Società italiana di economia pubblica

XX CONFERENZA

ECONOMIA DELLA TASSAZIONE
Sistemi tributari, pressione fiscale, crescita

Pavia, Università, 25 - 26 settembre 2008

ON THE EFFICIENCY OF EUROPEAN TELECOMMUNICATIONS REGULATORS

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pubblicazione internet realizzata con contributo della COMPAGNIA di San Paolo

società italiana di economia pubblica

dipartimento di economia pubblica e territoriale – università di pavia

On the Efficiency of European Telecommunications Regulators*

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February 2008

PRELIMINARY DRAFT

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Abstract

This paper uses a Data Envelopment Analysis, along with a smoothed bootstrap method, to evaluate and compare the performances of the National Regulatory Authorities (NRAs) in telecommunications across 18 European countries. This is a relevant issue that has been almost completely neglected in the literature on telecommunications regulation. After having discussed several desirable outcomes for a telecommunications regulator, we construct for each NRA of the sample an ad hoc database containing information about its regulatory inputs and outputs. The database is then used to run several bootstrapped DEA in order to rank NRAs according to their efficiency in carrying out their regulatory activities. We find that the authorities in Austria, Slovenia and the Slovak Republic are systematically the most efficient ones, while those in the Czeck Republic, Hungary and Poland are always the less efficient. We find only partial evidence of a trade-off between NRAs efficiency in pursuing retail efficiency and dynamic efficiency.

Keywords:
JEL classification: L86, L96.

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1 Introduction

The literature on regulation of public services grew rapidly during the last twenty years; the vast body of research now covers the most important theoretical and empirical aspects of regulation. Influential authors have been studying the role of informational constraints on regulatory activities (Baron and Myerson, 1982; Laffont and Tirole, 1986)), while other papers have been focusing on comparisons between different regulatory regimes (Beesley and Littlechild, 1989; Resende, 2000). Eventually, efficiency studies of regulated markets have focused on regulated firms [1] In general, this literature has tried to investigate the effects of regulation on static and productive efficiency of the regulated firms.

In this paper, we take a different perspective; our aim is to investigate on the performances of those who are in charge of regulating the markets, namely the National Regulatory Authorities (NRA, herafter). Quite surprisingly, in the literature on regulation the issue of the efficiency of the NRAs has been almost completely neglected; this is quite a relevant issue provided that in order to have a full assessment of the efficacy of the various regulatory measures, one cannot abstract from evaluating the ability of the regulatory bodies that are in charge of putting regulation into practice.

The only exception is Afonso and Scaglioni (2006). The authors assess the efficiency of NRAs across 16 European Union countries. To do so they build up a Composite Regulatory Performance Indicator by elaborating on two different sources, namely the Scorecard Report published by the European Competitive Telecommunications Association (ECTA) and the European Regulatory Institution Database (EURI) developed by the Regulation Initiative Research Group at London Business School. Nonetheless, their analysis presents many limitations and shortcomings due mainly to their output measures of NRAs activity which tend to identify the extent of the regulation rather than its effectiveness.[2] Unlike Afonso and Scaglioni (2006), our aim it to relate the NRAs activity

[1] Other relevant references...

[2] ECTA Scorecards have been extensively criticized; for a critique of the use of the ECTA Scorecard as a tool to measure NRAs performance see Weeks and Williamson (2006). According to these authors, ECTA Scorecard rewards those NRAs that regulate more, rather than those NRAs that regulate better. Similar critiques can be addressed to EURI indicators: unlike ECTA Scorecard, EURI rewards NRAs also according to their administrative efficiency (e.g. how much rapidly they are able to take a decision). Yet it does not link the NRAs activity to the efficiency of the regulated market.

directly to the performances of the regulated markets.

The regulation of public utilities is by now a widespread practice in industrialised countries and assessing the efficiency of NRAs is quite a general issue. In this paper we focus on telecommunications NRAs across 18 EU countries. The motivations for these choices are manifold. Among the various regulated sectors, that of telecommunications has a long history of regulation; secondly, it is certainly one of the most dynamic and articulated market, characterized by the coexistence of monopolistic and competitive segments and affected by a high rate of innovation. In this ever changing environment, the practice of regulation may be particularly complex: perhaps more then in other regulated sectors, in telecommunications regulators must find a balance between often diverging interests and need to keep pace with a highly dynamic environment. Finally, we have decided to restrict the analysis on EU countries since they are subject to a common European Regulatory Framework stated by the European Commission.

Telecommunications NRAs are financed by central government allocations, by the imposition of fees on regulated firms, and by the revenues from fines payed by companies that have been sanctioned. Furthermore, they are organized differently from private firms and, usually, they do not follow standard cost-minimization/profit maximization rules. For all these reasons the need to assess NRAs efficiency and to conduct a cross-country efficiency comparison seem of crucial interests in telecommunications. In this paper, we measure efficiency scores of NRAs using a Data Envelopment Analysis (DEA), a well known nonparametric estimation method of the production frontier. A bootstrap procedure is applied both to carry out proper inferential conclusions reducing the efficiency estimators bias and to evaluate their sample variability.

The paper is organized as follows. In next section we describe our methodological strategy and present the data used for study. In section 3 we present and discuss the results of the analysis. In the last section we conclude.

2 Methodological strategy

Our objective is to estimate a non-parametric stochastic efficiency frontier of the NRAs of eighteen European countries (Belgium, Czech Republic, Denmark, Germany, Spain, France, Ireland, Italy, Hungary, Netherlands, Austria, Poland, Portugal, Slovenia, Slovak Republic, Finland, Sweden and

UK), by using the Data Envelopment Analysis technique (DEA). In order to proceed with the estimation, we first need to define the productive process of a NRA; in other words, we treat each NRAs as a "Decision Making Unit" that employs a certain set of inputs to produce other outputs.

