previous analysis with the state of the local labour market variable. The presence of the social integration variable triggers an improvement in the efficiency level in one employment-centre, while other employment-centres become less efficient.
- In the fourth model, only one employment-centre in the district of Coimbra is efficient, although the average efficiency score of 14 districts increases. The presence of the social shock absorber variables slightly changes the results, highlighting the small level of relevance income support policies have to the matching process.
- Finally in the fifth model, we observe that one employment-centre in the district of Coimbra, two employment-centres in the district of Lieira and one employment-centre in the district Setubal are efficient; in this case, only the average efficiency score of the district of Vila Real remains unchanged with the lowest value. The district of Vila-Real is the most inefficient Portuguese district in the matching process.

In Table 1b, we report the same results for June 2001. In general, we observe that many of the employment-centres that were efficient in 1998 became inefficient in the year 2001. In addition, we observe in 2001 a general improvement of the efficiency score of the Portuguese PES over 1998. We will verify this last point in section 4.3 through statistical tests.

[Table 1a about here]

[Table 1b about here]

Figure 2 presents a scatter plot of PES efficiency scores grouped by district (horizontal axis). We report for brevity only the graphs related to the model V[9], respectively for 1998 (fig. 2a) and 2001 (fig. 2b). The dots

[8] The comparison of efficiency scores will always be made with respect to the benchmark model (Model I).
[9] For reason of space, we do not show the graphs of the other models; interested readers can request them from the authors.

represent the employment-centre efficiency scores, while the continuous line represents the average efficiency score of the entire Portuguese PES. Employment-centres with above average efficiency scores appear above this line, and those with below-average efficiency scores appear beneath it. The average efficiency score is 0.54 in 1998 and 0.653 in 2001. This suggests that, on average, the PES showed an improvement of efficiency in the matching process from 1998 to 2001; this is further supported by the higher number of employment-centres above the average in 2001 than in 1998. Both graphs show a high variability in the efficiency score within each district; in particular, we observe that the total variance of employment-centre efficiency scores is higher in 1998 (0.114) than in 2001 (0.078). This reveals a growing homogeneity in terms of efficiency in the matching process in the Portuguese PES between 1998 and 2001. The Portuguese PES, in the period examined, show an improvement in efficiency in the matching process and a tendency to become more homogeneous.

[Figura 2a about here]

[Figura 2b about here]

We conclude this analysis by considering the reference sets for the years 1998 and 2001. In particular, it is also possible to identify poorly performing organisations and their relatively efficient peers because the DEA-PCA method is able to produce information on the extent to which an efficient DMU is used as an efficient peer for other DMUs. These results appear in Tables A2a and A2b in the appendix, which display the frequency with which efficient employment-centres appear in the peer group of the inefficient ones. Note that, in all models and for both years, the employment-centre in Barreiro, which belongs to the district of Setubal, appears very frequently in the reference sets (42, 25, 38, 40 and 30 times for 1998 and 19, 31, 21, 44 and 36 times for 2001).

4.2 Different socio-economic environments and policy implications

In this section, from the five models considered in section 4.1 and summarised in Figure 1, we identify eight groups of employment-centres. In particular, we track the efficiency scores of these groups of employment-centres with the introduction of some environmental variables, i.e., state of the local labour market, social integration and social shock absorber.

In Figure 3, we report a summary of our results. Specifically, we denote by ↔ the employment-centres that maintain an efficiency score equal to an efficiency score of the benchmark model as we introduce the different environmental variables between the inputs; we denote by ↑ the employment-centres where efficiency score increase with respect the benchmark model.

The reference group for each employment-centre is reported in Tables A1a and A1b in the appendix.

[Figure 3 about here][10]

Consequently, the eight identified groups are segregated by several characteristics:

1) A first group consists of employment-centres that have the same efficiency score in all the models considered. In this case, all the environmental variables considered are indifferent to an employment-centre's job matching efficiency;

2) A second group of employment-centres are characterised by an increase in the efficiency score after the introduction of the variable "state of local labour market" and a return to the initial efficiency score when we consider the other environmental factors. In this case, the employment-centres are those that, compared to all other employment-centres, present a healthier labour market in terms of vacancy-to-unemployment ratio. These employment-centres are more sensitive to the characteristics of the labour market and to shocks to this market.

3) A third group of employment-centres are characterised by an increase in the efficiency score after introduction of the social integration variable and return to the initial efficiency score when we consider other environmental factors. These employment-centres are sensitive to the process of integration of disabled people into the labour market.

