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MEASURING INVESTMENT EFFICIENCY IN PUBLIC EDUCATION SOME CROSS-COUNTRY COMPARATIVE RESULTS

MIRCEA BADESCU

Institute for the Protection and Security of the Citizen

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European Commission
Directorate-General Joint Research Centre
Institute for the Protection and Security of the Citizen

Contact information
Address: Via E. Fermi 1, TP 361, Ispra (VA), 21202, Italy
E-mail: crell@jrc.it
Tel.: + 39 0332 789314
Fax: +39 0332 785733

http://www.crell. jrc.ec.europa.eu
http://www.jrc.ec.europa.eu

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Contents

Introduction

Investment in education and training is permanently on the political agenda of the European Union. The re-launched Lisbon strategy focuses on competitiveness, growth and productivity and strengthening social cohesion. Even more than in its first phase, the revised Lisbon strategy places strong emphasis on knowledge, innovation and the optimisation of human capital. Education and training are seen as critical factors to develop EU's long-term potential for competitiveness as well as for social cohesion. Investing in research, education and innovation play central roles in generating added value and contributing to the creation of more and better jobs.

By stressing that lifelong learning is central to the achievement of the Lisbon objectives the 2005 Spring European Council[1] confirmed that investing more and better in human capital is at the heart of the Lisbon strategy while the 2006 Spring European Council[2] outlined the twin challenges which Europe's education and training systems face. Building on the Lisbon Council's call for increased and improved investment in human resources, the "Education and Training 2010" work programme for Europe in the field of education and training is organised around quality, efficiency, access and openness of education and training systems and includes a specific objective investigating "Making the best use of resources"[3].

Recent policy documents underlined that the education and training policies should aim to improve the knowledge, skills and competences of society as a whole and of individuals, especially the most disadvantaged. They stated that reforms must be stepped up to ensure high quality education and training systems that are both efficient and equitable and that member states should *increase efficiency* by raising the average skill level in the population and *reduce inequality* by improving the life opportunities of those most in need. The Communication from the Commission of 8 September 2006 on "Efficiency and equity in European education and training systems" states that reforms must be stepped up to ensure high quality educational and training systems that are both efficient and equitable and that education and training systems are efficient if inputs used produce the maximum output.[4] This is also one of the messages of the 2006 joint progress report[5] of the Council and the Commission on the implementation of the Education and Training 2010.

Current work on efficiency of investment in education

Recent literature reviews that have been undertaken in the framework of Commission's activities on efficiency and equity in education and training policies shows a broad acceptance that efficient education and training systems can create economic growth and equitable systems can create social cohesion. A recent review of empirical evidence, especially from Europe, on how education and training policies can be designed to advance both efficiency and

[1] http://europa.eu.int/growthandjobs/key/index_en.htm
[2] European Council 23-24 March 2006, Presidency Conclusions par. 23
[3] http://europa.eu.int/comm/education/policies/2010/objectives_en.html#making
[4] Efficiency and equity in European education and training systems, Communication from the Commission, COM (2006) 481 final.
[5] http://europa.eu.int/eur-lex/lex/LexUriServ/site/en/oj/2006/c_079/c_07920060401en00010019.pdf

equity has been undertaken by Wößmann (2006) and some of the findings related to efficiency are presented below. Much of the literature can, however, be found in the forthcoming sections of this paper.

Research in the economics of education over the past decade has produced ample evidence that the monetary and non-monetary prosperity of individuals is related to their level of education and training. Education produces substantial returns to the individual in terms of earnings (cf. the surveys by Card 1999 and Harmon et al. 2003) and employability (e.g., OECD 2000, 2005) and significant effects on economic growth (e.g., Krueger and Lindahl 2001; de la Fuente and Doménech 2006). Ample evidence shows that the quantity and especially the quality of schooling, in terms of student performance on cognitive achievement tests, carry substantial payoffs of productivity and earnings in the labour market for the individual and society alike (cf. Barro 2001 and Wößmann 2002). Given that most European countries achieve virtually universal enrolment in primary and lower secondary schooling, implementing policies that increases the quality of schooling in terms of students' cognitive and non-cognitive skills may bring considerable benefits.

Research reviewed by Psacharopoulos (2006, 2005, 1994 and with Patrinos, 2004) shows that the returns to education are higher the lower a country's level of development (usually measured by per capita income). The main reason is the relative scarcity of human capital in less developed countries. As with any form of investment, returns to investing in education are subject to diminishing returns and decrease as human capital becomes more abundant. There are only few cross-country calculations of rates of return broken down by the socio-economic status of individuals. Aggregate rates of return to education for individuals from different socio-economic backgrounds do not show, on average, any major variations between the richest and the poorest although there are sizeable differences among graduates from different levels of education. Research shows that in the United States and France the returns to education among those whose father belongs to a higher socio-economic group are only about 1 percentage point higher relative to lower socio-economic groups (Psacharopoulos, 2006). Higher returns to schooling may be expected to encourage further schooling and so they may reduce inequity in the future. However, the high economic and social potential of investing in education and training measured by rates of return is largely unknown because of a lack of information and this explains why the returns to education and training, even when broken down by level of education, are rarely taken into account by individuals or governments when they make spending and investment decisions[6].

Another important issue refers to the need to collect the necessary data on inputs and outcomes in order to design policy interventions in ways that are amenable to rigorous empirical evaluation. For implementing better-informed policies to foster equity and efficiency in education and training, European countries will have to implement independent evaluation studies that create knowledge on what works and what does not. Such country-specific empirical assessments will be able to provide particularly useful and robust findings if evaluators are involved in designing the policy ex-ante, in order to set up a convincing evaluation design. There could also be scope for

[6] Commission Staff Working Document, accompanying document to the Communication from the Commission Efficiency and equity in European education and training systems, SEC(2006) 1096.

ensuring that country-specific assessments are done in as standardised a way as possible to facilitate learning across European systems.

Accounting for different categories of indicators in measuring the investment efficiency

The education and training landscape in the European Union has evolved in past decades and, as a result, the statistical frameworks developed by the data providers. At present the indicators reported for different categories (e.g. inputs, outputs, learning outcomes, etc.) can differ considerably and it is rather difficult to match the coverage of each individual data collection (definitions, methodology, timeliness, *etc.*) to the different needs. Identifying the most appropriate categories of indicators for measurement purposes in the field of investment efficiency remains a difficult exercise. The translation of educational variables into a set of inputs and outputs/outcomes that can be further used to measure investment efficiency has evolved in the past years mainly due to the increased availability of harmonised outcome data (mainly gathered through international large scale surveys). While the information collected through these surveys has become lately very interesting it should nevertheless be contextualised with the system level information. Below are some options (and the consequent limitations) when translating the existing statistical information into different categories of indicators for measuring investment efficiency in education.