The next subsection is devoted to the identification of the inputs and outputs of a representative NRA; this is not an immediate task and it requires a brief discussion. Once inputs and outputs have been defined, we are able to proceed with the DEA estimations; these will allow us to rank the NRAs according to their ability in performing various regulatory tasks.

2.1 NRAs as decision making units

Each NRA can be thought of as as an organization using resources to regulate the market. Using the typical efficiency analysis jargon, each NRA can be defined as a decision making unit (DMU hereafter), formed by groups of individuals who share the common goal of regulating the market.

Broadly speaking, a regulator should promote the interests of consumers, for example through the regulation of retail prices, guaranteeing enough incentives to producers to stay actively in the business at the same time. As it is widely discussed in the literature on regulation, the two goals of static and dynamic efficiency are often difficult to balance, specifically in a complex and dynamic environment such as that of telecommunications. We will discuss more in depth these issues in the following sections.

Putting these arguments in a more direct way, we consider each NRA as a DMU that uses a certain amount of resources (inputs) to obtain a certain degree of regulatory outcomes (outputs). Clearly, in order to proceed with the efficiency analysis, we need to identify clearly which inputs a NRA uses and how to measure the regulatory outputs. Moreover, we should also define some characteristic of the NRA's *production process*, for example with reference to its returns to scale. In what follows we will allow for variable returns to scale and, thanks to the non-parametric methodology employed, we do not impose any further restrictions on the characteristics of the decision process.

To have a better understanding of our efficiency analysis, a more precise description of what we mean by NRA "production process" may be helpful. A regulator exerts a certain amount of effort to regulate the market and to improve its efficiency; the relationship between market efficiency (Y^i) and the regulatory effort (e^i) can be described by a standard production function, namely

$Y^i = f(e^i)$. Market efficiency represents the output of a NRA activity and it can be measured either in static or dynamic terms by appropriate measures that we will discuss in sections 2.3 and 2.4. The exact amount of regulatory effort e^i is, to a large extent, not observable and it must be proxied by the amount of input employed; in our analysis we approximate the regulatory effort with two inputs: *i*) the staff employed in the NRA (L^i) and *ii*) the amount of financial resources spent by the same authority (B^i). Clearly, it is reasonable to assume a positive relationship between the amount of inputs employed by the NRA and the amount of regulatory effort; formally: $e^i = e(L^i, B^i)$, with $e_L > 0$, $e_B > 0$ and $e(0,0) = 0$.

Therefore, the impact of a change in the use of the two inputs on the degree of market efficiency can be derived by totally differentiating the NRA production function with respect to L and B:

$$dY^i = \frac{\partial f}{\partial e^i} \left(e_L dL^i + e_B dB^i \right).$$

This expression highlights two kinds of efficiencies; the term $(e_L dL^i + e_B dB^i)$ represents what we define as the authority internal efficiency, that is how much a larger use of inputs translate into more regulatory effort.

Conversely, the term $\frac{\partial f}{\partial e^i}$ measures a sort of external efficiency, i.e. to what extent a larger effort effectively translates into higher market efficiency. We call it "external" since it measures something that is actually out of the control of the NRA. For example, take the degree of up-take of new technologies as a measure of dynamic efficiency. The country i could show a low level of technology up-take either because the authority is really putting little regulatory effort, or, for example, because the attitude of the population towards the adoption of new technology is so low that the regulatory effort is completely overwhelmed. In other words, a NRA can appear to be inefficient either because it is unable to translate higher inputs into higher effort, or because the environmental conditions in which it operates make it more difficult to translate its regulatory effort into market efficiency.

The external efficiency is hard to estimate. In our analysis we implicitly assume that the external contribution is the same across NRA, that is $\frac{\partial f}{\partial e^i} = \frac{\partial f}{\partial e^j}$, $\forall i, j$. The legitimacy of such an assumption depends to a large extent on the measures of market efficiency used in the estimations. In order to make the assumption less problematic, whenever possible we tried to use measures of efficiency that are neutral with respect to the possible influence of external factors. As it will be clear, the measures that we use to account for static efficiency (i.e. retail prices) are often directly under the control of the regulator, therefore external/environmental factors should not play a too important role. Things can be rather different with respect the measures of dynamic efficiency; as explained in the example of the up-take, the diffusion of new technologies across the population can be deeply affected by external factors such as education and demographic structure. In this case, our results must be taken more cautiously.

2.2 DEA bootstrap

As anticipated, we measure the technical efficiency using the DEA method stemming from Farrell (1957). Because of the difficulty to obtain the distributions of DEA estimators except on simpler cases (Kneip et al., 2008), proper inferential conclusions may rely on suitable bootstrap procedures. A convenient choice is the homogeneous bootstrap algorithm proposed by Simar and Wilson (1998) and implemented in the R (Team, 2008) package FEAR[3]. Through this bootstrap procedure it is possible to reduce the bias of the estimated efficiency scores, estimate their standard errors and compute confidence intervals using methods described in Simar and Wilson (2000). The consistency of the bootstrap procedure is discussed in Kneip et al. (2008).

