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Education and Health in G7 Countries: Achieving Better Outcomes with Less Spending

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Abstract

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Enhancing the efficiency of education and health spending is a key policy challenge in G7 countries. The paper assesses this efficiency and seeks to establish a link between differences in efficiency across countries and policy and institutional factors. The findings suggest that reforms aimed at increasing efficiency need to take into account the nature and causes of inefficiencies. Inefficiencies in G7 countries mostly reflect lack of cost effectiveness in acquiring real resources, such as teachers and pharmaceuticals. We also find that high wage spending is associated with lower efficiency. In addition, lowering student-teacher ratios is associated with reduced efficiency in the education sector, while immunizations and doctors' consultations coincide with higher efficiency in the health sector. Greater autonomy for schools seems to raise efficiency in secondary education.

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I. INTRODUCTION AND MAIN CONCLUSIONS

A key policy challenge in G7 countries is to improve the performance of education and health systems while containing their cost. Education and health outcomes are critically important for social welfare and economic growth and thus, spending in these areas constitutes a large share of public spending. But there is concern about the efficiency of such spending. In education, there are questions about the ability of school systems to maximize the potential of students and respond effectively to changes in the demand for education outcomes. In health, there is concern about the rapid rise of the cost of health care and the impact on competitiveness, as well as trade-offs between the efficiency and equity of health systems.

This paper attempts to assess the efficiency of education and health spending in G7 countries. It asks whether countries could achieve better education and health outcomes at current levels of spending or, conversely, whether countries could have the same outcomes at lower levels of spending. We seek to establish a link between observed differences in efficiency across G7 countries and discuss the role of policy and institutional factors in explaining efficiency differences. The paper also discusses efficiency-enhancing reforms for the education and health sectors. The analysis involves addressing complicated issues of what drives outcomes in education and health and should be regarded as exploratory. Follow-up work on data and other parts of the analysis are needed for more definitive answers.

The paper is organized as follows. Section II provides the background and relevant literature for the analysis. Section III describes trends in education and health spending and outcomes in G7 countries. It also explores the issue of how efficiency in the education and health sectors in the G7 can be measured, and how observed differences between countries may be related to policy choices and institutions. Section IV makes some suggestions for reforms in the education and health sectors in G7 countries. The technical aspects of the analysis are elaborated in Appendix I.

Based on the quantitative analysis of education and health spending and outcomes for the G7, this paper finds that:

- Public spending on education and health systems varies greatly in G7 countries, and so do education and health outcomes. Spending is particularly high in relation to outcomes in education and health in France, Germany, the U.K., and the U.S.; that is, the question of how to increase the efficiency of spending on education and health is most relevant for these countries. On the other hand, Canada's education spending is relatively efficient, as is health spending in Italy and Japan.
- Part of the differences in spending efficiency can be attributed to exogenous factors such as GDP, demographics, and differences in lifestyle.

- Policies and institutions are also associated with differences in efficiency. In particular, countries that spend a relatively large share of their education and health budgets on wages and salaries tend to be less efficient. Also, lower student-teacher ratios are associated with reduced efficiency in the education sector, while immunizations and doctors' consultations (but not the number of doctors per se) are positively correlated with efficiency in the health sector. Greater autonomy for schools seems to raise efficiency in secondary education.
- Effective education and health reform should aim at enhancing efficiency. This should take into account the stage at which the inefficiencies arise. Further, reforms should seek to balance devolution (of responsibility and resources) and enhanced market competition with regulation to ensure accountability.
- Cross-country studies, such as this one, can provide important insights into policy challenges that countries face. However, further work on data and sectoral issues is needed to deepen the findings of this paper.

II. EDUCATION AND HEALTH SPENDING, OUTCOMES, AND ECONOMIC GROWTH: BACKGROUND AND LITERATURE REVIEW

A large volume of research has emphasized the importance of education outcomes to human development, economic growth, and productivity.¹ However, the findings also note the mixed evidence for the relationship between education spending and student performance in developed nations. Recent G8 statements have recognized the need to improve all aspects of the quality of education and the promotion of high standards in education of mathematics, science, technology, and foreign languages.²

On health issues, the G7 countries have focused on complex issues of high and rapidly rising cost and concerns about equity. Cost-enhancing technological advances and, to a lesser extent, aging populations and increased demand for health services as populations become wealthier, are pushing up health care prices faster than general price levels. This has prompted governments to introduce measures to reduce the cost of health care (Cutler, 2002; Newhouse, 1992). But efforts in G7 countries to constrain health spending by rationing or increasing competition have run into concerns about disadvantaged groups' access to health care.

¹ See Table 5 for a comprehensive literature review of the association between human development and economic growth.

² See the Moscow Declaration of the G8 Ministerial Meeting on Education (June 1–2, 2006), available on the Internet at http://www.ungei.org/news/files/unesco_B95DEC8C.pdf, and the G8 Statement on Education for Innovative Societies in the 21st Century of July 16, 2006, available at <http://en.g8russia.ru/docs/12.html>.