The inputs

Two categories of input can be distinguished for measurement purposes. The first type covers factors under the control of the education system, to a larger extent the resources used in school process such as teacher-student ratios, average instruction time, *etc*. The second covers so-called 'non-discretionary' factors which are not under the control of education providers but constitutes important determinants of the educational process.[7] When measuring the cost efficiency the financial inputs need to be used. They differ somewhat more among the European countries than physical inputs, due mainly to the disparities in employee compensations which account differently as part of total expenditure by educational institutions. These disparities may reflect teaching quality and the availability of other potentially important resources available in schools as well as labour market factors unrelated to efficiency (see the next section in this paper). Since competence builds up over the school life of a pupil it is better to use cumulative spending over the typical or the average duration of studies. Ideally the cumulative spending should be based on constant monetary units in order to filter out the effect of different price levels (and exchange rate fluctuations) data should therefore be converted in equivalent monetary units through deflators (usually the Gross Domestic Product (GDP) household final consumption). The use of Purchasing Power Parities (PPP) filters out differences in price levels between countries but it still does not filter out differences in salary levels (which relate to differences in productivity and per capita income). Typically as *per capita* income increases so does the price of non-tradable services, education included and failure to take account of this phenomenon will thus exaggerate the differences in spending between richer and poorer countries. An alternative approach would be to relate the proportion of GDP that goes to education even when using this indicator the private spending and the

[7] Research shows that for instance pupils' socio-economic background could also be related to efficiency, but they are of a fundamentally different nature Barro and Lee (2001) found that student performance is positively correlated to the level of school resources, such as pupil-teacher ratio, and also to family background (income and education of parents). Hanushek and Kimko (2000), Hanushek and Luque (2003) found that adult schooling attainment levels have a positive and significant effect on student performance but little evidence exists to assert a link between resources allocated and test results in education institutions. Afonso and St. Aubyn (2005) showed that inefficiencies in education at the country level are strongly related to the two variables, as the estimated coefficients are statistically significant and negatively related to the efficiency measure implying that the country moves closer to the production frontier.

differences in the age distribution of the population are overlooked. To correct for this, one option is to use the GDP public and private spending per student; this indicator filters out many of the structural and economic differences between countries but its unit is so small and is therefore rather difficult to be used. Although no financial measure may eliminate all the possible bias, some are better proxies than others.

The outputs can be measured very broadly (in terms of educational attainment of the population) or more narrowly (in terms of graduation rates or study duration). From this perspective, the graduation rates can be used as a proxy for educational outputs as they are an indicator of the current production rate of higher-level knowledge for each country's education system (see Box 1). Countries with high graduation rates are most likely to be developing or maintaining a highly skilled labour force. Rising skill demands in countries have made upper secondary qualifications the foundation for further learning and training opportunities and, as a result, young people who leave without an upper secondary qualification tend to face severe difficulties in entering the labour market. On the outputs side too, it should also be noted that, for the EU countries, Eurostat has defined the educational output as the "quantity of teaching received by the students, adjusted to allow for the quality of the services provided for each type of education". EU member states are required to introduce direct measures of output for certain government services (including health care and education) with the dissemination of 2006 national accounts.[8]

The outcomes are conceptually more complex. An approach which takes the quality of teaching (and learning) into account would focus more on intermediate outcomes such as literacy rates at particular ages or longer-term earnings thus giving a better understanding of educational contributions to human capital. Specifically, the measures adopted to capture the outcomes are related to the two main objectives of educational systems: educational achievement and its equality. In the latest policy papers it is stressed that educational systems should also be charged with goals such as mitigating inequality, a measure of the homogeneity of the literacy scores could also be treated as an outcome at the national level.[9] Many of the indicators that measure the learning outcomes of individuals (skills and knowledge acquisition) could be derived from data collected through surveys like PISA or PIRLS.[10] In the case of PISA the survey aims at evaluating real-life student abilities at the end of their compulsory schooling (thus avoiding the difficulties of comparing students across countries when participation is voluntary). Using the individual learning outcomes to measure the investment efficiency does have some drawbacks. Related to these concerns is the fact that educational outcomes should also be judged by how many of the young continue their education to the end of the compulsory stage, which has obvious implications for human capital accumulation. By matching the literacy scores with background and institutional information at the system level on a comparable basis allow the analysis of efficiency to be situated in a policy context. Even if differences in structures are taken into account there might still be residuals as regards differences in talents that cannot be filtered out; ideally the value added by education should be measured but this is again rather complicated.

[8] The United Kingdom is one of the front-runners in implementing the output-based approach, a direct measure of education output introduced in 1998. The current measure reflects pupil attendance (rather than number of pupils) and adjustments based on past trends in exam results (*Atkinson Review*, 2005).

[9] The weight given to these objectives may vary across countries, reflecting social preferences, but, subject to the fact that pupils' socio-economic background may differ, there do not seem to be trade offs between the level of educational attainment and the homogeneity of student achievement (OECD, 2005).

[10] **PIRLS** (Progress in International Reading Literacy Study) is an international study conducted by the International Association for Evaluation of Educational Achievement (IEA) to monitor, on a regular basis and within an internationally agreed common framework, the outcomes of education systems in terms of student achievement for different school grades. **PISA** (Programme for International Student Assessment) is an international study conducted by the OECD to monitor, on a regular basis and within an internationally agreed common framework, the outcomes of education systems in terms of student achievement for students aged 15 years old.

Methodological considerations

The concept

Educational efficiency is defined in the recent policy documents as a measure of how resources allocated to the educational system (funds, expertise, human resources, time, etc.) are converted into individual outputs (e.g. educational achievements, employability, earnings) as well as into outcomes for the economy and society.[11] In defining educational efficiency a first distinction is made based on outcomes: ***internal efficiency*** relates to outcomes within the education and training systems (e.g. course enrolment and completion rates, average/theoretical duration of studies, the highest level of education reached, etc.) whereas ***external efficiency*** relates to outcomes measured very broadly (in terms of the increments to economic welfare or societal outcomes). Secondly, it is important to distinguish between ***technical efficiency*** (use to compare the non-monetary inputs and outputs) and ***cost efficiency*** (use to compare monetary inputs with non-monetary outputs).[12] Finally, for measurement purposes there is an important distinction between ***input efficiency*** which shows how much less input an entity (*i.e*. school, university, country, *etc*.) could use to achieve the same level of output and ***output efficiency*** which shows how much more output the entity should be able to produce with the same amount of resources.

The method

Most of the available studies on investment efficiency in the public sector use non-parametric approaches, such as Data Envelopment Analysis (DEA) or Free Disposable Hull (FDH). Both methods were originally developed for companies that convert inputs into outputs but their use can be extended to generate efficiency rankings for countries. **Data Envelopment Analysis** implies the use of linear programming techniques in order to estimate an efficiency frontier that could be further used as a benchmark to measure the relative performance of countries. The method involves constructing an efficiency frontier and using it as a benchmark to measure the position of each entity against it for a set of indicators. The entities will perform better or less well, depending on their position relative to the frontier. **Free Disposable Hull** also implies the identification of an efficiency frontier exploiting the information of observed input-output combinations but does not assume the existence of a convex production frontier. In the FDH framework it is possible to rank the efficiency by comparing each individual performance with a production possibility frontier (*i.e*. the highest possible level of output/outcome for a given level of input), as is it also possible to determine the lowest level of input which will be needed to obtain a certain level of output/outcome. The method allows for the identification of the so-called inefficient producers, both in terms of input and output/outcome efficiency. Non-parametric approaches have some drawbacks. The estimates of efficiency are particularly sensitive to measurement error, statistical noise and outliers, the small-sample bias may lead to the underestimation of the degree of inefficiency (as the number of inputs and outputs rises) and the estimates of inefficiency could be affected by irrelevant inputs and outputs.

