INDICATOR B7

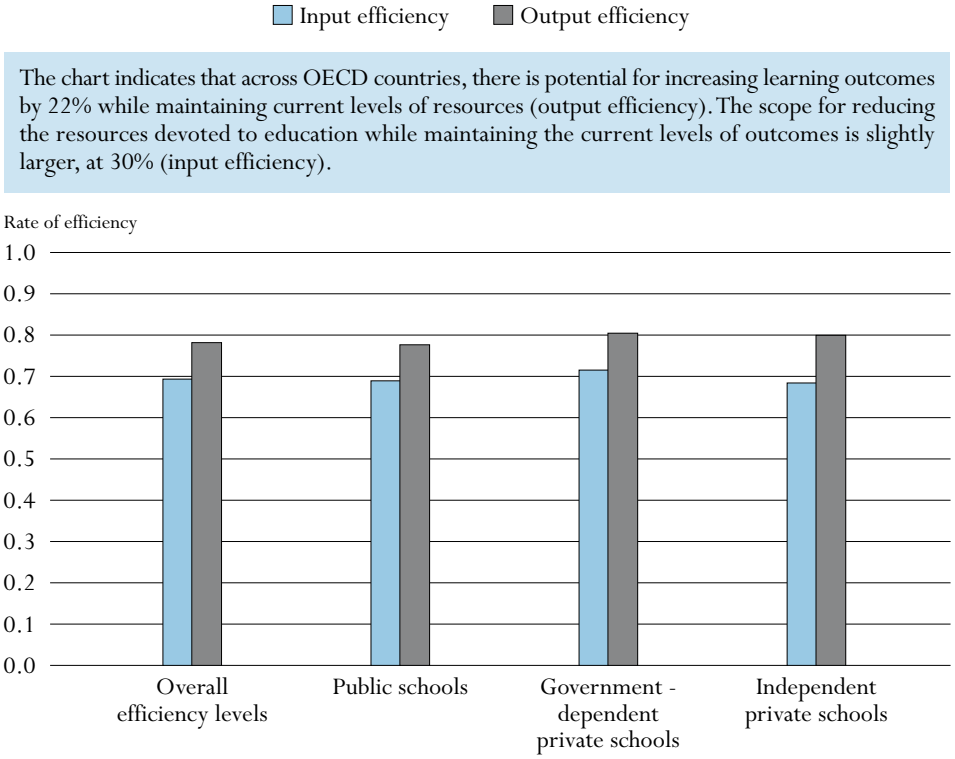
HOW EFFICIENTLY ARE RESOURCES USED IN EDUCATION?

This indicator examines the relationship between resources invested and outcomes achieved in primary and lower secondary education across OECD countries and thus raises questions about the efficiency of their education systems.

Key results

Chart B7.1. Efficiency levels in primary and lower secondary education

This chart shows the potential for increasing learning outcomes at current levels of resources in primary and lower secondary education across OECD countries as a whole.



Source: OECD. Table B7.1. See Annex 3 for notes (*www.oecd.org/edu/eag2007*).

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Other highlights of this indicator

- Differences in estimates of efficiency for different types of school (*e.g.* public and private) tend to be modest, when looking at the OECD as whole, though efficiency savings are greater for smaller schools than for larger schools.

Policy context

The relationship between the resources devoted to education and the outcomes achieved has been the focus of much education policy interest in recent years. Seeking to achieve more and better education for the whole population is a goal of governments. However, with increasing pressure on public budgets there is intense interest in ensuring that funding – public funding in particular – is well directed, in order to achieve the desired outcomes in the most effective way possible. Internationally, much attention is of course paid to which education systems achieve most in terms of the quality and equity of learning outcomes, but there is also considerable interest in knowing which systems achieve most given the inputs provided. Could the same outputs be achieved with fewer inputs? Could more outputs be achieved with the same inputs?