A key issue in the debate about education and health spending is how (and how strongly) it translates into sectoral outcomes and economic growth. Underlying the policy discussions on education and health is a concern that public and private spending is high in relation to outcomes (education attainment, health status, and economic growth). Prior research on this has yielded the following insights (see Table 5):

- Education attainment is a key driver of economic growth, with attainment at higher levels of education gaining importance as economies become more developed. Health status is also found to have a positive impact on growth.
- However, the evidence for a positive relationship between education spending and attainment is mixed, with a number of studies finding no evidence of a statistically significant relationship. Similarly, there is limited evidence for a positive link between health spending and health status. But public spending has been found to benefit the poor by enhancing their access to health services.
- Selected policies, institutions, and environmental factors, on the other hand, have a clear impact on education attainment. In particular, family background and teacher quality have been identified as important explanatory variables for student achievement. School autonomy and emphasis on assessing student performance are likely to raise education attainment, while teacher unions' influence may have a negative impact. The effect of other factors on education attainment is ambiguous; these include the impact of class size, decentralization, and the relative importance of public and private education.
- Key factors for explaining health status include lifestyle (e.g., the consumption of alcohol and tobacco, and diet), income level, occupational and socioeconomic status, urbanization, and medical technology. In addition, education attainment is an important explanatory factor for health outcomes. As in education, the impact of the mix of private and public spending on outcomes is not clear.
- Improved achievement at lower levels of education promotes both equity and economic growth. However, improved achievement at higher levels of education may benefit the well-off most. In health, there is a strong tradeoff between policies aimed at enhancing cost effectiveness of spending and improving the equity of outcomes.

III. SPENDING AND OUTCOMES IN EDUCATION AND HEALTH: EMPIRICAL ANALYSIS

This section discusses cross-country empirical evidence on the relationship between spending and outcomes in the education and health sector. It starts with a description of recent trends in education and health spending and outcomes. Then, differences in the relationship between spending and outcomes are assessed for G7 countries. Finally, an attempt is made to identify factors that may affect these differences.

A. Trends in Education and Health Spending and Outcomes

Spending on education and health varies considerably within the group of G7 countries.³ Total education spending (including funded from private sources) has been considerably higher in the U.S. than in other G7 countries, particularly at the tertiary level (Figure 1 and Table 6 in Appendix II). Average G7 spending on primary and secondary education is near average levels in the OECD but G7 countries spend more on average on tertiary education.⁴ Public health spending is highest in Germany and the U.S., and lowest in Italy, Japan, and the U.K. (Figure 2 and Table 6).⁵ Average public health spending in OECD countries is below spending levels in G7 countries.

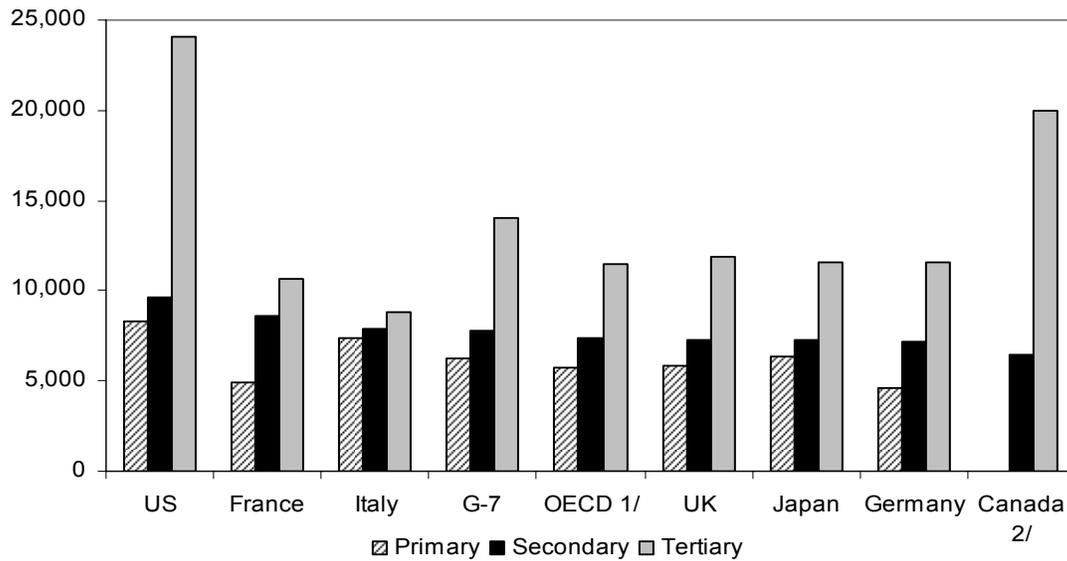
G7 countries have markedly increased overall (public and private) spending on education and health in real terms over the last decade. Between 1995 and 2003, real overall spending per student from public sources increased at an average rate of 2.2 percent per year in primary and secondary education and 1.8 percent in tertiary education (Table 1). Spending trends differed considerably between G7 countries, with Germany posting relatively small spending increases and Canada and Japan increasing their spending at rates well above the average for the G7. Average health expenditure from public and private sources increased by 3.8 percent per year in real per capita terms in the G7 over the period 1995–2003. Increases in health spending were significantly larger for the U.K. and U.S. than for Germany.