4) A fourth group of employment-centres are characterised by an increase in the efficiency score after introduction of the "social shock absorber" variable and return to the initial efficiency score when considering other environmental factors. Employment-centres of this group make good use of policies in favour of young and unemployed people;

5) A fifth group of employment-centres are characterised by an increase in the efficiency score after introduction of the "state of the labour market" and "social integration" variables and return to the initial efficiency score when we consider the "social shock absorber" variable. Consequently, social policies aimed at promoting the employment of disabled people and the presence of a healthy labour market will facilitate the process of matching jobs;

6) A sixth group of employment-centres are characterised by an increase in the efficiency score after introduction of the "state of the labour market" and "social shock absorber" variables and return to the initial efficiency score when we consider the "social integration" variable. In terms of efficiency, in addition to presenting a healthier labour market, these centres also make good use of income support policies;

7) A seventh group of employment-centres are characterised by an increase in the efficiency score after introduction of the "social integration" and "social shock absorber" variables and return to the initial efficiency score when we consider the "state of the labour market" variable. In this case, the presence of both an open social environment and an appropriate use of income support policies will favour employment-centres in the matching process;

[10] We do not comment on the last model (Model V) because this model includes all environmental factors and does not allow us to distinguish the effect on the efficiency score of individual environmental variables.

8) We conclude with a group of employment-centres characterised by an increase in the efficiency score for all environmental variables included one by one in the analysis. In this case, the presence of social and employment policies and a healthy labour market will favour the employment-centres in improving their performance in the matching process. These employment-centres will be able to focus on several factors, either taken individually or jointly, to improve their performance in the matching process.

These results are important because they note substantial differences across the Portuguese PES. Some employment-centres (first group) do not increase efficiency in the presence of any variables, while others do so only with some variables present, such as a healthy labour market (second group), an open social environment (third group), a sensitive environment to the problems of youth and the unemployed (fourth group), or a combination of the three environmental factors considered one or two at a time (eighth, fifth, sixth and seventh group). In particular, we observe that the addition of the environmental variables highlights the employment-centres that were apparently inefficient. Hence, in these employment-centres, environmental variables are very important in determining their efficiency, but with a different weight for each unit evaluated. In terms of policy, this highlights the need for targeted and different interventions depending on the context. An efficient matching process will require investments in the following:

- labour market policies in employment-centres belonging to the second and eighth group;
- social policies in employment-centres belonging to the third group and eighth group;
- income support policies in employment-centres belonging to the third, fourth and eighth group;
- a mix of socio-economic policies in the areas where operating the employment-centres belonging to the eighth, fifth, sixth and seventh group.

4.3 Are environmental variables significant in improving the performance of the Portuguese PES?

In this last sub-section, we implement statistical tests that will allow us to verify the following:

- whether the introduction of environmental variables produces a significant impact on the efficiency of the matching process in Portuguese PES;
- whether the efficiency scores have changed over the period 1998-2001.

Concerning the first point, we implement Wilcoxon signed-rank[11] and the sign tests[12] that will allow us to compare the efficiency score of models that control for environmental variables (respectively models II, III, IV and V) with efficiency scores of a benchmark model (I model).

The Wilcoxon signed-rank test is constructed taking the difference between the efficiency scores realised by the Portuguese PES in two different models. In particular because we are interested in evaluating the relevance of environmental factors, we will compare the efficiency scores of each model that considers the

[11]The null hypothesis is that both distributions are the same.

[12]The null hypothesis is that the median of the differences is zero; no further assumptions are made about the distributions. This, in turn, is equivalent to the hypothesis that the true proportion of positive (negative) signs is one-half.

environmental variables between inputs to efficiency scores obtained by the implementation of the benchmark model.

Regarding the efficiency scores relative to June 1998 (Table 2), the Wilcoxon signed-rank test confirms the significance of the environmental variables in determining an improvement of the Portuguese PES efficiency in the matching process, thus rejecting the null hypothesis. This result is always true for each model (from II to V) compared with the benchmark model.

We obtain the same result with the sign test[13]; this test, rejecting the null hypothesis, allows us to state that the medians of the models from II to V are not equal to the median of the benchmark model (Model I). In particular, we observe that the presence of variables that take into account the state of health of the labour market, the degree of social openness, the presence of social shock absorber and all environmental factors are relevant in determining an improvement of the efficiency of the Portuguese PES in matching unemployed workers and vacant jobs. Consequently, economic policy measures designed to improve the conditions of the local labour market and to create a more open and more careful socio-economic environment, giving more support to young people and supporting the unemployed, appear to be desirable for improving the efficiency of the Portuguese PES. Regarding the efficiency score of June 2001 (Table 3), the Wilcoxon signed-rank and the sign tests confirm the results obtained for June 1998.

[Table 2 about here]

[Table 3 about here]

Finally, similarly to above, we apply the Wilcoxon signed-rank and the sign tests to the five specifications considered in the paper to test if the efficiency scores are significantly changed over the period 1998-2001 (Table 4). Both tests reject the null hypothesis of equivalence between the average and median values of the efficiency scores between June 1998 and June 2001. In other words, they both show that the change in the efficiency scores occurred over the analysed period is significant in statistical terms; in addition, it is interesting to note that the efficiency of Portuguese PES has increased significantly in June 2001 when compared to June 1998.

[Table 4 about here]

Conclusion

Since the mid-90s, the efficiency of public employment services has been drawing increased attention from labour economists, as it has been singled-out as a key-determinant of labour market performance.

In this paper we assess the efficiency of the Portuguese PES, analysing 55 employment-centres in June 1998 and in June 2001, using administrative data provided by the Instituto do Emprego e Formação Profissional.