Evidence and explanations

This indicator begins with a brief discussion of the issues relevant to measuring efficiency in education. It then examines the correlation between spending and performance and considers what this can say about the efficiency of education systems. Finally, it presents results from analyses conducted by the OECD Economics Department in the context of its "Public Spending Efficiency" project, which applies a modelling approach to measuring educational efficiency. When interpreting the country averages presented in this indicator, it is important to keep in mind that there are substantial differences across countries in the proxy measures of efficiency and that such differences may explain at least part of the observed differences between countries in education outlays.

Student performance and spending per student

Box B7.1 below discusses some of the issues in developing measures of efficiency in education. Given the challenge in properly addressing these issues, it is worth first of all reflecting on what a straightforward comparison of the relationship between education spending and student outcomes indicates about the efficiency of education systems.

Chart B7.2 presents such a comparison by comparing countries' actual spending per student, on average, from the beginning of primary education between the ages of 6 and 15 years, with their average student performance in mathematics from PISA 2003. Spending per student is approximated by multiplying public and private expenditure on educational institutions per student in 2002 at each level of education by the theoretical duration of education at the respective level, between the ages of 6 and 15 years. The results are expressed in USD using purchasing power parities.

Chart B7.2 shows a positive relationship between spending per student and mean mathematics performance. As expenditure per student on educational institutions increases, so also does a country's mean performance. However, the relationship is not a strong one – expenditure per student in fact explains merely 15% of the variation in mean performance between countries.

Deviations from the trend line suggest that moderate spending per student cannot automatically be equated with poor performance by education systems. Spending per student up to the age of 15 years in the Czech Republic is roughly one-third of, and in Korea roughly one-half of, spending levels in the United States, but while both the Czech Republic and Korea are among the top ten performers in PISA, the United States performs below the OECD average. Similarly, Spain and the United States perform almost equally well, but while the United States spends roughly USD 80 000 per student up to the age of 15 years, in Spain this figure is merely USD 47 000.

Box B7.1. Measuring efficiency in education

As in any field, measuring efficiency in education is concerned with a comparison of inputs with outputs in order to assess the degree to which goals are achieved while minimising resource usage. Defining appropriate measures of input and output is key in being able to do this and presents a particular challenge in service sectors like education especially with regard to outputs, which are often difficult to measure. Indeed, in measuring education's contribution to Gross Domestic Product in the system of National Accounts only now is there a shift away from the traditional "output equals input" approach to one that attempts to measure the output in volume terms more directly.

Defining inputs and outputs

Two main types of inputs determine educational outcomes. The first type covers discretionary factors under the control of the education system, such as teacher numbers, teacher-student ratios, class sizes, instruction time, teacher quality and other resources in schools. The second type covers non-discretionary or environmental inputs, such as the innate ability of students and students' socio-economic background.

At its most basic level, output can be measured by quantity indicators such as course enrolment and completion rates, study duration or the level of education reached. However, an approach that takes the quality of teaching (and learning) into account focuses more on outcomes, *i.e.* the effective transfer of knowledge and skills – this is, in effect, a quality adjusted output.

The relationship between input volumes (*e.g.* teachers) and outputs provide a measure of technical efficiency, while the relationship between outputs and expenditure inputs provide a measure of cost efficiency.

Approaches to measuring efficiency

The fact that outputs in the public sector are amorphous and intangible in many respects makes it difficult to define a supply function in the conventional sense, while the fact that public sector organisations produce goods that are free at the point of use means that prices of outputs are not determined by market forces. As economic efficiency cannot be directly measured, a technique is needed to proxy an efficiency frontier which would allow relatively accurate benchmarking. One possible approach for doing this is through a non-parametric technique called Data Envelopment Analysis (DEA).

In DEA, efficiency is measured relative to the observed most efficient units (schools or countries). A frontier is constructed such that all observations lie either on or within the frontier so that the frontier represents best practice. Potential efficiency gains for specific countries or schools can then be measured by their position relative to the frontier. Assumptions need to be made about the shape of the efficiency frontier depending on the assumed returns to scale. In Table B7.1, non-increasing returns to scale are assumed. Here, constant returns to scale are assumed between the origin and the observation with the highest input/output ratio and variable returns to scale are assumed thereafter.