2.3 Inputs and outputs

Although our analysis covers a wide set of European countries (all the biggest European countries - Austria, Belgium, Denmark, Germany, Spain, France, Ireland, Italy the Netherlands, Portugal, Finland, Sweden and the UK - plus five of the most relevant 2004 accession countries - Czech Republic, Hungary, Poland, Slovenia and Slovak Republic), still we have a problem of small sample size; with a total of 18 DMUs, we are restricted to run DEAs based on small sets of inputs and outputs in order to preserve their informative power.[4] For this reason, we have decided to carry out a series of different 2 inputs/1 output DEAs; they are all based on the same two inputs, *a*) the number of workers employed in the regulatory activity, and *b*) the total amount of financial resources spent by the NRAs in their own activity (total budgeted cost), while we allow the output measure

[3]FEAR is available from the P.W. Wilsons home page http://www.clemson.edu/economics/faculty/wilson

[4]It is well known that when the number of DMUs is not sufficiently large, running DEAs on large sets of in-uts/outputs yields to uninformative efficiency scores. See....

to change. This is not a great limitation; furthermore, our methodology based on running a series of input constant-DEAs allows us to compare efficiency scores across different output measures and across countries, thus suggesting, for example, possible different regulatory approaches.

In order to compare the efficiency of the various NRAs, we clearly need to make their inputs homogeneous; while this is not an issue with respect the amount of employers,[5] there is clearly the need to make the amount of resources used by NRAs comparable across different countries.

The natural way to proceed is to indicate the value of total budgeted cost in terms of Purchasing Power Parities (PPP), and actually this is the way we will carry out. [6]

The definition of the outputs is by far more articulated. The outcome of a NRA should be identified with the efficiency gains induced by its activity. Efficiency can take different forms; on the one side, static efficiency occurs when production costs are minimized (production efficiency) and/or when the price that consumers are charged for a good or service equals the marginal cost of the resources used in production (allocative efficiency); on the other hand, dynamic efficiency relates to demand creation and innovation.

Usually, industry regulators face a trade-off as they attempt to maximize static social welfare through price regulation, while providing firms with sufficient incentives to innovate at the same time [7].

These issues are of particular importance in telecommunications, probably the most dynamic industry among those subject to sector specific regulation; here, the tension between static and dynamic efficiency is so crucial that the issue is explicitly mentioned in the new European regulatory framework for electronic communications services where it is clearly stated that the scope of regulation is to promote competition in the provision of electronic communications networks, electronic communications services and associated facilities and to encourage efficient investment

[5] Unfortunately, we do not have information neither about the division of NRAs workforce between skilled and un-skilled workers nor about the amount of workers classified according to their tasks (i.e. number of engineers, lawyers, economists). However, we have to add that should such information be available, we hardly would be able to use it given the low number of observations

[6] It should be noted, that this normalization penalize the bigger and more developed countries of the sample. Other, normalization methods should be taken into account in a future draft of this work, in order to properly tackle such a drawback.

[7] For an overview about this see Laffont and Tirole (1993). For specific aspects regarding telecommunications sector see Laffont and Tirole (2000)

in infrastructures and to promote innovation (Framework Directive, Article 8.2.).

NRAs may influence innovation in telecommunications through either the effects they produce on prices or through their impact on the dynamics of market entry (Bourreau and Dogan (2001)). In telecoms, both retail and wholesale (interconnection) charges are heavily regulated and this may have an impact on operators profits and, consequently, on their incentives to invest in innovative activities. At the same time, regulation may alter the terms of entry (it is often asymmetric, in the sense that entrant operators are often not subject to regulatory impositions) and, again, this is likely to impact on the degree of innovation undertaken both by the incumbents and by entrant operators. In order to reconcile static with dynamic efficiency, European countries have implemented a set of common regulations based on the key regulatory instrument of local loop unbundling; local loop unbundling (LLU) is the regulatory process in which incumbent operators lease, wholly or in part, at a regulated price the local segment of their telecommunications network, usually pairs of copper wire, to competitors in order to let them provide voice and broadband services on the retail market.

Therefore, market efficiency can be measured both in terms of price reductions and degree of competition at the retail level (*retail efficiency*), and in terms of number of unbundled lines (which proxies the up-take of broadband technologies) and in terms of amount of operators' investments (in a more *dynamic perspective*).

2.4 Data

We constructed an *ad-hoc* database drawing data and information from several sources concerning both the organization of the NRAs (as for the inputs) and the development and trend of the telecommunications market (as for the outputs). When not differently specified, variables are referred to year 2005. All monetary variables are expressed in PPP 2005.[8]

Staff and reported budgeted cost have been obtained from NRAs Annual Reports. This information has been treated in order to determine the actual amount of inputs employed to regulate the telecommunications sector; in fact, in many European countries the regulatory authority has various responsibilities, ranging from regulation of telecommunications, to spectrum allocation (as in the majority of the cases); in few cases, the authority exerts its control also on other markets different from telecommunications or it is in charge of a bundle of different activities that go beyond

[8] PPP rates are taken from Eurostat

telecommunications regulation.[9] We have taken into account of the different tasks and organizational structures of NRAs by appropriately adjusting the observed number of employers in order to obtain for each NRA a reliable measure about the stuff actually in charge of telecoms regulation.[10] This has also allowed us to derive an adjusted measure of the reported budgeted cost imputable to telecoms regulation.[11]

The definition of the outputs of a NRA is more articulated. As we have discussed above, the activity of a telecom NRA is aimed at promoting static and dynamic efficiency; therefore the "amount" of efficiency can be seen as the output of a NRA. According to the various measures that can be used to measure static and dynamic efficiency in telecommunications described in section 2.3, we have selected a set of variables that we believe are the best indicators of market efficiency. In particular, at the retail level we have distinguished between fixed and mobile telephony; therefore, we have considered the following indicators:

- fixed telephony: the price of a 3 (alternatively 10) minutes local call set by the incumbent operator (3LCINC/alternatively 10LCINC);[12]

- mobile telephony: the price of mobile services has been approximated using three mobile price baskets corresponding to different level of usage.[13] The low-usage basket (MOBL) includes 360voice calls, 396SMS messages and 8 MMS per year; the medium usage basket (MOBM), which includes 780 calls, 600 SMS messages and 8MMS messages and the high-usage basket (MOBH) that includes 1680 voice calls, 660SMS messages and 12MMS messages.[14]

[9]For example, BNetzA, the German Federal Network Agency, regulates non only telecommunications, but it also exerts its control on various network industries such as Electricity, Gas, Post, Railway; in the UK, Ofcom, is the regulator of the communications industries - television, radio, telecommunications and wireless communications services - and it has also the role of competition authority in these sectors.