[13] The sign test is implemented under the alternative hypothesis that the models with environmental variables have an efficiency score higher than benchmark model.

Efficiency is evaluated with respect to the number of matches measured for each employment-centre at per month by means of a non-parametric approach to efficiency measurement, represented by DEA-PCA. To this purpose, we have obtained measures of technical efficiency from CCR production frontiers.

By DEA-PCA, we implement five models: a benchmark model (including labour demand, labour supply and mismatch variables), to which, in turn, we add environmental variables (state local labour market variable, social integration variable, social shock absorber variables and all environmental variables) in different steps of the analysis (cascade analysis). We find that, according to the full model, the Portuguese PES reached approximately 0.54 of its efficiency potential in June 1998 and 0.65 in June 2001. However, even though the employment-centres become more homogenous between June 1998 and June 2001, we find that they greatly diverge individually in terms of efficiency scores. Specifically, we identify eight groups of employment-centres that allow us to highlight the differences between them.

Moreover, the use of a "cascade" analysis shows that environmental variables are very important in determining the efficiency of a large number of employment-centres in providing the matching process between labour demand and supply, but with a different weight for each unit evaluated. Hence, these results indicate the substantial differences in the Portuguese employment-centres. In fact, the efficiency of some employment-centres depends on some factors that appear to be irrelevant to other employment-centres. Hence, the present study represents a source of useful information to promote the matching process between labour demand and supply. Environmental variables highlight the need for targeted and different interventions depending on the context. In terms of policy, an efficient matching process may be reached by adopting different interventions across employment-centres. In some cases, more investment in labour market policies is needed; in other cases, employment-centres require social policies, while others require income support policies. Finally, some employment-centres require a mix of these interventions to accomplish efficient matching.

References

Adler N., Golany B. 2001 Evaluation of deregulated airline networks using data envelopment analysis combined with principal component analysis with an application to Western Europe. *European Journal of Operational Research* 132 (2), 18-31

Adler N., Golany B. 2002 Including principal component weights to improve discrimination in data envelopment analysis. *Journal of Operational Research Society* 53, 985-991

Adler N., Golany B. 2006 Data reduction through principal component analysis (DEA-PCA). Cook W. and Zhu J. (eds): Modeling Problem Structure and data varieties using data envelopment analysis: A Problem-Solving Handbook, Springer: New York

Adler N., Yazhemsky E. 2010 Improving discrimination in data envelopment analysis: PCA-DEA or variable reduction. *European Journal of Operational Research* 202, 273-284

Brandt N., Burniaux J.M., Duval R. 2005 Assessing the OECD jobs strategy: past developments and reforms. OECD Economics Department Working Paper no. 429

Cerioli A., Zani S. (2007) Analisi dei dati e data mining per le decisioni aziendali. Milano: Giuffrè Editore.

Charnes, A., Cooper, W.W., Rhodes, E. 1978 Measuring the efficiency of decision making units. *European Journal of Operational Research* 2, 429-444

Charnes, A., Cooper, W.W., Rhodes, E. 1981 Evaluating program and managerial efficiency: an application of Data Envelopment Analysis to program follow through. *Management Science* 27, 668-697

Cooper, W.W., Seiford, L.M., Tone, K. 2000 Data Envelopment Analysis: a comprehensive text with models, applications, references and DEA-Solver software. Kluwer, Boston

Jamet S. 2006 Improving labour market performance in France. OECD Economic Department Working Papers no. 504. OECD Publishing

Lindeboom M., van Ours J.C., and Renes G. 1994 Matching employers and workers: an empirical analysis of the effectiveness of search. *Oxford Economic Papers*, 46(1), 45-67

OECD (1998) The Public Employment Service. Greece, Ireland, Portugal, Paris

Petrongolo B., Pissarides C.A. 2001 Looking into the black box: a survey of the matching function. *Journal of Economic Literature*, 39(2), 390-431

Portugal P. 2008 Unemployment duration in the Portuguese labour market. Economic Bullettin, Banco do Portugal (Winter)

Sheldon G.M. 2003 The efficiency of public employment services: a non parametric matching function analysis for Switzerland. *Journal of Productivity Analysis* 20(1), 49-70

Thanassoulis, E. 2001 Introduction to the theory and application of data envelopment analysis: a foundation text with integrated software. Kluwer, Norwell

Ueda, T., Hoshiai, Y. 1997 Application of principal component analysis for parsimonious summarisation of DEA inputs and/or outputs. *Journal of the Operations Research Society of Japan* 40, 446-478

van Ours J.C. 1991 The efficiency of Dutch labour market in matching unemployment and vacancies. *De Economist* 139(3), 358-378

van Ours J.C. 1994 Matching unemployed and vacancies at the public employment office. *Empirical Economics* 19, 37-54

APPENDIX

[Table A1a about here]

[Table A1b about here]

[Table A2a about here]

[Table A2b about here]

Figure 1 Analysis plan

INPUT	OUTPUT: number of matching between labour demand and supply				
	Model I	Model II	Model III	Model IV	Model V
Labour demand	♣	♣	♣	♣	♣
Labour supply	♣	♣	♣	♣	♣
Mismatch variables	♣	♣	♣	♣	♣
State of local labour market		♣			♣
Social integration			♣		♣
Social shock absorber				♣	♣