Once an efficiency frontier is determined, efficiency shortfalls can be assessed from two perspectives: first, an input oriented measure, which estimates by how much inputs could be scaled back without reducing the level of outputs; second, an output orientation, which estimates how much outputs could be increased given the current levels of inputs.

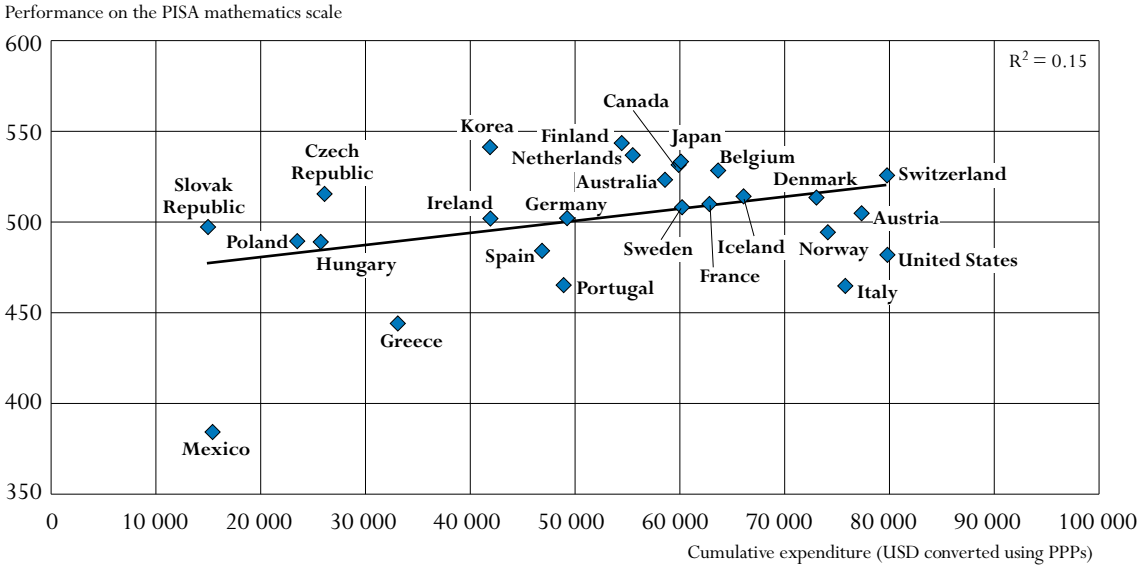
DEA permits quite robust inferences to be made about relative inefficiencies but they are subject to shortcomings with respect to possible measurement errors. However, techniques for detecting outliers or sample biases can be used to estimate confidence intervals for individual units. In general, the estimates of potential efficiency gains are more certain when the estimated potential gain is greater.

Countries that perform significantly higher than would be expected from their spending per student alone include Australia, Belgium, Canada, the Czech Republic, Finland, Japan, Korea and the Netherlands. Countries that perform significantly below the level of performance predicted from spending per student include Greece, Italy, Mexico, Norway, Portugal, Spain and the United States.

In summary, the results suggest that, while spending on educational institutions is a necessary prerequisite for the provision of high-quality education, spending alone is not sufficient to achieve high levels of outcomes and the effective use of these resources is important in achieving good outcomes.

Chart B7.2. Student performance and spending per student

Relationship between performance in mathematics and cumulative expenditure on educational institutions per student between the ages of 6 and 15 years, in USD, converted using purchasing power parities (PPPs)



Source: OECD PISA 2003 database. Table 2.6.

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Why is it that some countries perform better than others with similar levels of investments?