The model

[11] Efficiency and equity in European education and training systems, Communication from the Commission, COM (2006) 481 final.
[12] Based on the typology proposed by Lockheed and Hanushek (see Concepts of Educational Efficiency and Effectiveness, in T. Husén and T. Neville Postlethwaite (eds.), *International Encyclopaedia of Education*, 2nd Edition, Volume 3, Oxford, Pergamon, 1994.

The model used in this paper makes use of quantity measures, in which the inputs are transformed into quantitative measures (*e.g.* average instruction time expressed in minimum recommended number of teaching hours, ratio of teachers to students, *etc*.) that are used to obtain a certain level of learning outcomes, such as knowledge, skills, and competencies[13]. Authors such as Barro and Lee (2001) or Hanushek and Luque (2002), have applied the "education production function approach" coming up with the below form of the function:

$$y = G(r, f) + e$$

where:

- *y:* the educational outcome;
- *r*: the resources allocated to education;
- *f*: the family factors that may affect the educational output, (e.g. parents income or instruction level);
- *e:* stands for other unmeasured factors with an influence on the outcome;

The function *G* is assumed to be linear and is estimated by least squares methods.

In this analysis, we compare resources allocated to levels of education production processes to outcomes using both discretionary and non-discretionary inputs. Differently from the regression analysis, the outputs are also measured by more than one variable. The approach used in this paper is essentially different from the production function one as it does not assume that all decision units operate on the production function. Moreover, the production function envelops the data and has no *a priori* functional form. The objective here is to measure by how much input quantity can be proportionally reduced without changing the output quantities. Due to the very limited number of observations at the national level, the specifications have been kept as simple as possible in order to minimise the problems associated with small samples.[14] The techniques used in this paper measure efficiency relative to the observed most efficient units; in essence, the non-parametric approaches are constrained optimisation problems. The aim of DEA and FDH is to construct a frontier such that all observations lie either on or within the frontier. The shape of the DEA efficiency frontier depends on the assumptions about returns to scale (which can be constant, variable and non-increasing). By comparing the results under the different assumptions about returns to scale it is possible to identify whether the country would be at its technically most efficient scale if inefficiency was eliminated[15].

Cross-country comparative measures of investment efficiency in public education

Several indicators were discussed during SGIB meetings which have led to the use of some of them in the report *Progress towards the Lisbon Objectives in Education and Training (2006).* A decision was taken towards computation, in the medium term, of new measures for investment efficiency.[16] To provide a point of comparison between the countries, the paper reports a baseline specification of technical efficiency at different levels

[13] In the research literature on efficiency of investment the financial measures are usually considered to be the most relevant to assess public spending and appears to be more interesting for the use of policy-makers. This is also the case for education and training in the European Union, where education expenditure is largely (over 90%) from public sources.
[14] The computations use linear programming, not subject to statistical problems such as simultaneous equation bias and specification errors.
[15] In the empirical analysis presented in this paper conceptions about the shape of the frontier were kept to a minimum. Convexity is the only one considered here on top of the sensible efficiency concept embedded in the DEA/FDH analysis.

(compulsory and non-compulsory education). In a DEA context the results can largely depends on the choice of inputs and outputs considered as once the number of outputs rises, measured efficiency will increase and some countries will be regarded as 100% efficient. There is thus an onus on limiting the number of dimensions but there are no clear methods of choosing the correct number to include.

Although non-parametric methods have been already used in some studies on efficiency in education, the approach adopted here extends previous research by conducting the analysis for a larger number of European countries and combining the data from different sources. The variables used in the empirical analysis are constructed from different databases (the joint Unesco-OECD-Eurostat (UOE) data collection, IEA or OECD's databases) which are all designed so that data is comparable across countries for the same reference year. Taking into consideration the arguments presented in the above sections of this paper[17] and the data availability, the preferred specifications for the models are:

- **Inputs:**

Two main types of quantitative inputs are used in this paper to calculate the efficiency scores for compulsory education. On the discretionary input side the two indicators used in the calculations are: the average number of hours of teaching instruction received by pupils (Source: Eurydice, 2003) and the number of teachers per 100 students[18] (Source: UOE, 2003). In another model specification the educational attainment of adults expressed as percentage of population aged 25-64 having completed at least upper secondary education (Source: EU Labour Force Survey, 2003) was used as a non-discretionary input. In order to obtain estimates of cost efficiency different categories of expenditure were translated into financial inputs and further used in the models for both compulsory and non-compulsory levels of education. The preferred specifications included the cumulative expenditure per student over the theoretical duration of studies in absolute terms or adjusted by GDP per capita (Source: OECD, 2003) and the ratio of private to public expenditure (Source: OECD, 2003).

- **Outputs and individual learning outcomes:**

Learning outcomes of individuals (skills and knowledge acquisition) are derived from data collected through surveys like PIRLS and PISA which account for the cumulative output of primary and compulsory education. The reading literacy scores and the equity objective measured by the homogeneity of literacy scores ($25^{th}/75^{th}$) were used in the calculations, with the assumption that the higher the ratio, the greater homogeneity in student performance (Sources: IEA-PIRLS, 2001 and OECD-PISA, 2003).

- **The efficiency scores:**

There are different possibilities to compute the efficiency scores. In a one-stage approach the efficiency scores will be computed taking the quasi-fix factors as non-discretionary into account and hence using the discretionary resource inputs to estimate the efficiency of countries. A two-stage approach would compute the scores in the first

[16] New Indicators on Education and Training, Commission Staff Working Paper, SEC (2004) 1524.
[17] Such input measures were also used in several research papers: Barro (2001), Hanushek and Luque (2003), Afonso and St. Aubyn (2005).
[18] Estimates of the average class size are quite similar across most countries at the primary and lower secondary level, while variation in the more easily measured student to teacher ratio is somewhat greater (see the data annex).

stage using only discretionary inputs and correct them afterwards by estimating the impact of non-discretionary inputs using regression models (Afonso and St. Aubyn, 2005) or to correct the scores already in the first stage of differential non-discretionary input endowments in a regression analysis and hence estimating them on the discretionary inputs (Borge and Naper, 2005). In this paper we only employed the one-stage approach (computations made with Efficiency Measurement System http://www.wiso.uni-dortmund.de/lsfg/or/scheel/ems/).

The specific measures adopted to capture outcomes related to the two main objectives of educational systems are educational achievement and its equality. In Table 1 the efficiency scores computed for different combinations of inputs and outputs, shows how much less input a country could use to achieve the same level of output. Countries with an input efficiency score of 100% are located on the production possibility frontier, which means that no other country analysed reports a higher output level using the same or less input than these countries. The position of each country on the efficiency scale is also important, taking into account the notion of '*peers*' (i.e. the country that give the efficient production). In the case of Cyprus, for example, the country that gives the efficient production (i.e. the 'peer') is Slovakia, where there are fewer average hours per year spent in school and a higher number of teachers to 100 students and which performed better in PIRLS. All countries which come up as efficient scored above average in PIRLS, have a number of teachers per 100 students and are below average in terms of annual average teaching hours. The main advantage of this model is that it makes use of quantity measures instead of financial measures as inputs, which provides a better balance in the relative importance of the inputs used by each country. However results should be treated with care due to the relatively small number of countries for which data is available[19].