TABLE 1a. DEA-PCA efficiency scores by Portuguese PES, 1998

DISTRICT	MODEL I			MODEL II			MODEL III			MODEL IV			MODEL V		
	EC	Eff. EC	Eff-score	EC	Eff. EC	Eff-score	EC	Eff. EC	Eff-score	EC	Eff. EC	Eff-score	EC	Eff. EC	Eff-score
Aveiro	2	0	0.424	2	0	0.563	2	0	0.424	2	0	0.522	2	0	0.611
Beja	1	0	0.391	1	0	0.391	1	0	0.401	1	0	0.391	1	0	0.401
Braga	4	0	0.234	4	0	0.235	4	0	0.322	4	0	0.234	4	0	0.322
Bragança	2	1	0.633	2	1	0.635	2	1	0.633	2	1	0.665	2	1	0.665
Castelo Branco	2	1	0.885	2	1	0.947	2	1	0.885	2	1	0.956	2	1	0.990
Coimbra	2	0	0.722	2	1	0.786	2	0	0.722	2	1	0.760	2	1	0.786
Evora	1	0	0.700	1	0	0.700	1	0	0.711	1	0	0.700	1	0	0.711
Faro	5	1	0.584	5	1	0.684	5	1	0.598	5	1	0.587	5	1	0.694
Guarda	2	0	0.289	2	0	0.343	2	0	0.289	2	0	0.296	2	0	0.345
Lieira	3	0	0.643	4	1	0.683	3	0	0.643	3	0	0.672	3	2	0.707
Lisboa	8	2	0.582	8	2	0.638	8	2	0.600	8	2	0.591	8	2	0.655
Porto Alegre	1	0	0.484	1	0	0.484	1	0	0.484	1	0	0.485	1	0	0.485
Porto	7	0	0.251	7	0	0.278	7	0	0.262	7	0	0.276	7	0	0.303
Santarem	5	1	0.416	5	1	0.432	5	1	0.417	5	1	0.464	5	1	0.483
Setubal	5	2	0.694	5	2	0.700	5	3	0.738	5	3	0.703	5	3	0.741
Viana do Castelo	2	0	0.240	2	0	0.281	2	0	0.288	2	0	0.275	2	0	0.329
Vila Real	1	0	0.001	1	0	0.001	1	0	0.001	1	0	0.001	1	0	0.001
Viseu	2	0	0.107	2	0	0.116	2	0	0.141	2	0	0.113	2	0	0.148
Average			0.472			0.510			0.491			0.494			0.540

Source. Our elaboration based on IEFP data

Note. EC: number of employment-centers in the district; Eff. EC: number of efficient EC in the district; Eff-score: average efficiency score.

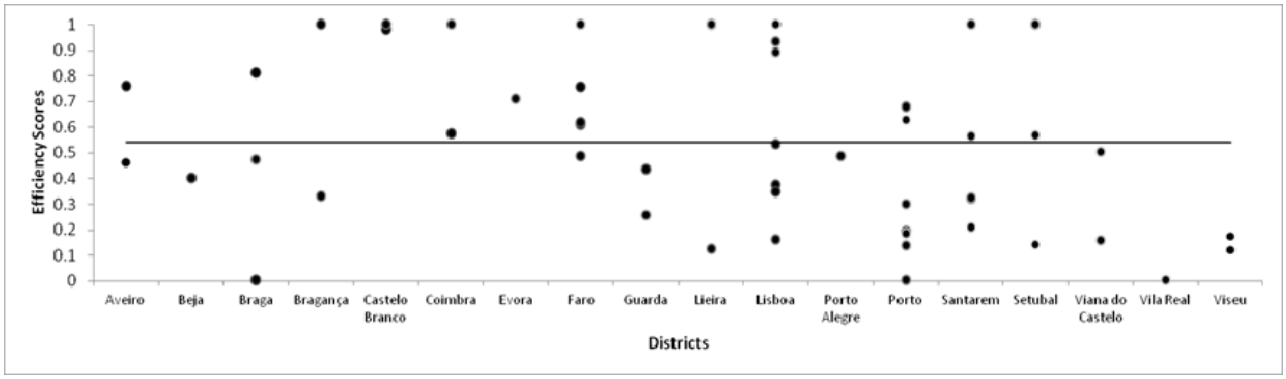
TABLE 1b. DEA-PCA efficiency scores by Portuguese PES, 2001