Many factors influence the relationship between spending per student and student performance. These factors will include the organisation and management of schooling within the system (*e.g.* layers of management and distribution of decision making, geographic dispersion of

the population), the organisation of the immediate learning environment of the students (*e.g.* class size, hours of instruction), the quality and remuneration of the teacher workforce as well as characteristics of the students themselves, most notably their socio-economic background. Given this, it is clear that a simple correlational approach between one input and one output variable is insufficient to provide measures of efficiency.

On the input side, there is a need to distinguish between input variables that are within the control of the education providers (teacher numbers, teacher-student ratios, class sizes, instruction time, teacher quality) and those that are not (*i.e.* non-discretionary). In particular, among non-discretionary inputs, the socio-economic background of the students needs to be taken into account as the strength of the influence of this on student outcomes is so great. Student immigrant status and language spoken at home are also important in this regard. In general, it is important to ensure that there is close correspondence between the chosen inputs and the outputs that they are designed to produce.

On the output side, the chosen variables should reflect the goals of the education system, given the chosen input variables. Ideally, then these should cover achievement goals across the curriculum including for example social and civic engagement skills. Importantly, the chosen variables should measures both the quality and equity of achievements within the system.

Inevitably this calls for a more sophisticated assessment of efficiency than can be achieved with simple correlations.

Measures of efficiency in primary and lower secondary public education

The OECD Economics Department has explored the use of Data Envelopment Analysis (DEA) as a means of producing internationally comparative measures of efficiency (OECD, 2007). In DEA, efficiency is measured relative to the observed most efficient units (schools or countries), considering the specified input and output variables (see Box B7.1). As much of this work is exploratory at this stage, only OECD-wide estimates of efficiency are shown in this indicator.

Table B7.1 summarises the estimates of efficiency derived from school level data considering the median school, averaged across all OECD countries. The output variable used in the analysis is the average PISA scores of students and the input variables used are the teacher-student ratio, computer availability, socio-economic backgrounds and language spoken at home of students. By considering volumes rather than values of inputs, these are measures of technical rather than cost efficiency. The model assumes non-increasing returns to scale (see Box B7.1).

The results suggest that the scope for reducing inputs while holding outputs constant (input efficiency) is on average around 30% for the median school. Potential gains from maximising outputs from the current level of inputs are slightly smaller: the average PISA scores of students in the median school is around 22% below the level suggested possible by the efficiency frontier.

Differences in estimates in efficiency for different types of school tend to be modest. The median public school in the overall sample is slightly less efficient than both the median government dependent private school and median independent private school. Schools that rely on public sources for the majority of their funding also tend to be slightly less efficient than other schools. Perhaps as one might expect, smaller schools tend to be less efficient than larger schools, particularly in terms of the extent that inputs could be reduced for the same level of output (Chart B7.1).

In addition to the technical limitations of DEA analysis noted in Box B7.1, the specification of the variables to be used as inputs and outputs is also important to the robustness of the results. As discussed earlier, how well the chosen input and output variables measure, respectively, the resources devoted to education and the intended outputs, is key. Inevitably, the chosen variables in the analysis presented here are limited by the available international datasets. For instance, arguably, the PISA outcome measures provide only a partial measure of the intended goals of education systems and in the case of inputs, to get a fuller picture of these resources devoted to out-of-school learning should perhaps be taken into account also.

Definitions and methodologies

The educational expenditure figures are taken from the UOE data collection on education statistics administered by the OECD (for details see Annex 3 at *www.oecd.org/edu/eag2007*). The student achievement scores are based on assessments administered in 2003 as part of the Programme for International Student Assessment (PISA) undertaken by the OECD.

The cumulative expenditure figures for a given country is approximated as follows: let n(0), n(1) and n(2) be the typical number of years spent by a student from the age of six up to the age of 15 years in primary, lower secondary and upper secondary education. Let E(0), E(1) and E(2) be the annual expenditure per student in USD converted using purchasing power parities in primary, lower secondary and upper secondary education, respectively in 2002. The cumulative expenditure is then calculated by multiplying current annual expenditure E by the typical duration of study n for each level of education i using the following formula:

$$CE = \sum_{i=0}^{2} n(i) * E(i)$$

Estimates for n(i) are based on the International Standard Classification of Education (ISCED).