Results are also available for a related model which is specified with one discretionary output (number of teachers per 100 students), a non-discretionary input (educational attainment of adults expressed as percentage of population aged 25-64 having completed at least upper secondary education) and one output. The same group of countries (and Romania) performed less well but a change in the peers can be seen for some countries. In the case of Slovenia, for instance, when the social background is added in the model, the country that gives the efficient production is Slovakia.

Moving the measurement towards the end of compulsory education (proxy by students aged 15) the following results are available (see Table 2). Finland and Sweden came up as efficient since they have scored above average in PISA and they are below average in terms of annual average teaching hours and number teachers per 100 students. This group of countries would be able to attain the same level of output with a reduction in resources of 25% in some cases. Results are available for a related model which is specified with a non-discretionary input that proxy the background of students (educational attainment of adults expressed as percentage of population aged 35-

[19] At the school level recent research work has been undertaken by Borge and Naper (2005) in order to calculate the efficiency potential in the lower-secondary schools in Norway and to analyze the efficiency variation across municipalities. The paper uses the DEA framework with assessment grades adjusted for family background as outputs and teaching hours as inputs, a factor that is under direct control of the educational institutions. The results show that a high level of municipal revenue contributes to both high student performance and high resource-use per student. The authors found that efficient municipalities with roughly the same number of students are characterized by relatively low resource-use per student and students from these municipalities score better. In recent paper Fuchs (2006) assesses the efficiency of an educational system comparing the efficiency variation within a country, between schools rather than at a system level. Such an approach could be a useful complementary approach at a country-level in order to identify inefficiencies of the educational system given country-specific factors which is the main drawback for the cross-country comparisons.

44 having completed at most lower secondary education). This is an interesting result because it indicates the role of parents' educational attainment level: for the same input/output mix, countries like Czech Republic and Poland (and to a lesser extent Germany) become efficient due to lower proportions of less educated adults aged 35-44. By adding in the model parents' educational background some countries would be able to attain the same level of output with a reduction of up to 1/3 in the resources allocated to education. These findings could complement other empirical evidences of the role of family background in explaining the students' results.

It is possible to estimate cost efficiency though for a smaller number of countries, complementing the estimates of technical efficiency (see Table 3). However, when constructing the relevant indicators of spending, particular care is needed. The cost efficiency estimates in this paper use the same baseline and specification as those of technical efficiency but the teacher-student variable is replaced with the cumulative spending over the theoretical duration of studies for primary and lower secondary education (adjusted by GDP per capita) and with the ratio of private to public expenditure. The approach uses estimates of cumulative education spending per full-time equivalent student based on the OECD's *Education at a Glance* data (which are expressed in equivalent US$ converted using the PPP for GDP household final consumption).

Measuring efficiency when one considers the financial resources allocated to a sector is somehow different from assessing efficiency from the measurement of resources in physical terms. The case of Hungary clearly illustrates this point: the country is not efficient in physical terms but, as the educational resources considered in the model are comparatively cheaper, it becomes efficient in financial terms. An opposite example is provided by France that only arises as efficient when inputs are physically measured and this may well result from the fact that resources are comparatively more expensive than in other countries. It seems natural that in some countries the cost of resources is higher than in others and this has obviously an impact in measuring the efficiency. Therefore, this supplementary set of results (using as inputs financial indicators instead of quantity measures) can show a different picture on the relative importance of the inputs used by each country.

Results from the estimates of cost efficiency for the compulsory education show that, overall, the potential gains from eliminating cost inefficiencies are similar to those from eliminating technical inefficiency: potential cuts of over 15% in some countries (see Table 4). As in the case of technical efficiency, some countries perform better with respect to the outputs whereas for some countries (Italy or Germany) the potential efficiency gains are noticeably higher than they are in terms of technical efficiency. Sweden again only arises as efficient at this level when inputs are physically measured and this may well result from the fact that resources are comparatively more expensive. An opposite example is provided by Slovakia and Poland (and to a lesser extent by Czech Republic) all countries that perform less well in physical terms (under DEA VRS assumptions) but because the resources considered in the model are comparatively cheaper, they both become efficient in financial terms.

Research shows that there is no clear, systematic relationship, between student achievement and the amount of resources spent on schools while the results for teacher education and experience and for endowment with instructional material are more mixed (see Hanushek 2003 for an overview; Wößmann 2005, Wößmann 2003 for

cross-country evidence; and Gundlach et al. 2001 for evidence from several European countries over time). Therefore, a substantial gain in measured test scores is not likely to change with the increase in spending unless changes also take place in the institutional structures of the national school systems. In a cross-country analysis, Wößmann (2003, 2005) provides evidence for a strong complementarity between efficiency and equity policies in the sense that public funding of schools combines very well with private operation. Public funding is likely to improve efficiency, presumably because it allows additional choice and thus competition for families who could otherwise not choose because they are credit constrained; when public money goes to privately operated schools, this is the most efficiency-conducive combination. Thus education systems where the state finances the system and the private sector runs the schools seem to outperform other kinds of system. Along the same line Schütz et al. (2005) find that public funding improves equity and combining private operation with public funding may thus be conducive to both efficiency and equity.

It is possible to estimate the cost efficiency for non-compulsory levels of education (though for a smaller number of countries and using outputs which differ somewhat more among the European countries). Some cross-country comparative results are presented in Table 5. The differences in scores are sizeable as the costs in higher education vary largely across countries and there is evidence showing this.[20] Johnes and Johnes (2005) estimated a multi-product cost function for UK higher education institutions. Using panel data, they show that science undergraduates cost between twice and three times as much to produce as do non-science undergraduates and that post-graduate education is markedly more costly than undergraduate education. Afonso and Santos (2004) studied the efficiency of public expenditure in 45 Portuguese public universities and 36 faculties or institutes using graduates as quantitative output. They computed efficiency scores for each university as well as estimates of efficiency losses, based on which they ranked the universities and identified the most efficient cases. These findings might have clear implications for the further expansion of higher education in some countries since, if current efficiency levels are given, any further expansion should be effected within existing institutions in order to minimise the global costs.

[20] Differences among the European countries are due mainly to the duration of studies as students can choose from a range of institutions and enrolment options in order to find the best fit between their degree objectives, abilities and personal interests. Many students enrol on a part-time basis while others work while studying, or attend more than one institution before graduating (see the appendix on terms in this paper).

Box 1. Using the existing statistical frameworks to generate indicators on investment efficiency

As mentioned before, identifying the most appropriate indicators for measuring the investment efficiency based on the information available in the statistical frameworks remains a difficult exercise. In this paper it was possible to study the investment efficiency by identifying a set of educational variables related to individual learning outcomes (such as literacy scores), to policy levers (financial, teaching, etc.) and to social and family background of students. However, other than the indicators employed in this paper can be further used in the Commission's work in this field.