DISTRICT	MODEL I			MODEL II			MODEL III			MODEL IV			MODEL V		
	EC	Eff. EC	Eff-score	EC	Eff. EC	Eff-score	EC	Eff. EC	Eff-score	EC	Eff. EC	Eff-score	EC	Eff. EC	Eff-score
Aveiro	2	0	0.685	2	0	0.714	2	0	0.709	2	0	0.697	2	0	0.739
Beja	1	0	0.354	1	0	0.354	1	0	0.425	1	0	0.361	1	0	0.425
Braga	4	0	0.481	4	0	0.500	4	0	0.484	4	0	0.500	4	0	0.518
Bragança	2	0	0.246	2	0	0.246	2	0	0.274	2	0	0.510	2	0	0.510
Castelo Branco	2	0	0.705	2	1	0.781	2	1	0.718	2	1	0.794	2	1	0.799
Coimbra	2	1	0.882	1	1	0.882	2	1	0.882	2	1	0.882	2	1	0.882
Evora	1	1	1.000	1	1	1.000	1	1	1.000	1	1	1.000	1	1	1.000
Faro	5	1	0.733	5	2	0.776	5	1	0.773	5	1	0.744	5	2	0.810
Guarda	2	0	0.497	2	0	0.681	2	0	0.534	2	0	0.592	2	0	0.687
Lieira	3	0	0.831	4	1	0.875	3	0	0.834	3	0	0.849	3	1	0.907
Lisboa	8	1	0.444	8	1	0.448	8	1	0.447	8	1	0.454	8	1	0.456
Porto Alegre	1	0	0.117	1	0	0.117	1	0	0.136	1	0	0.117	1	0	0.136
Porto	7	0	0.497	7	0	0.518	7	0	0.613	7	0	0.572	7	0	0.638
Santarem	5	1	0.629	5	1	0.676	5	1	0.641	5	1	0.629	5	1	0.689
Setubal	5	2	0.740	5	2	0.742	5	2	0.741	5	3	0.775	5	3	0.775
Viana do Castelo	2	0	0.520	2	0	0.584	2	0	0.520	2	0	0.553	2	0	0.593
Vila Real	1	0	0.174	1	0	0.174	1	0	0.174	1	0	0.210	1	0	0.210
Viseu	2	0	0.492	2	0	0.566	2	0	0.703	2	0	0.625	2	0	0.711
Average			0.576			0.607			0.609			0.617			0.653

Source. Our elaboration based on IEFP data

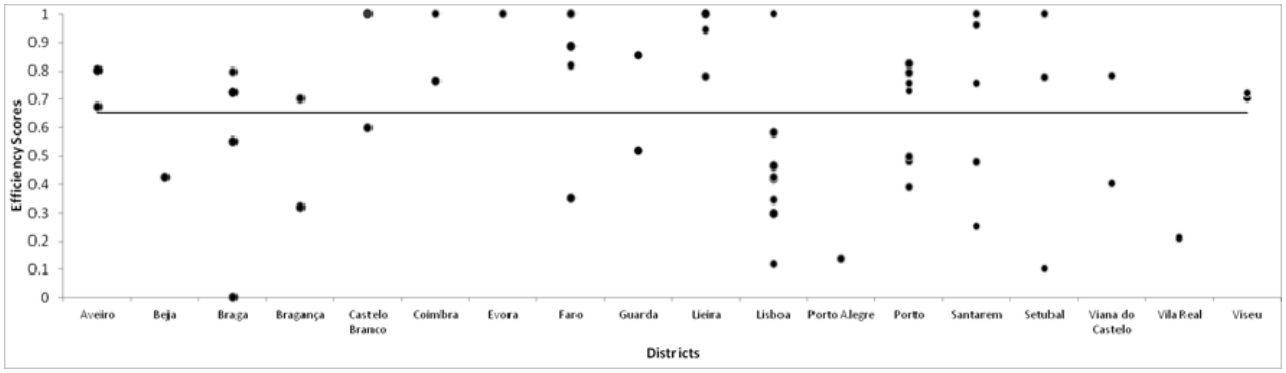
Note. EC: number of employment-centers in the district; Eff. EC: number of efficient EC in the district; Eff-score: average efficiency score.

Figura 2a: PES Efficiency scores grouped by District, V MODEL: 1998



Source. Our elaboration based on IEFP data

Figura 2b: PES Efficiency scores grouped by District, V MODEL: 2001



Source. Our elaboration based on IEFP data

Figure 3. Groups of employment-centers respect to the benchmark model[1]

Groups	Environmental Variables		
	State of local labour market	Social integration	Social shock absorber
First group	↔	↔	↔
Second group	↑	↔	↔
Third group	↔	↑	↔
Fourth group	↔	↔	↑
Fifth group	↑	↑	↔
Sixth group	↑	↔	↑
Seventh group	↔	↑	↑
Eight group	↑	↑	↑

↔, ↑: respectively efficiency score equal and greater to the benchmark model.

[1] We do not comment on the last model (Model V), because this model including all environmental factors and does not allow us to distinguish the effect on the efficiency score of the individual environmental variables.

Table 2. WILCOXON SIGNED-RANK AND SIGN TEST, JUNE 1998

	Wilcoxon Signed-Rank Test	Sign Test (one sided)
Model I against:	H0: Model X = Model I Ha: Model X ≠ Model I	H0: Median Model X - Median Model I = 0 Ha: Median Model X - Median Model I > 0
Model II	5.434***	0.000
Model III	4.217***	0.000
Model IV	4.643***	0.000
Model V	5.961***	0.000

Source. Our elaboration based on IEFP data

Note. ***, **, *: 1,5,10%.; X: respectively, Model II, III, IV and V.