[10]Where necessary, these information have been complemented with additional details gathered through personal contacts

[11]Adjusted budgeted cost has been estimated multiplying the per-employee total budget by the number of employees in charge of telecoms regulation.

[12]This information has been obtained from 11th Report of the European Electronic Communications Regultion and Markets.

[13]Source: OECD 2007 - Communications Outlook.

[14]The OECD basket distributes these between peak and off-peak hours and uses an average call duration to make the calculations.

With respect to the other relevant aspect of *retail efficiency*, i.e. the market of access to the incumbent infrastructures, we have distinguished between the market of broadband access and that of voice access; we have proxied the degree of competition that the regulator has been able to implement on these two markets, measured in terms of the market share reached by the other alternative operators. The idea is that a larger market share of other alternative operators corresponds to a more intense competition and, therefore, to a more efficient market. Specifically, we have defined the following indicators of market efficiency at the wholesale level:

- Voice telephony: market share of the other alternative operators in the market for voice access (VOOAO) obtained by dividing the sum of fully unbundled lines, other operators' number of cable and fiber optic lines by the sum of total voice access path activated in the market.[15].

- Broadband: market share of the other alternative operators in the market for broadband access (BBOAO) obtained by dividing the sum of the amount of all the broadband access paths available to the other access operators by the sum of total broadband access paths.[16]

In order to assess the ability of a NRA to promote the uptake of new technologies, mainly broadband access to the Internet, we have built the variable PENBB, obtained by dividing the total amount of retail broadband access paths in a given country by the population in 2005 in the same country. Note that this measure can be considered as a possible indicator of both static and dynamic efficiency. A statically efficient market is characterized by cost-oriented retail prices; therefore, we should expect a larger degree of broadband penetration in those countries characterized by a more efficient market for broadband access.

At the same time, in order to provide broadband access to customers, telecom operators need to invest in infrastructures; although, the type and the amount of investments required to provide broadband services heavily depends on the type of access platform used, i.e. DSL versus cable access, yet the amount of broadband access lines sold to final customers is a good proxy of the amount of investment undertaken by the operators.

[15] Among the incumbent operator access path we have to consider also its PSTN activated main lines and ????

[16] The broadband access paths considered are WLL, Cable, Leased lines, Fiber to the Home, Satellite, Power Lines Communications. In addition to these channels, in order to obtain the total broadband access paths we took into account Local Loop Unbundled DSL (LLU-DSL), Incumbent's DSL, Incumbent's Own Network, Shared Access (SA), Bitstream and Resale lines. Source, ???

Note that PENBB is a highly autocorrelated variable, in the sense that the amount of broadband penetration reached in 2005 in a certain country, strictly depends on the level in 2004; this implies that those countries that have reached a high level of penetration in 2004 may appear to perform very well in 2005 even if during this period they have not experienced a significant increase in broadband penetration. At the same time, in a country where, for example, broadband access represents a more recent phenomenon, we might observe a significant increase in broadband penetration in 2005 but we may end up considering its market (and its NRA as well) less efficient than the previous one simply because in absolute terms its amount of broadband penetration is still below the other country.

In order to partially avoid problems of possible inaccurate evaluation, we use as output measure the product of PENBB with its variation with respect to 2004 (ΔPENBB); by doing so, we consider efficient a NRA that in 2005 has been able achieve a high level of broadband penetration or that it has successful in increasing significantly broadband penetration in 2005 with respect to 2004.

Finally, as a measure of the dynamic efficiency of telecommunications, we use the ratio between the average amount of investment in fixed telecommunications between 2004 and 2006 (5???), and average amount of total investment in the economy (namely, the gross fixed capital formation ???) for the same years (AVTLCINVSH). We have expanded the time horizon to two years simply because investment is a long run decision and by restricting the observation to a one year only may lead to inaccurate evaluations of the overall intensity of investments in telecommunications.

3 Results and discussion

We are now ready to present and discuss the results of our efficiency analysis. Each table shows the efficiency score obtained by each NRA with respect a particular measure of the output; for each authority we provide both the bias-corrected score obtained through the bootstrap procedure together with the estimated standard error,[17] and the uncorrected efficiency score obtained through a standard (un-bootstrapped) DEA procedure. NRAs are ranked according to their bias-corrected efficiency score.

Tables 1 to 9 reveal that irrespectively of the output measure used to evaluate the efficiency,

[17]For completeness, in the appendix we provide also diagrams showing confidence intervals.

when efficiency is measured using the level of the reported budgeted cost and the number of people employed in regulatory activities as the production inputs, the top and at the bottom positions of the various rankings are occupied by almost always the same NRAs.

More specifically, the authorities of Slovenia, Austria, and Slovakia rank always among the top five positions, while those of Czech Republic, Hungary and Poland always rank in the last three positions. From this simple observation seems to emerge that irrespectively of the kind of efficiency we are actually accounting for (either static or dynamic efficiency), a group of NRAs obtains always good performances while others, typically new accession countries, appears to be clearly less efficient. This is a first interesting result that seems to suggest that despite the standard regulatory trade-off between static and dynamic efficiency, regulators are generally efficient/inefficient in their activities in promoting market efficiency.