The estimates of efficiency shown in Table B7.1 and Chart B7.1 have been taken from the papers produced by the OECD Economics Department as part of the project to assess public spending efficiency in primary and secondary education.

The estimates of possible efficiency savings shown in Table B7.1 relate to the median school in each OECD country in terms of PISA 2003 performance and are generated from a Data Envelopment Analysis (DEA) model assuming non-increasing returns to scale. The model uses the PISA score as the output variable and teacher-student ratio, computer availability, socio-economic and language backgrounds as the input variables. In DEA, a frontier is constructed such that all observations (in this case school performance in PISA 2003) lie either on or within the frontier so that the frontier represents best practice. Potential efficiency gains can then be measured by a country's or school's position relative to the frontier.

Further references

For more information see "Performance Indicators for Public Spending Efficiency in Primary and Secondary Education", OECD Economics Department Working Paper No. 546, available on line at *www.oecd.org/eco/Working_Papers.*

Table B7.1.

Estimates of technical efficiency[1] for primary and lower secondary public sector education

	Input efficiency[2]	Output efficiency[3]	Number of schools
Overall level of efficiency	0.693	0.782	6 204
Of which:			
Public schools	0.689	0.777	4 834
Government-dependent private schools	0.715	0.805	672
Independent private schools	0.684	0.799	194
Public funds >50%	0.693	0.780	5 469
Public funds <50%	0.693	0.803	397
Small schools	0.669	0.770	3 102
Large schools	0.712	0.794	3 102

1. Efficiency estimates are for the median school in each OECD country in terms of PISA 2003 performance and are derived from a Data Envelopment Analysis assuming non-increasing returns to scale. The model uses the PISA score as output and the teacher to student ratio, computer availability, socio-economic and language backgrounds as inputs.
2. Indicates scope for scaling back inputs without reducing the level of outputs.
3. Indicates scope for boosting outputs given the current levels of inputs.

Source: OECD Economics Working Paper No. 546, available at *www.oecd.org/eco/working_papers.*

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Reader's Guide

Coverage of the statistics

Although a lack of data still limits the scope of the indicators in many countries, the coverage extends, in principle, to the entire national education system (within the national territory) regardless of the ownership or sponsorship of the institutions concerned and regardless of education delivery mechanisms. With one exception described below, all types of students and all age groups are meant to be included: children (including students with special needs), adults, nationals, foreigners, as well as students in open distance learning, in special education programmes or in educational programmes organised by ministries other than the Ministry of Education, provided the main aim of the programme is the educational development of the individual. However, vocational and technical training in the workplace, with the exception of combined school and work-based programmes that are explicitly deemed to be parts of the education system, is not included in the basic education expenditure and enrolment data.

Educational activities classified as "adult" or "non-regular" are covered, provided that the activities involve studies or have a subject matter content similar to "regular" education studies or that the underlying programmes lead to potential qualifications similar to corresponding regular educational programmes. Courses for adults that are primarily for general interest, personal enrichment, leisure or recreation are excluded.

Calculation of international means

For many indicators an OECD average is presented and for some an OECD total.

The OECD average is calculated as the unweighted mean of the data values of all OECD countries for which data are available or can be estimated. The OECD average therefore refers to an average of data values at the level of the national systems and can be used to answer the question of how an indicator value for a given country compares with the value for a typical or average country. It does not take into account the absolute size of the education system in each country.

The OECD total is calculated as a weighted mean of the data values of all OECD countries for which data are available or can be estimated. It reflects the value for a given indicator when the OECD area is considered as a whole. This approach is taken for the purpose of comparing, for example, expenditure charts for individual countries with those of the entire OECD area for which valid data are available, with this area considered as a single entity.