Table 3. WILCOXON SIGNED-RANK AND SIGN TEST, JUNE 2001

	Wilcoxon Signed-Rank Test	Sign Test (one sided)
Model I against:	H0: Model X = Model I Ha: Model X ≠ Model I	H0: Median Model X - Median Model I = 0 Ha: Median Model X - Median Model I > 0
Model II	4.542***	0.000
Model III	4.742***	0.000
Model IV	5.194***	0.000
Model V	6.015***	0.000

Source. Our elaboration based on IEFP data

Note. ***, **, *: 1,5,10%; X: respectively, Model II, III, IV and V.

Table 4. WILCOXON SIGNED-RANK AND SIGN TEST

	Wilcoxon Signed-Rank Test	Sign Test (one sided)
2001 against 1998	H0: Model 2001 = Model 1998 Ha: Model 2001 ≠ Model 1998	H0: Median Model 2001 - Median Model 1998 = 0 Ha: Median Model 2001 - Median Model 1998 > 0
Model I	2.514**	0.009
Model II	2.154**	0.024
Model III	2.547**	0.009
Model IV	2.745**	0.008
Model V	2.314**	0.011

Source. Our elaboration based on IEFP data

Note. ***, **, *: 1,5,10%.

Table A1a DEA-PCA efficiency scores by Portuguese employment-centers: 1998

			Efficiency-score				
District	Employment-centers	Group	Model I	Model II	Model III	Model IV	Model V
Aveiro	AVEIRO	6	0.564	0.665	0.564	0.761	0.761
Aveiro	AGUEDA	2	0.284	0.461	0.284	0.284	0.462
Beja	SINES	3	0.391	0.391	0.401	0.391	0.401
Braga	BRAGA	5	0.462	0.465	0.812	0.462	0.812
Braga	FAFE	1	0.002	0.002	0.002	0.002	0.002
Braga	GUIMARAES	1	0.473	0.473	0.473	0.473	0.473
Braga	BARCELOS	1	0.001	0.001	0.001	0.001	0.001
Bragança	BRAGANCA	6	0.267	0.271	0.267	0.330	0.330
Bragança	MACEDO DE CAVALEIROS	1	1.000	1.000	1.000	1.000	1.000
Castelo Branco	CASTELO BRANCO	6	0.770	0.894	0.770	0.913	0.981
Castelo Branco	COVILHA	1	1.000	1.000	1.000	1.000	1.000
Coimbra	FIGUERA DA FOZ	6	0.923	1.000	0.923	1.000	1.000
Coimbra	LOUSA	2	0.521	0.573	0.521	0.521	0.573
Evora	EVORA	3	0.700	0.700	0.711	0.700	0.711
Faro	FARO	4	0.467	0.467	0.476	0.484	0.486
Faro	PORTIMAO	5	0.552	0.728	0.615	0.552	0.757
Faro	VILA REAL DE SANTO ANTONIO	2	0.525	0.609	0.525	0.525	0.609
Faro	LOULE	1	1.000	1.000	1.000	1.000	1.000
Faro	LAGOS	2	0.376	0.619	0.376	0.376	0.619
Guarda	SEIA	1	0.256	0.256	0.256	0.256	0.256
Guarda	PINHEL	6	0.322	0.431	0.322	0.337	0.434
Lieira	LEIRIA	6	0.876	0.945	0.876	0.942	1.000
Lieira	FIGUEIRO DOS VINHOS	6	0.097	0.106	0.097	0.118	0.123
Lieira	ALCOBACA	2	0.958	1.000	0.958	0.958	1.000
Lisboa	AMADORA	8	0.285	0.334	0.310	0.329	0.375
Lisboa	CASCAIS	1	1.000	1.000	1.000	1.000	1.000
Lisboa	CONDE REDONDO	8	0.127	0.151	0.162	0.129	0.163
Lisboa	PICOAS	3	0.339	0.339	0.347	0.339	0.347
Lisboa	TORRES VEDRAS	8	0.585	0.898	0.619	0.613	0.933
Lisboa	VILA FRANCA DE XIRA	1	1.000	1.000	1.000	1.000	1.000
Lisboa	SINTRA	2	0.480	0.533	0.480	0.480	0.533
Lisboa	BENFICA	5	0.840	0.849	0.882	0.840	0.893
Porto Alegre	ELVAS	4	0.484	0.484	0.484	0.485	0.485
Porto	AMARANTE	7	0.117	0.117	0.142	0.193	0.193
Porto	MATOSINHOS	5	0.102	0.138	0.103	0.102	0.138
Porto	PENAFIEL	1	0.627	0.627	0.627	0.627	0.627
Porto	POVOA DO VARZIM/VILA DO CONDE	6	0.524	0.671	0.524	0.590	0.678
Porto	SANTO TIRSO	2	0.184	0.186	0.184	0.184	0.186
Porto	VILA NOVA DE GAIA	8	0.202	0.211	0.256	0.234	0.300
Porto	FELGUEIRAS	1	0.002	0.002	0.002	0.002	0.002
Santarem	ABRANTES	8	0.229	0.301	0.234	0.235	0.320
Santarem	SANTAREM	2	0.201	0.208	0.201	0.201	0.208
Santarem	TOMAR	1	0.323	0.323	0.323	0.323	0.323
Santarem	TORRES NOVAS	6	0.328	0.329	0.328	0.565	0.565
Santarem	SALVATERRA DE MAGOS	1	1.000	1.000	1.000	1.000	1.000
Setubal	ALMADA	1	1.000	1.000	1.000	1.000	1.000
Setubal	BARREIRO	1	1.000	1.000	1.000	1.000	1.000
Setubal	MONTIJO	4	0.127	0.127	0.127	0.140	0.140
Setubal	SETUBAL	8	0.969	0.999	1.000	1.000	1.000
Setubal	SEIXAL	3	0.376	0.376	0.567	0.376	0.567
Viana do Castelo	VIANA DO CASTELO	8	0.366	0.426	0.463	0.402	0.502
Viana do Castelo	VALENCA	6	0.114	0.136	0.114	0.149	0.157
Vila Real	VILA REAL	1	0.001	0.001	0.001	0.001	0.001
Viseu	VISEU	8	0.106	0.118	0.175	0.119	0.175
Viseu	TONDELA	2	0.108	0.115	0.108	0.108	0.121