The scores obtained by the remaining 12 NRAs reveals a less clear and more articulated evidence. For example, Tables 4 and 5 reveal that the Spanish, the Irish and, partially, also the Danish regulatory authorities have been quite successful in fostering static efficiency measured in terms of prices for local calls, the NRA in the UK comes out to a good performers in terms of promoting competition in the market of broadband access (see Table 2) while in Finland the regulatory activity has been efficient in promoting broadband penetration (see Table 1).

It is interesting to investigate a bit more in details on these issues by checking wether there is any systematic pattern in the efficiency scores, i.e. wether there are countries in which the authority is able to obtain a reasonable level of efficiency with respect to some measure of output while being inefficient in others.

This is a relevant issue, since for example we could think of a regulator that for some reasons puts higher efforts towards, for example, dynamic efficiency objectives (by providing larger incentives towards, lets' say, incentives in infrastructures) but this may actually occur at the cost of achieving less static efficiency. It deserves to be noted, that although the countries of our sample adopt the same European regulatory framework, at the time of our observation the various telecommunications sectors were actually characterized by being at different stages of development. Moreover, some countries have a longer history of telecommunications regulation (i.e. the United Kingdom), while others, specifically the new EU accession countries, have introduced regulation quite recently.

This heterogeneity in the various regulatory experiences may translate into differences in the "preferences" of the regulators, some of which may be more interested into, let's say, price reductions while others into more investments in infrastructures.

To address these issues we have drawn some scatter diagrams, aimed at contrasting efficiency scores rankings in pairs. In Figure 1 we have placed the bias corrected efficiency scores that we have obtained using the broadband penetration measure of output (see Table 1) on the horizontal axis the scores for the efficiency in the investment (Table 9) on the vertical one: each NRA is represented by a point in the diagram. Simple visual inspection reveals a positive correlation between efficiency scores in the two measure of output. In Figures 2 and 3 we repeat the same exercise for different pairs of efficiency measures (investments and price for a 3 minutes local call in Figure 2 and investments and the degree of competition in voice access market in Figure 3) but the positive relationship seems to persist.

This analysis suggests that what makes a difference between two NRAs is not really a different preference towards a certain type of output or another, but rather their general degree of productive efficiency: exactly as we have seen for the best and the worst performers whose performances was steadily at the top/bottom of the various rankings, also for the intermediate performers they keep being placed almost always in the intermediate positions for the entire set of outputs, a part few isolated cases.

In table 10 we present an average ranking that sums up all the previous ones.

4 Conclusions

In this paper we have addressed the issue of the efficiency in the performances of NRAs across 18 EU countries in telecommunications sector. To do this we carried out DEAs along with a smoothed bootstrap method relating NRA inputs to several measure of telecommunications market efficiency. Our main findings can be summarized in the following points:

1. two clear-cut set of best performer and worst performer NRAs emerges;
2. countries belongings in the middle of the various rankings appears to perform pretty differently according to different measure of telecommunications market efficiency;

3. positions of the NRAs in DEAs referred to different market efficiency measures appear to be correlated.

Two main extensions can be carried on starting from this research. First, alternative ways to normalize inputs of NRAs activity should be investigated. Second, cluster analysis techniques can be used in order to endogenously define the clusters that in this paper we have set exogenously. Third, cluster analysis techniques could permit us to summarize in a unique ranking the results of each ranking we presented in the paper. Finally, future research could be dedicated to an extension of the analysis to other public utilities. In this sense, should necessary data be available, we think it could be potentially very interesting to apply a similar analysis to those utilities whose productive process is characterized by natural monopoly conditions. In this specific case, our analysis should be a first step towards the evaluation of the cost of an effective regulation, a cost that must be included in an ideal cost-benefit analysis of privatization of such a public utility.

References

Afonso, A. and Scaglioni, C. (2006). An assessment of telecommunication regulation performance in european union. *ISEG-UTL Working Paper*, (07).

Baron, D. and Myerson, R. (1982). Regulating monopoly with unknown costs. *Econometrica*.

Beesley, M. and Littlechild, S. (1989). The regulation of privatized monopoly in uk. *RAND Journal of Economics*, 20(3).

Bourreau, M. and Dogan, P. (2001). Innovation and regulation in the telecommunications industry. *Telecommunication Policy*, 25(3):167–184.

Farrell, M. (1957). The measurement of productive efficiency. *Journal of the Royal Statistical Society Series A*, (120):253–281.

Kneip, A., Simar, L., and Wilson, P. (2008). Asymptotics and consistent bootstraps for dea estimators in non-parametric frontier models. *Econometric Theory*.

Laffont, J. and Tirole, J. (1986). Using cost observation to regulate firms. *Journal of Political Economy*, 94(3):614–641.

Laffont, J. and Tirole, J. (1993). *A Theory of Incentive in Procurement and Regulation*. MIT Press.

Laffont, J. and Tirole, J. (2000). *Competition in Telecommunications*. MIT Press.

Resende, M. (2000). Regulatory regimes and efficiency in us local telephony. *Oxford Economic Papers*, 52:447–470.

Simar, L. and Wilson, P. (1998). Sensitivity analysis of efficiency scores: How to bootstrap in nonparametric frontier models. *Management Science*, 44:49–61.

Simar, L. and Wilson, P. (2000). A general methodology for bootstrapping in non-parametric frontier models. *Journal of Applied Statistics*, 27:779–802.

Team, R. D. C. (2008). *R: A language and environment for statistical computing*. R Foundation for Statistical Computing, Wien. ISBN 3-900051-07-0, URL http://www.R-project.org.