On the output side, **graduation rates** can be proxies for measuring efficiency of investment as they show the current production rate of high-level knowledge for each country's education system. Countries with high graduation rates especially at higher levels of education are most likely to be developing or maintaining a highly skilled labour force and see the payoff of their early investments. One drawback of this indicator is that the measurement limitations can create problems for the search for evidence of efficiency. For some European countries it seems difficult to provide the unduplicated number of graduates due to the way this indicator is calculated (requiring detailed information about the typical ages at the starting and the end of the programme, the theoretical duration of the programme and assume full-time participation and no repetition).

Dropout and survival rates can also be useful indicators of the internal efficiency of education systems on the output side, too. In countries where students leave the education system at the end of the lower secondary level they are likely to face severe difficulties in entering and staying employed the labour market than their more educated counterparts. School dropout is often difficult to measure as so many actions can be regarded as a drop-out (eg leaving a programme before the end; taking time off during a programme; transferring to another programme whether "better" or "worse" transferring to another institution whether to the same programme or not; finishing the programme but failing the final examinations; succeeding in the final examinations but not entering the next level of education, etc.). High dropout rates may well indicate that the education system is not meeting the needs of its clients. Students may not find that the educational programmes offered meet their expectations or their labour market needs or they may find that programmes take longer than the number of years which they can justify being outside the labour market.

On the outcome side, the **relative earnings from employment** (captured by the index of earning differentials) can be viewed as a measure of returns to investments in education. This indicator provides useful information on the incentives for individuals to develop and maintain appropriate levels of skills through wage differentials, in particular through the enhanced earnings of individuals completing additional education. The higher the earnings that result from increases in human capital, the higher the returns on that investment and the premium paid for enhanced skills. A better non-compulsory education system will increase the return to this type of education (ie the better the upper secondary education and tertiary graduates meet the labour market needs, the more companies will be willing to pay for them). The measurement limitations can create problems for the search for evidence of efficiency by using this indicator. There is also one important distinction to be made here between the causal returns to education and the correlation between earnings of individuals that graduates from different education pathways. Some research (Card 1999) seems to indicate that the standard estimates of the return to education are about the same as the causal return but the individual salaries are also largely depending on labour market factors and different institutional arrangements. As a result, shifts in relative demand for different types of labour are also likely to influence the wages and salaries.

On the outcome side, **rate of return to investment in education** represents a more complete measure of the returns in time compared to the cost of initial investment in education. Frequently used in the literature (see Psacharopoulos 2006, 2005, 1994 and with Patrinos, 2004) the potential of this measure in the work on efficiency is largely unknown mainly due to lack of updated information. This could explain why this measure is rarely used by governments when they make spending and investment decisions.

Conclusions

1. In this paper issues related to investment efficiency in education have been approached by:

- Identifying a set of educational variables related to individual learning outcomes (such as literacy scores), to policy levers (financial, teaching, institutional, etc.) and to social and family background of students (the educational attainment of parents) that could be used to measure the efficiency of public investment in education;

- Computing efficiency indicators for each country for which data is available;

- Comparing efficiency across different levels of education (compulsory and non-compulsory);

- Comparing technical efficiency (when inputs are physically measured) and cost efficiency (when financial cost is considered);

- Comparing different methods (DEA and FDH), evaluating the robustness of results;

- Identifying research-based initiatives on the topic using either national or international data;

2. The efficiency scores can be seen as a useful tool for cross-country comparisons but cannot account for all the structural differences at the system level. Efficiency scores can be calculated for several years, allowing for an analysis of changes in efficiency for the same combinations of inputs and outputs. Clearly, and after measuring efficiency, identifying the inefficiency source would be of great importance in policy terms. The general question with regard to such a procedure is how far the country-specific efficiency scores are informative and whether they are useful in being calculated and analysed on a regular basis as part of the Commission work on indicators and benchmarks.

3. Measuring efficiency when one considers the financial resources allocated to a sector is different from assessing efficiency from the measurement of resources in physical terms. The case of Sweden clearly illustrates this point. This is a country that only arises as efficient, in compulsory education when inputs are physically measured and this may well result from the fact that resources are comparatively expensive. An opposite example is provided by Czech Republic and Slovakia (and to a lesser extent by Hungary and Poland): they perform less well in physical terms but since the resources considered in the model are comparatively cheaper, they become efficient in financial terms.

4. Some countries appear as efficient no matter what method or model is considered. The Czech Republic is a good education performer, and spends relatively less on education with surprisingly good results in comparative terms. Sweden and Finland are also different cases. Finland is the best performer in compulsory education

accounting for the learning outputs (proxy here by the PISA reading scores) and does not spend too many resources whereas Sweden is also a good performer but spend comparatively more.

5. Results using both methods DEA and FDH were broadly comparable. DEA is more stringent, meaning that a country which is efficient under DEA is also efficient under FDH, but the reverse is not true.

6. As an important part of education provision is public, it could be the case that inefficient provision is related to public sector inefficiency but this issue has to be further investigated. Countries are also different in what concerns the mix of public and private funding of education (see the statistical annex) and therefore a possible source of inefficiencies could derive from this.

7. Other structural differences across countries can play a role in explaining the results. Different levels of educational attainment of the adult population could imply different outcomes in education. This opens the way to a different but related line of research, which is to explain why some countries perform better than others when it comes to public education.

Statistical Annex

Table 1 Efficiency at primary level of education in some European countries (quantity inputs)

Countries		Model 1				Model 2			
		FDH	*Peers*	**DEA CRS**	*Peers*	**FDH**	*Peers*	**DEA CRS**	*Peers*
Bulgaria	**BG**	100.00%		100.00%	-	100.00%		92.76%	*FR,SK*
Czech Republic	**CZ**	100.00%	-	99.53%	*SK*	100.00%		100.00%	-
Germany	**DE**	100.00%	-	100.00%	-	100.00%		99.84%	*SK*
Greece	**EL**	70.73%	*BG*	68.70%	*BG*	64.63%	*DE*	62.08%	*FR*
France	**FR**	100.00%	-	100.00%	-	100.00%		100.00%	-
Italy	**IT**	63.74%	*BG*	60.51%	*BG,SK*	63.74%	*BG*	57.75%	*FR*
Cyprus	**CY**	98.08%	*SK*	98.08%	*SK*	98.08%	*SK*	92.53%	*FR*
Latvia	**LV**	100.00%	-	100.00%	-	100.00%		100.00%	-
Hungary	**HU**	65.96%	*LV*	65.28%	*LV*	65.96%	*LV*	56.54%	*SK*
Netherlands	**NL**	100.00%	-	92.54%	*SK*	100.00%		87.06%	*FR*
Romania	**RO**	100.00%	-	96.45%	*SK*	91.07%	*SK*	89.54%	*SK*
Slovenia	**SI**	75.90%	*BG*	70.74%	*LV*	65.38%	*SK*	62.99%	*SK*
Slovakia	**SK**	100.00%		100.00%	-	100.00%		100.00%	-
Sweden	**SE**	100.00%	-	75.20%	*LV*	100.00%		68.08%	*SK*