Source. Our elaboration based on IEFP data

Table A1b DEA-PCA efficiency scores by Portuguese employment-centers: 2001

			Efficiency-score				
District	Employment-centers	Group	Model I	Model II	Model III	Model IV	Model V
Aveiro	AVEIRO	7	0.754	0.754	0.803	0.765	0.803
Aveiro	AGUEDA	6	0.616	0.675	0.616	0.630	0.675
Beja	SINES	7	0.354	0.354	0.425	0.361	0.425
Braga	BRAGA	7	0.649	0.649	0.659	0.724	0.724
Braga	FAFE	1	0.001	0.001	0.001	0.001	0.001
Braga	GUIMARAES	1	0.798	0.798	0.798	0.798	0.798
Braga	BARCELOS	2	0.478	0.552	0.478	0.478	0.552
Bragança	BRAGANCA	7	0.296	0.296	0.353	0.701	0.701
Bragança	MACEDO DE CAVALEIROS	4	0.196	0.196	0.196	0.320	0.320
Castelo Branco	CASTELO BRANCO	8	0.975	1.000	1.000	1.000	1.000
Castelo Branco	COVILHA	6	0.436	0.562	0.436	0.589	0.599
Coimbra	FIGUERA DA FOZ	1	1.000	1.000	1.000	1.000	1.000
Coimbra	LOUSA	1	0.765	0.765	0.765	0.765	0.765
Evora	EVORA	1	1.000	1.000	1.000	1.000	1.000
Faro	FARO	2	0.958	1.000	0.958	0.958	1.000
Faro	PORTIMAO	3	0.793	0.793	0.827	0.793	0.886
Faro	VILA REAL DE SANTO ANTONIO	1	1.000	1.000	1.000	1.000	1.000
Faro	LOULE	8	0.624	0.785	0.745	0.676	0.819
Faro	LAGOS	5	0.293	0.306	0.337	0.293	0.349
Guarda	SEIA	8	0.488	0.855	0.561	0.666	0.855
Guarda	PINHEL	4	0.507	0.507	0.507	0.519	0.519
Lieira	LEIRIA	6	0.936	1.000	0.936	0.962	1.000
Lieira	FIGUEIRO DOS VINHOS	6	0.749	0.761	0.749	0.778	0.780
Lieira	ALCOBACA	5	0.808	0.864	0.819	0.808	0.943
Lisboa	AMADORA	1	0.463	0.463	0.463	0.463	0.463
Lisboa	CASCAIS	1	0.345	0.345	0.345	0.345	0.345
Lisboa	CONDE REDONDO	1	0.420	0.420	0.420	0.420	0.420
Lisboa	PICOAS	2	0.290	0.297	0.290	0.290	0.297
Lisboa	TORRES VEDRAS	8	0.362	0.384	0.363	0.426	0.426
Lisboa	VILA FRANCA DE XIRA	1	1.000	1.000	1.000	1.000	1.000
Lisboa	SINTRA	7	0.561	0.561	0.581	0.577	0.581
Lisboa	BENFICA	4	0.114	0.114	0.114	0.118	0.118
Porto Alegre	ELVAS	3	0.117	0.117	0.136	0.117	0.136
Porto	AMARANTE	7	0.346	0.346	0.824	0.508	0.824
Porto	MATOSINHOS	5	0.332	0.481	0.455	0.332	0.481
Porto	PENAFIEL	4	0.669	0.669	0.669	0.728	0.728
Porto	POVOA DO VARZIM/VILA DO CONDE	7	0.456	0.456	0.458	0.497	0.497
Porto	SANTO TIRSO	1	0.757	0.757	0.757	0.757	0.757
Porto	VILA NOVA DE GAIA	7	0.387	0.387	0.389	0.392	0.392
Porto	FELGUEIRAS	7	0.536	0.536	0.742	0.793	0.793
Santarem	ABRANTES	2	0.734	0.960	0.734	0.734	0.960
Santarem	SANTAREM	3	0.193	0.193	0.253	0.193	0.253
Santarem	TOMAR	2	0.463	0.475	0.463	0.463	0.477
Santarem	TORRES NOVAS	1	0.756	0.756	0.756	0.756	0.756
Santarem	SALVATERRA DE MAGOS	1	1.000	1.000	1.000	1.000	1.000
Setubal	ALMADA	4	0.682	0.682	0.682	0.777	0.777
Setubal	BARREIRO	1	1.000	1.000	1.000	1.000	1.000
Setubal	MONTIJO	1	1.000	1.000	1.000	1.000	1.000
Setubal	SETUBAL	8	0.922	0.930	0.923	1.000	1.000
Setubal	SEIXAL	3	0.099	0.099	0.101	0.099	0.101
Viana do Castelo	VIANA DO CASTELO	6	0.380	0.385	0.380	0.404	0.404
Viana do Castelo	VALENCA	6	0.661	0.783	0.661	0.703	0.783
Vila Real	VILA REAL	4	0.174	0.174	0.174	0.210	0.210
Viseu	VISEU	8	0.682	0.683	0.687	0.704	0.704
Viseu	TONDELA	8	0.302	0.449	0.719	0.547	0.719