Weeks, M. and Williamson, B. (2006). *A Sound Basis for Evidence Based Policy? A Critique of the ECTA Regulatory Scorecard and SPC Network Papers on Investment and Broadband.* A report for ETNO by Indepen.

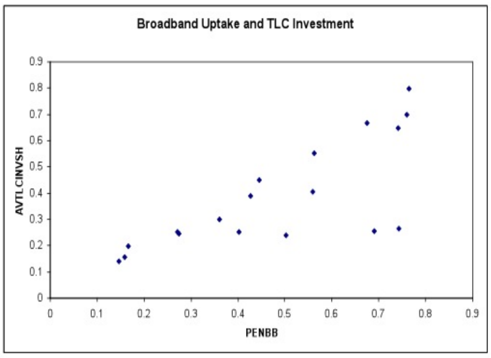


Figure 1

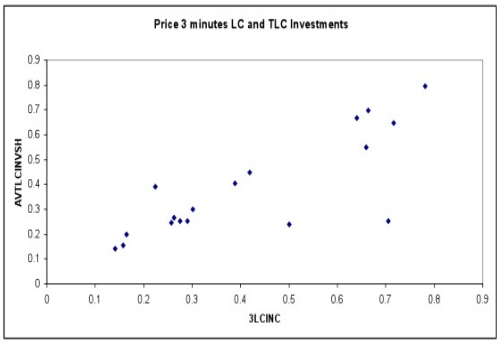


Figure 2

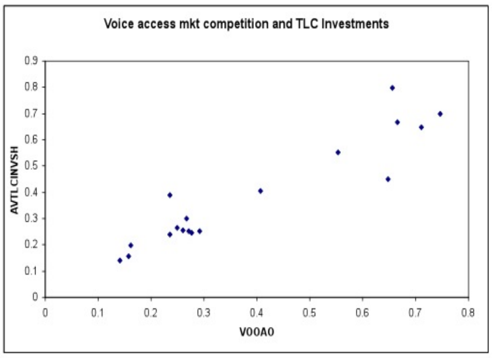


Figure 3

Table 1: PENBB

Country	bias corrected	s.e.	uncorrected
Austria	0,764	0,077	1
Slovenia	0,76	0,083	1
Finland	0,743	0,106	1
Slovakia	0,741	0,089	1
Denmark	0,69	0,123	1
Ireland	0,675	0,055	0,776
Spain	0,562	0,047	0,654
France	0,56	0,052	0,703
Sweden	0,503	0,055	0,636
Netherlands	0,445	0,044	0,543
UK	0,427	0,041	0,516
Germany	0,402	0,039	0,496
Belgium	0,361	0,033	0,445
Italy	0,275	0,022	0,328
Portugal	0,272	0,023	0,318
Hungary	0,167	0,013	0,188
Czech	0,159	0,012	0,18
Poland	0,146	0,015	0,185
Mean	0,481		

Table 2: BBOAO

Country	bias corrected	s.e.	uncorrected
Slovenia	0.758	0.07	1
Slovakia	0.717	60.08	1
Austria	0.682	0.10	1
UK	0.655	0.11	1
Ireland	0.65	0.06	0.782
Spain	0.553	0.05	0.662
Netherlands	0.426	0.05	0.558
France	0.391	0.05	0.517
Sweden	0.318	0.04	0.457
Germany	0.296	0.03	0.384
Belgium	0.293	0.03	0.369
Italy	0.279	0.03	0.325
Portugal	0.274	0.02	0.318
Finland	0.266	0.03	0.332
Denmark	0.263	0.03	0.323
Hungary	0.16	0.02	0.19
Poland	0.142	0.01	0.185
Czech	0.139	0.02	0.186
Mean	0.403		

Table 3: VOOAO

Country	bias corrected	s.e.	uncorrected
Slovenia	0.746	0.080	1
Slovakia	0.711	0.080	1
Ireland	0.666	0.062	0.776
Austria	0.656	0.097	1
Netherlands	0.648	0.106	1
Spain	0.553	0.052	0.654
France	0.407	0.043	0.503
Germany	0.292	0.032	0.386
Italy	0.277	0.026	0.325
Portugal	0.271	0.025	0.318
Belgium	0.267	0.037	0.369
Denmark	0.26	0.028	0.322
Finland	0.249	0.030	0.337
Sweden	0.236	0.028	0.31
UK	0.235	0.024	0.284
Hungary	0.162	0.015	0.188
Czech	0.157	0.014	0.185
Mean	0.385		

Table 4: 3LCINC

Country	bias corrected	s.e.	uncorrected
Austria	0.781	0.086	0.965
Slovakia	0.716	0.083	1
Denmark	0.705	0.107	1
Slovenia	0.664	0.100	1
Spain	0.659	0.114	1
Ireland	0.64	0.071	0.776
Sweden	0.501	0.065	0.692
Netherlands	0.419	0.048	0.543
France	0.388	0.045	0.503
Belgium	0.301	0.030	0.361
Germany	0.291	0.044	0.407
Portugal	0.275	0.026	0.318
Finland	0.263	0.029	0.332
Italy	0.257	0.029	0.325
UK	0.224	0.025	0.284
Hungary	0.164	0.015	0.188
Czech	0.158	0.014	0.18
Poland	0.141	0.014	0.185
Mean	0.419		