Source: CRELL computations

Model 1: Average teaching hours, Teachers per 100 students/PIRLS scores, Equity objective

Model 2: Adult attainment, Teachers per 100 students/PIRLS scores

FDH/DEA: Full Disposable Hull/Data Envelopment Analysis

CRS/VRS/NIRS: Constant/Variable/Non-increasing returns to scale

Table 2 Efficiency for compulsory education in some European countries (quantity inputs)

Countries		Model 1				Model 2			
		FDH	*Peers*	**DEA VRS**	*Peers*	**DEA VRS**	*Peers*	**FDH**	*Peers*
Belgium	**BE**	87.28%	*SE*	87.15%	*SE*	53.19%	*FI*	53.19%	*FI*
Bulgaria	**BG**	94.67%	*SK*	87.69%	*LV*	66.67%	*FI*	72.95%	*FI*
Czech Republic	**CZ**	100.00%	-	92.33%	*LV*	100.00%	-	100.00%	-
Germany	**DE**	91.84%	*FI*	88.47%	*FI*	83.56%	*FI*	100.00%	-
Greece	**EL**	94.34%	*FI*	94.34%	*FI*	94.34%	*FI*	94.34%	*FI*
Spain	**ES**	81.43%	*FI*	77.70%	*FI*	66.67%	*FI*	66.67%	*FI*
France	**FR**	91.94%	*FI*	85.91%	*FI,LV*	69.44%	*FI*	69.44%	*FI*
Italy	**IT**	84.54%	*SE*	80.94%	*LV*	51.55%	*FI*	51.55%	*FI*
Latvia	**LV**	100.00%	-	100.00%	-	100.00%	*CZ*	100.00%	*CZ*
Luxembourg	**LU**	82.33%	*SE*	81.71%	*LV*	45.05%	*FI*	45.05%	*FI*
Hungary	**HU**	83.35%	*CZ*	74.64%	*LV*	53.19%	*FI*	72.40%	*DE*
Poland	**PL**	98.84%	*FI*	88.92%	*LV*	79.07%	*CZ*	100.00%	-
Romania	**RO**	100.00%	-	97.08%	*LV*	68.49%	*FI*	87.28%	*FI*
Slovakia	**SK**	100.00%	-	95.01%	*LV*	96.96%	*CZ*	98.59%	*CZ*
Finland	**FI**	100.00%	-	100.00%	-	100.00%	-	100.00%	-
Sweden	**SE**	100.00%	-	100.00%	-	70.87%	*FI*	100.00%	-

Source: CRELL computations

Model 1: Average teaching hours, Teachers per 100 students/PISA reading scores, Equity objective

Model 2: Adult attainment, Teachers per 100 students/PISA reading scores

FDH/DEA: Full Disposable Hull/Data Envelopment Analysis

CRS/VRS/NIRS: Constant/Variable/Non-increasing returns to scale

Table 3 Efficiency at primary level of education in some European countries (financial inputs)

Countries		Model 1				Model 2			
		DEA VRS	*Peers*	**DEA NIRS**	*Peers*	**FDH**	*Peers*	**DEA VRS**	*Peers*
Czech Republic	**CZ**	100.00%		100.00%	-	100.00%	-	100.00%	-
Germany	**DE**	100.00%		100.00%	-	71.06%	*HU*	64.64%	*CZ*
Greece	**EL**	62.45%	*CZ*	61.25%	*CZ*	44.90%	*CZ*	36.02%	*SK*
France	**FR**	71.43%	*CZ*	71.43%	*CZ*	46.02%	*CZ*	37.61%	*SK*
Italy	**IT**	95.43%	*SE*	92.93%	*SE*	35.69%	*HU*	34.08%	*HU*
Hungary	**HU**	100.00%		100.00%	-	100.00%	-	100.00%	-
Netherlands	**NL**	100.00%		100.00%	-	100.00%	-	90.94%	*SE*
Slovakia	**SK**	100.00%		100.00%	-	100.00%	-	100.00%	-
Sweden	**SE**	100.00%		100.00%	-	100.00%	-	100.00%	-

Source: CRELL computations

Model 1: Cumulative expenditure to GDPc, Private to public expenditure/PIRLS scores, Equity objective

Model 2: Cumulative expenditure per student/PIRLS scores

FDH/DEA: Full Disposable Hull/Data Envelopment Analysis

CRS/VRS/NIRS: Constant/Variable/Non-increasing returns to scale

Table 4 Efficiency at compulsory level of education in some European countries (financial inputs)

Countries		Model 1				Model 2			
		FDH	*Peers*	**DEA VRS**	*Peers*	**DEA CRS**	*Peers*	**DEA NIRS**	*Peers*
Czech Republic	**CZ**	100.00%		98.92%	*NL*	71.53%	*SK*	86.05%	*PL*
Denmark	**DK**	81.38%	*FI*	78.44%	*FI*	24.80%	*SK*	30.55%	*PL*
Germany	**DE**	85.07%	*NL*	82.55%	*NL,SK*	37.27%	*SK*	45.56%	*PL*
Ireland	**IE**	100.00%		100.00%	-	35.80%	*SK*	66.51%	*SK*
France	**FR**	85.00%	*NL*	83.32%	*NL*	35.71%	*SK*	45.36%	*PL*
Italy	**IT**	92.88%	*FI*	88.35%	*FI*	31.53%	*SK*	33.83%	*SK*
Hungary	**HU**	95.19%	*IE*	90.91%	*IE,NL*	72.93%	*SK*	82.70%	*PL,SK*
Netherlands	**NL**	100.00%		100.00%	-	40.58%	*SK*	72.87%	*PL*
Austria	**AT**	98.05%	*FI*	92.73%	*FI*	30.71%	*SK*	37.54%	*PL*
Poland	**PL**	100.00%		100.00%	-	78.14%	*SK*	100.00%	-
Portugal	**PT**	86.31%	*FI*	78.83%	*IE*	41.68%	*SK*	45.58%	*SK*
Slovakia	**SK**	100.00%		100.00%	-	100.00%		100.00%	-
Finland	**FI**	100.00%		100.00%	-	37.30%	*SK*	100.00%	-
Sweden	**SE**	100.00%		100.00%	-	30.86%	*SK*	56.37%	*PL*

Source: CRELL computations

Model1:Cumulative expenditure to GDPc, Private to public expenditure/PISA reading scores, Equity objective

Model 2: Cumulative expenditure per student/PISA reading scores

FDH/DEA: Full Disposable Hull/Data Envelopment Analysis

CRS/VRS/NIRS: Constant/Variable/Non-increasing returns to scale

Table 5 Efficiency at tertiary level of education in European countries (financial inputs)