Source. Our elaboration based on IEFP data

Table A2a. Reference sets, June 1998

Peer set Model I	Frequency to other DMUs	Peer set Model II	Frequency to other DMUs	Peer set Model III	Frequency to other DMUs	Peer set Model IV	Frequency to other DMUs	Peer set Model V	Frequency to other DMUs
MACEDO DE CAVALEIROS	1	MACEDO DE CAVALEIROS	1	MACEDO DE CAVALEIROS	2	MACEDO DE CAVALEIROS	1	MACEDO DE CAVALEIROS	1
COVILÃ	15	COVILÃ	16	COVILÃ	26	COVILÃ	11	COVILÃ	23
CASCAIS	3	CASCAIS	2	CASCAIS	1	CASCAIS	5	CASCAIS	2
VILA FRANCA DE XIRA	31	VILA FRANCA DE XIRA	22	VILA FRANCA DE XIRA	20	VILA FRANCA DE XIRA	24	VILA FRANCA DE XIRA	13
ALMADA	3	ALMADA	1	ALMADA	2	ALMADA	3	ALMADA	2
BARREIRO	42	BARREIRO	25	BARREIRO	38	BARREIRO	40	BARREIRO	30
SALVATERRA DE MAGOS	22	SALVATERRA DE MAGOS	21	SALVATERRA DE MAGOS	17	SALVATERRA DE MAGOS	23	SALVATERRA DE MAGOS	22
LOULÉ	0	LOULÉ	12	LOULÉ	2	LOULÉ	0	LOULÉ	11
		FIGUEIRA DA FOZ	21			FIGUEIRA DA FOZ	4	FIGUEIRA DA FOZ	15
		ALCOBAÇA	14					ALCOBAÇA	10
				SETÚBAL	13	SETÚBAL	8	SETÚBAL	2
								LEIRIA	6

Source. Our elaboration based on IEFP data

Table A2b. Reference sets, June 2001

Peer set Model I	Frequency to other DMUs	Peer set Model II	Frequency to other DMUs	Peer set Model III	Frequency to other DMUs	Peer set Model IV	Frequency to other DMUs	Peer set Model V	Frequency to other DMUs
MACEDO DE CAVALEIROS	1	MACEDO DE CAVALEIROS	1	MACEDO DE CAVALEIROS	2	MACEDO DE CAVALEIROS	1	MACEDO DE CAVALEIROS	1
COVILÃ	15	COVILÃ	16	COVILÃ	26	COVILÃ	11	COVILÃ	23
CASCAIS	3	CASCAIS	2	CASCAIS	1	CASCAIS	5	CASCAIS	2
VILA FRANCA DE XIRA	31	VILA FRANCA DE XIRA	22	VILA FRANCA DE XIRA	20	VILA FRANCA DE XIRA	24	VILA FRANCA DE XIRA	13
ALMADA	3	ALMADA	1	ALMADA	2	ALMADA	3	ALMADA	2
BARREIRO	42	BARREIRO	25	BARREIRO	38	BARREIRO	40	BARREIRO	30
SALVATERRA DE MAGOS	22	SALVATERRA DE MAGOS	21	SALVATERRA DE MAGOS	17	SALVATERRA DE MAGOS	23	SALVATERRA DE MAGOS	22
LOULÉ	0	LOULÉ	12	LOULÉ	2	LOULÉ	0	LOULÉ	11
		FIGUEIRA DA FOZ	21			FIGUEIRA DA FOZ	4	FIGUEIRA DA FOZ	15
		ALCOBAÇA	14					ALCOBAÇA	10
				SETÚBAL	13	SETÚBAL	8	SETÚBAL	2

Source. Our elaboration based on IEFP data