Table 5: 10LCINC

Country	bias corrected	s.e.	uncorrected
Spain	0.838	0.054	0.94
Austria	0.822	0.073	0.965
Slovakia	0.783	0.091	1
Slovenia	0.768	0.099	1
Italy	0.759	0.114	0.946
Finland	0.714	0.142	1
Ireland	0.683	0.052	0.776
Netherlands	0.678	0.051	0.782
France	0.668	0.051	0.779
Sweden	0.565	0.067	0.692
Denmark	0.53	0.046	0.613
Germany	0.332	0.040	0.407
Belgium	0.318	0.025	0.361
Portugal	0.286	0.020	0.318
UK	0.246	0.019	0.284
Hungary	0.174	0.010	0.188
Czech	0.167	0.009	0.18
Poland	0.153	0.014	0.185
Mean	0.527		

Table 6: MOBL

Country	bias corrected	s.e.	uncorrected
Austria	0.78	0.079	0.965
Slovenia	0.73	0.078	1
Slovakia	0.721	0.087	1
Sweden	0.689	0.108	0.939
Finland	0.669	0.117	1
Ireland	0.663	0.057	0.776
Denmark	0.579	0.075	0.75
Spain	0.546	0.047	0.654
Netherlands	0.51	0.051	0.657
France	0.393	0.040	0.503
Belgium	0.296	0.028	0.361
Italy	0.277	0.024	0.325
Portugal	0.268	0.025	0.337
Germany	0.26	0.028	0.337
UK	0.244	0.021	0.284
Hungary	0.164	0.014	0.188
Czech	0.158	0.013	0.18
Poland	0.141	0.016	0.187
Mean	0.449		

Table 7: MOBM

Country	bias corrected	s.e.	uncorrected
Austria	0.769	0.081	0.965
Slovenia	0.748	0.078	1
Slovakia	0.739	0.087	1
Finland	0.72	0.106	0.976
Netherlands	0.679	0.068	0.864
Ireland	0.672	0.059	0.776
Denmark	0.665	0.116	1
Sweden	0.607	0.079	0.786
Spain	0.573	0.048	0.654
France	0.426	0.043	0.541
Belgium	0.298	0.029	0.361
Italy	0.282	0.025	0.325
Portugal	0.272	0.024	0.318
Germany	0.26	0.027	0.337
UK	0.238	0.021	0.284
Czech	0.16	0.013	0.18
Hungary	0.157	0.013	0.188
Poland	0.148	0.015	0.191
Mean	0.467		

Table 8: MOBH

Country	bias corrected	s.e.	uncorrected
Austria	0.753	0.080	1
Slovenia	0.732	0.082	1
Slovakia	0.732	0.118	1
Finland	0.701	0.086	1
Ireland	0.663	0.114	1
Denmark	0.662	0.060	0.776
Spain	0.571	0.050	0.654
Netherlands	0.533	0.151	0.703
Sweden	0.519	0.052	0.636
France	0.398	0.026	0.543
Belgium	0.296	0.141	0.516
Italy	0.274	0.121	0.496
Portugal	0.273	0.063	0.445
UK	0.268	0.025	0.328
Germany	0.258	0.025	0.318
Czech	0.159	0.015	0.188
Hungary	0.153	0.013	0.18
Poland	0.143	0.015	0.185
Mean	0.449		

Table 9: AVTLCINVSH

Country	bias corrected	s.e.	uncorrected
Austria	0.797	0.084	0.965
Slovenia	0.699	0.084	1
Ireland	0.667	0.063	0.776
Slovakia	0.648	0.104	1
Spain	0.551	0.053	0.654
Netherlands	0.449	0.047	0.543
France	0.406	0.044	0.503
UK	0.39	0.056	0.551
Belgium	0.301	0.030	0.361
Finland	0.266	0.029	0.332
Denmark	0.254	0.027	0.322
Germany	0.253	0.026	0.337
Portugal	0.252	0.027	0.318
Italy	0.247	0.028	0.325
Sweden	0.239	0.025	0.307
Hungary	0.198	0.024	0.263
Czech	0.155	0.014	0.18
Poland	0.14	0.019	0.199
Mean	0.384		

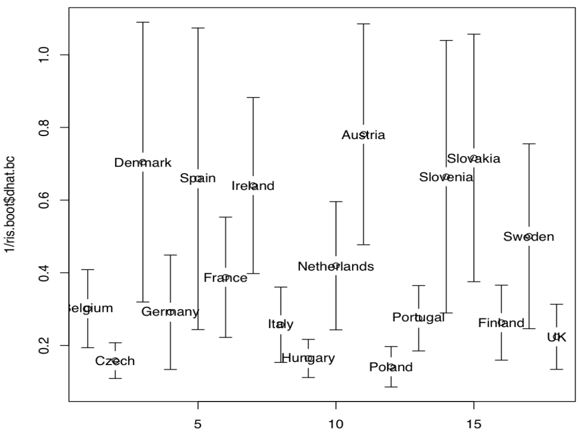


Fig 1: three minutes local call incumbent

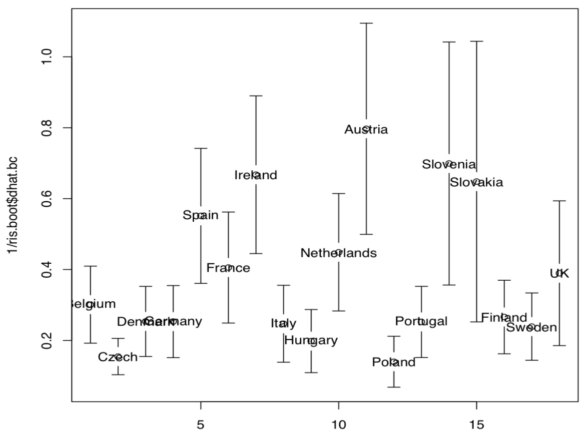
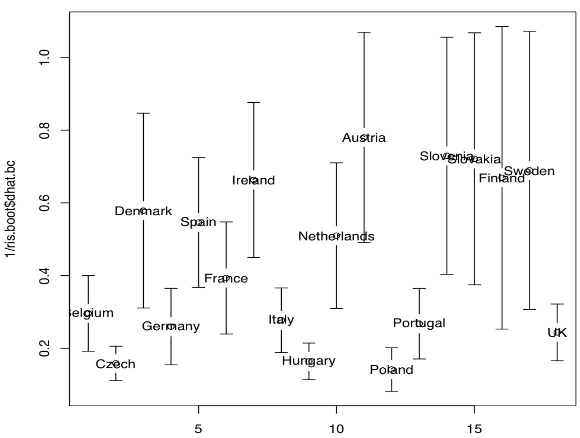