Countries		Model 1				Model 2	
		FDH	*Peers*	**DEA VRS**	*Peers*	**DEA VRS**	*Peers*
Belgium	**BE**	100.00%		90.60%	*IE*	50.49%	*SK*
Denmark	**DK**	85.60%	*EL*	84.71%	*EL*	34.46%	*SK*
Germany	**DE**	100.00%		100.00%	-	100.00%	
Ireland	**IE**	100.00%		100.00%	-	58.35%	*SK*
Greece	**EL**	100.00%		100.00%	-	100.00%	
Spain	**ES**	77.80%	*EL*	70.40%	*EL*	54.13%	*EL*
France	**FR**	94.66%	*EL*	75.90%	*IE*	44.12%	*SK*
Italy	**IT**	87.78%	*EL*	84.39%	*EL*	55.83%	*EL*
Hungary	**HU**	57.03%	*EL*	46.01%	*IE*	55.14%	*SK*
Austria	**AT**	100.00%		100.00%	-	64.76%	*DE,EL*
Slovakia	**SK**	96.24%	*EL*	77.24%	*IE*	100.00%	
Finland	**FI**	68.41%	*EL*	68.34%	*EL*	40.38%	*EL*
Sweden	**SE**	54.32%	*EL*	50.16%	*EL*	23.76%	*SK*
United Kingdom	**UK**	100.00%	-	88.49%	*EL,IE*	40.31%	*SK*

Source: CRELL computations

Model 1: Cumulative expenditure to GDPc, Private to public expenditure/Average duration of studies

Model 2: Cumulative expenditure/Average duration of studies

FDH/DEA: Full Disposable Hull/Data Envelopment Analysis

CRS/VRS/NIRS: Constant/Variable/Non-increasing returns to scale

Data annex **Primary level**

Country	Average teaching time minimum recommended (annual hours)	Cumulative expenditure per student over the theoretical duration of studies (PPP US$)	Ratio of cumulative expenditure per student to GDP per capita (PPP US$)	Ratio of private to public expenditure	Number of teachers to 100 students	Mean score on PIRLS reading scale for students in the 4th grade	Homogeneity of PIRLS scores (25th/75th)
*Source**	*Eurydice*	*OECD*	*OECD*	*OECD*	*UOE*	*IEA*	*IEA*
Reference year	*2002/03*	*2003*	*2003*	*2003*	*2003*	*2001*	*2001*
Belgium	849	37082	1.37	m	7.6	m	m
Bulgaria	504	m	m	m	5.8	550	0.8
Czech Rep	636	11365	0.76	0.05	5.4	537	0.8
Denmark	720	46884	1.60	0.02	9.2	m	m
Germany	698	18498	0.73	0.21	5.3	539	0.8
Estonia	661	m	m	m	m	m	m
Ireland	m	38078	1.28	0.03	5.3	m	m
Greece	713	25309	1.49	0.07	8.2	524	0.8
Spain	810	28971	1.36	0.07	7.0	m	m
France	958	24697	0.92	0.08	5.1	525	0.8
Italy	980	36829	1.45	0.02	9.1	541	0.8
Cyprus	840	m	m	m	5.2	494	0.8
Latvia	478	m	m	m	6.2	545	0.9
Lithuania	530	m	m	m	8.2	543	0.9
Luxembourg	894	68886	m	m	9.2	m	m
Hungary	786	13144	1.01	0.05	9.4	543	0.9
Malta	795	m	m	m	5.4	m	m
Netherlands	940	35015	1.22	0.06	6.2	554	0.9
Austria	690	28558	1.01	0.02	m	m	m
Poland	731	17153	1.66	0.01	8.4	m	m
Portugal	910	27019	1.51	0.03	m	m	m
Romania	555	m	m	m	5.6	512	0.8
Slovenia	664	m	m	m	7.8	502	0.8
Slovakia	652	8078	0.71	0.08	5.1	518	0.8
Finland	627	31926	1.21	0.01	6.0	m	m
Sweden	741	43744	1.63	0.01	8.1	561	0.9
United Kingdom	861	35103	m	0.15	5.0	m	m
Mean	739	30334	1.22	0.06	6.8	533	0.8
Median	726	28971	1.25	0.05	6.2	539	0.8
Maximum	980	68886	1.66	0.21	9.4	561	0.9
Minimum	478	8078	0.71	0.01	5.0	494	0.8
Standard dev.	141	14284	0.32	0.05	1.6	19	0.0
Missing	1	8	10	10	3	12	12

m:missing. (*) For details about country data please consult Eurostat, Eurydice, IEA and OECD websites

Data annex **Compulsory level**

Country	Average teaching time minimum recommended (annual hours)	Cumulative expenditure per student over the theoretical duration of studies	Ratio of cumulative expenditure per student to GDP per capita (PPP US$)	Ratio of private to public expenditure	Number of teachers to 100 students	Mean score on PISA reading scale for students aged 15 yrs	Homogeneity of PISA scores ($25^{th}/75^{th}$)
*Source**	*Eurydice*	*OECD*	*OECD*	*OECD*	*UOE*	*OECD*	*OECD*
Reference year	*2002/03*	*2003*	*2003*	*2003*	*2003*	*2002/03*	*2003*
Belgium	849	m	m	m	9.4	507	0.7
Bulgaria	890	m	m	m	7.5	430	0.7
Czech Rep	851	27122	1.83	0.05	7.0	489	0.8
Denmark	910	78717	2.69	0.02	m	492	0.8
Germany	931	52262	2.05	0.21	6.4	491	0.7
Estonia	840	m	m	m	m	m	m
Ireland	m	57065	1.91	0.03	7.1	515	0.8
Greece	910	m	m	0.07	5.3	472	0.7
Spain	1050	m	m	0.07	7.5	481	0.8
France	930	55107	2.05	0.08	7.2	496	0.8
Italy	908	59894	2.36	0.02	9.7	476	0.7
Cyprus	840	m	m	m	7.8	m	m
Latvia	732	m	m	m	7.6	491	0.8
Lithuania	859	m	m	m	11.1	m	m
Luxembourg	900	119147	m	m	11.1	479	0.8
Hungary	1021	26219	2.01	0.05	9.4	482	0.8
Malta	835	m	m	m	10.0	m	m
Netherlands	1289	50148	1.75	0.06	m	513	0.8
Austria	960	63433	2.24	0.02	m	491	0.8
Poland	865	25233	2.44	0.01	7.9	497	0.8
Portugal	930	45494	2.54	0.03	m	478	0.8
Romania	779	m	m	m	7.3	428	0.7
Slovenia	817	m	m	m	7.7	m	m
Slovakia	813	18606	1.64	0.08	7.1	469	0.8
Finland	855	57749	2.19	0.01	5.0	543	0.8
Sweden	741	66083	2.46	0.01	8.2	514	0.8
United Kingdom	912	m	m	0.15	5.7	m	m
Mean	893	53485	2.15	0.06	7.9	487	0.8
Median	878	55107	2.12	0.05	7.6	491	0.8
Maximum	1289	119147	2.69	0.21	11.1	543	0.8
Minimum	732	18606	1.64	0.01	5.0	428	0.7
Standard dev.	109	25086	0.32	0.05	1.7	26	0.0
Missing	1	12	13	10	5	6	6

m:missing. (*) For details about country data please consult Eurostat, Eurydice and OECD websites