Note that both the OECD average and the OECD total can be significantly affected by missing data. Given the relatively small number of countries, no statistical methods are used to compensate for this. In cases where a category is not applicable (code "a") in a country or where the data value is negligible (code "n") for the corresponding calculation, the value zero is imputed for the purpose of calculating OECD averages. In cases where both the numerator and the denominator of a ratio are not applicable (code "a") for a certain country, this country is not included in the OECD average.

For financial tables using 1995 data, both the OECD average and OECD total are calculated for countries providing both 1995 and 2004 data. This allows comparison of the OECD average and OECD total over time with no distortion due to the exclusion of certain countries in the different years.

For many indicators an EU19 average is also presented. It is calculated as the unweighted mean of the data values of the 19 OECD countries that are members of the European Union for which data are available or can be estimated. These 19 countries are Austria, Belgium, the Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Italy, Ireland, Luxembourg, the Netherlands, Poland, Portugal, the Slovak Republic, Spain, Sweden and the United Kingdom.

Classification of levels of education

The classification of the levels of education is based on the revised International Standard Classification of Education (ISCED-97). The biggest change between the revised ISCED and the former ISCED (ISCED-76) is the introduction of a multi-dimensional classification framework, allowing for the alignment of the educational content of programmes using multiple classification criteria. ISCED is an instrument for compiling statistics on education internationally and distinguishes among six levels of education. The glossary available at *www.oecd.org/edu/eag2007* describes in detail the ISCED levels of education, and Annex 1 shows corresponding typical graduation ages of the main educational programmes by ISCED level.

Symbols for missing data

Six symbols are employed in the tables and charts to denote missing data:

a Data is not applicable because the category does not apply.

c There are too few observations to provide reliable estimates (*i.e.* there are fewer than 3% of students for this cell or too few schools for valid inferences). However, these statistics were included in the calculation of cross-country averages.

m Data is not available.

n Magnitude is either negligible or zero.

w Data has been withdrawn at the request of the country concerned.

x Data included in another category or column of the table (*e.g.* *x*(2) means that data are included in column 2 of the table).

~ Average is not comparable with other levels of education.

Further resources

The website *www.oecd.org/edu/eag2007* provides a rich source of information on the methods employed for the calculation of the indicators, the interpretation of the indicators in the respective national contexts and the data sources involved. The website also provides access to the data underlying the indicators as well as to a comprehensive glossary for technical terms used in this publication.

Any post-production changes to this publication are listed at *www.oecd.org/edu/eag2007*.

The website *www.pisa.oecd.org* provides information on the OECD Programme for International Student Assessment (PISA), on which many of the indicators in this publication draw.

Education at a Glance uses the OECD's StatLinks service. Below each table and chart in *Education at a Glance 2007* is a url which leads to a corresponding Excel workbook containing the underlying data for the indicator. These urls are stable and will remain unchanged over time. In addition, readers of the *Education at a Glance* e-book will be able to click directly on these links and the workbook will open in a separate window.

Codes used for territorial entities

These codes are used in certain charts. Country or territorial entity names are used in the text. Note that in the text the Flemish Community of Belgium is referred to as "Belgium (Fl.)" and the French Community of Belgium as "Belgium (Fr.)".

AUS	Australia	ITA	Italy
AUT	Austria	JPN	Japan
BEL	Belgium	KOR	Korea
BFL	Belgium (Flemish Community)	LUX	Luxembourg
BFR	Belgium (French Community)	MEX	Mexico
BRA	Brazil	NLD	Netherlands
CAN	Canada	NZL	New Zealand
CHL	Chile	NOR	Norway
CZE	Czech Republic	POL	Poland
DNK	Denmark	PRT	Portugal
ENG	England	RUS	Russian Federation
EST	Estonia	SCO	Scotland
FIN	Finland	SVK	Slovak Republic
FRA	France	SVN	Slovenia
DEU	Germany	ESP	Spain
GRC	Greece	SWE	Sweden
HUN	Hungary	CHE	Switzerland
ISL	Iceland	TUR	Turkey
IRL	Ireland	UKM	United Kingdom
ISR	Israel	USA	United States

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