Fig 2: AVTLCINVSH CPLEuroFig



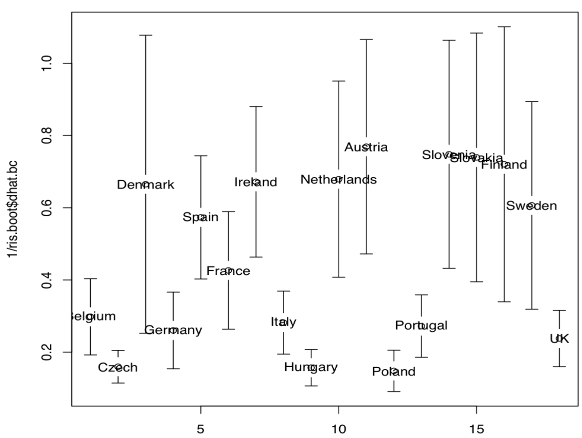


Table 10: AVTLCINVSH

Country	bias corrected
Austria	0.756
Slovenia	0.734
Slovakia	0.723
Ireland	0.664
Spain	0.601
Netherlands	0.532
Denmark	0.512
Finland	0.510
Sweden	0.464
France	0.449
Italy	0.325
UK	0.325
Belgium	0.303
Germany	0.294
Portugal	0.271
Hungary	0.167
Czech	0.157
Poland	0.144
Mean	0.441

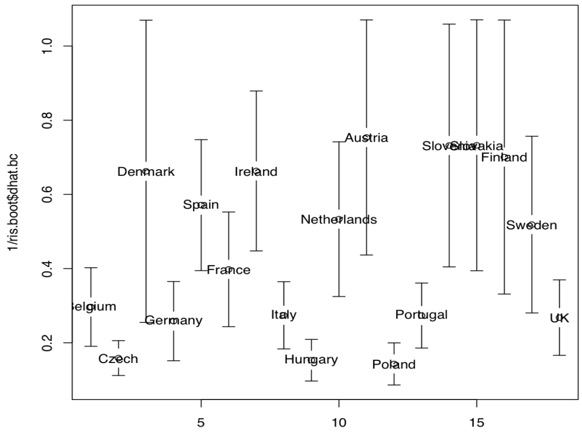


Fig 1: MOBL tuttoCPLfigure

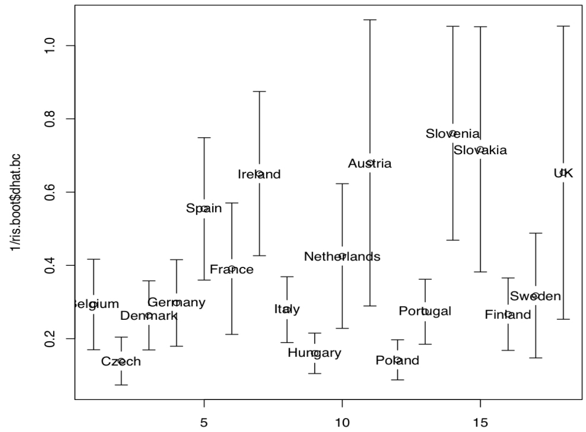


Fig 2: ?????

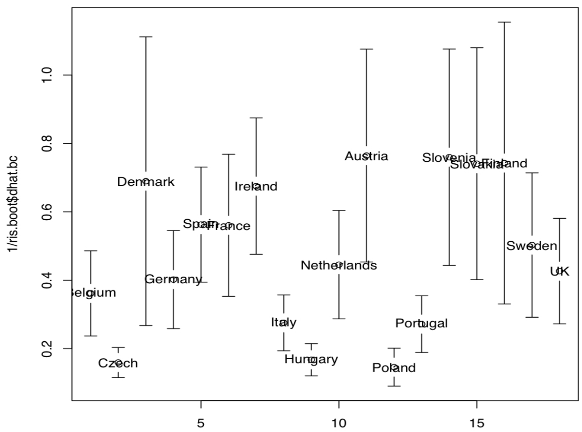


Fig 1: PENBB CPLeuroFigure

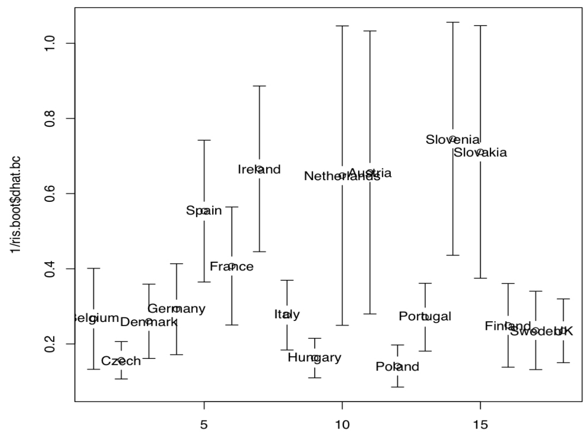


Fig 2: VOLAO CPLeuroFig