Data annex: Tertiary level

Country	Average duration of studies	Cumulative expenditure per student over the theoretical duration of studies	Ratio of cumulative expenditure per student to GDP per capita	Ratio of private to public expenditure
*Source**	*UOE*	*OECD*	*OECD*	*OECD*
Reference year	*2002/03*	*2003*	*2003*	*2003*
Belgium	2.99	35392	1.31	0.15
Bulgaria	4.21	m	m	m
Czech Rep	m	m	m	0.20
Denmark	3.70	51852	1.77	0.03
Germany	5.36	62187	2.44	0.15
Estonia	3.42	m	m	m
Ireland	3.24	30264	1.03	0.19
Greece	5.25	25850	1.52	0.02
Spain	4.66	41673	1.95	0.30
France	4.02	43030	1.60	0.23
Italy	5.01	43906	1.73	0.39
Cyprus	m	m	m	m
Latvia	3.06	m	m	m
Lithuania	4.15	m	m	m
Luxembourg	m	m	m	m
Hungary	4.05	34734	2.66	0.27
Malta	m	m	m	m
Netherlands	5.24	m	m	0.27
Austria	5.30	65424	2.31	0.07
Poland	m	m	m	0.09
Portugal	m	m	m	0.45
Romania	3.54	m	m	m
Slovenia	m	m	m	m
Slovakia	3.82	17870	1.58	0.16
Finland	4.85	58489	2.22	0.03
Sweden	4.68	75221	2.79	0.12
United Kingdom	4.34	51529	1.46	0.42
Mean	4	45530	1.88	0.20
Median	4	43468	1.75	0.18
Maximum	5	75221	2.79	0.45
Minimum	2.99	17870	1.03	0.02
Standard dev.	0.78	16237	0.53	0.13
Missing	7	13	13	9

m:missing. (*) For details about country data please consult Eurostat and OECD websites

Appendix – Terminology[21]

Benefits of education can be classified in economic terms (productivity associated with the investment) and non-economic terms (better health, greater social cohesion, and more informed and active citizens). In the public sector, the benefits include increased revenues from income taxes on higher wages.

Costs of education are usually the opportunity costs of people not participating in the production of output as well as the full costs of the provision of education, rather than just the cost borne by the individual. In the public sector, the costs of education include public direct and indirect expenditure on education, as well as lost income tax revenues on students' foregone earnings.

Cumulative expenditure per full-time equivalent (FTE) student over typical/average duration of studies are estimations based on constant monetary units in order to filter out the effect of different price levels (and exchange rate fluctuations). Data are converted in equivalent monetary units through deflators (usually the GDP household final consumption). The use of purchasing power parities filters out differences in price levels between countries but it still does not filter out differences in salary levels (which relate to differences in productivity and per capita income). The varying enrolment patterns can affect the interpretability of expenditure on education per student. In particular, comparatively low annual expenditure on education per student can result in comparatively high overall costs of education if the typical duration of studies is long. Therefore OECD also calculates cumulative expenditure on education over the typical/average duration of studies by multiplying annual expenditure per student by an estimate of the /typical average duration of studies (see below).

Duration of studies differs a lot among countries as students can choose from a range of institutions and enrolment options in order to find the best fit between their degree objectives, abilities and personal interests. Many students enrol on a part-time basis while others work while studying, or attend more than one institution before graduating. Using the **approximation formula**, the latter estimate is approximated by the rate of turnover of the existing stock of enrolments, obtained from the ratio of flow data (entrants and leavers) to the corresponding numbers of students enrolled. The estimate is based on a number of simplifying assumptions: first, it is assumed that transition rates are constant over time. Second, expenditure in the current reference year is assumed to be typical of the total duration of studies. Using the **chain method**, the duration of study is defined as the sum of the probabilities, for each year of study, that a student who has entered tertiary education will still be enrolled in that year of study.

Efficiency refers to management of the relationship between outputs achieved and the cost of inputs used to produce these outputs. Efficiency (input) shows how much less input an entity (*i.e.* school, university, country, *etc.*) could use to achieve the same level of output. Efficiency (output) shows how much more output the entity should be able to produce with the same amount of resources that is currently using.

[21] A paper which contains a detailed description of concepts and principles related to better use of resources was produced by Working Group E "Making the best use of resources" http://europa.eu.int/comm/education/policies/2010/doc/besttool.pdf.

Effectiveness refers to the extent to which an organization achieves its objectives. Effectiveness requires organizations to seek for the best practice in combinations of educational resources. To address this in an educational context would require allocating the amount of resources per student based on the costs required to provide the education as stipulated in an agreed framework (*e.g.* educational output performance, curriculum standards, *etc*.). Effectiveness reflects much more the regulations (*i.e.* national, local, *etc*.), as the effectiveness of each educational institution must be evaluated in relation to resources that have been provided against the explicit standards established through these regulations.

Intended instruction time refers to the number of hours per year for which students ought to receive instruction in both the compulsory and non-compulsory parts of the curriculum. It does not include non-compulsory time beyond the school day, homework, individual tutoring or private study taken before or after school.

Rate of return to education represents measures of the returns obtained, over time, relative to the costs of the initial investment in education. There are several categories of rates of return. The **fiscal rate of return** is the discount rate that equalises the costs of education (*i.e.* public direct and indirect expenditures on education, as well as lost income tax revenues on students' forgone earnings) to the benefits of education for the public sector (*i.e.* increased revenues from income taxes on higher wages). The **social rate of return** is the discount rate that equalises the social costs of education (*i.e.* the opportunity costs of people not participating in the production of output and the full cost of provision of education, rather than just the cost borne by the individual) to the social benefits of education (i.e. the increased productivity associated with investment in education and a host of possible non-economic benefits, such as greater social cohesion, more active citizens, *etc*.). The **private rate of return** is the discount rate that equalises the costs of education during the period of study (*i.e.* the tuition fees, foregone earnings net of taxes adjusted for the probability of being in employment minus the resources made available to students in the form of grants and loans) to the gains from education thereafter.

Relative earnings from employment are defined as the mean earnings (income from work before taxes) of persons at a given level of educational attainment divided by the mean earnings of persons with upper secondary education. This ratio is then multiplied by 100. The estimates are restricted to individuals with income from employment during the reference period. Upper secondary attainment is taken as the reference point as this is a key decision point in student's educational career in most countries.

Public expenditure on education includes spending by public authorities at all levels (*i.e.* expenditure on education by ministries of education or equivalent public institutions).

Private expenditure on education includes all the expenditure funded by private sources (*i.e.* households, companies, non-profit organizations etc.), and they can include a broad range of expenses such as: fees (school, boarding, *etc*.), employers' expenditure on initial vocational training, teaching materials, *etc*.

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Abstract

This paper presents some cross-country comparative measures of efficiency in public education, using existing data for European countries. It also presents an overview of different approaches to the question of efficiency of investment in public education and the measurement thereof. Although non-parametric methods have been already used in some studies on investment efficiency in the education sector, the approach adopted here extends previous research by conducting the analysis combining the data from different sources. The variables used in the empirical analysis are constructed from different databases (the joint Unesco-OECD-Eurostat data collection, IEA or OECD's databases) which are all designed so that data is comparable across countries for the same reference year.

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