³ Spending is measured in equivalent U.S. dollars using GDP purchasing power parity (PPP). This is intended to eliminate unit cost differences across countries and to measure spending such that a similar package of education and health services could be bought at the same level of spending across countries. In education, expenditure is measured per student in PPP terms by level of education: primary, secondary (including post-secondary non-tertiary), and tertiary education. These per-student education expenditure data are only available for overall spending funded both by public and private sources (the complicated nature of the arrangements for funding of education institutions prevent a breakdown between spending funded from public and from private sources). Health resources are measured as health spending per capita in PPP terms; data on public and private spending are separately available. Data on spending and outcomes in education are from OECD (2006a) and the OECD PISA database available at http://pisaweb.acer.edu.au/oecd/oecd_pisa_data.html. For health, the source is the OECD at http://www.oecd.org/document/30/0,2340,en_2649_37407_12968734_1_1_1_37407,00.html and OECD (2005). See Appendix I for more details on data issues.

⁴ Mexico and Turkey are outliers in many respects, and were excluded from the OECD group for the analysis of this paper.

⁵ Italy may not be part of the low-spending group any longer as its public spending on health increased markedly in the last few years.

**Figure 1. Total Education Spending per Student by Level of Education, 2003
(PPP dollars)**

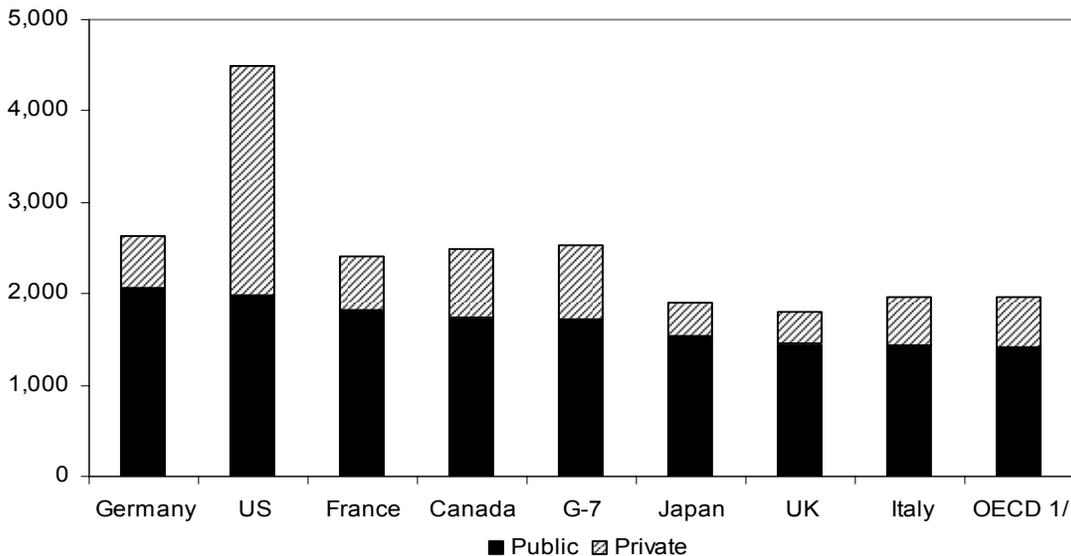


Source: OECD Education at a Glance 2006, www.oecd.org/edu/eag2006.

1/ Excludes Mexico and Turkey (because of outlying data). Countries are ranked by level of total secondary education spending.

2/ Data for primary and secondary education are averaged for Canada.

**Figure 2. Total Health Spending per Capita by Source, 1998–2001
(Period average in PPP dollars)**



Source: OECD Health Data 2006, www.ecosante.fr.

1/ Excludes Mexico and Turkey (because of outlying data). Countries are ranked by level of public health spending.

Table 1. Trends in Health and Education Spending, 1995–2003

	Education			Health	
	Real overall spending (public and private, average annual increase in percent) 1/		Public spending (cumulative increase in percent of GDP)	Real overall spending (public and private, average annual increase in percent) 2/	Public spending (cumulative increase in percent of GDP)
	Primary and secondary education	Tertiary education			
Canada	2.2	3.1	-1.6	3.4	0.4
France	...	...	...	3.2	1.0
Germany	0.6	1.0	-0.1	2.0	0.2
Italy	1.2	3.1	-0.1	3.1	1.1
Japan	3.0	1.7	0.0	...	0.8
U.K.	2.9	0.0	0.3	4.2	1.0
U.S.	3.1	1.2	0.4	3.8	0.8
G7	2.2	1.8	-0.2	3.3	0.8
OECD 3/	3.6	0.7	0.2	5.2	0.8

Sources: OECD Education at a Glance 2006, www.oecd.org/edu/eag2006; OECD Health Data 2006, www.ecosante.fr; and IMF staff calculations.

1/ The average annual real percent increase over 1995–2003 in per student public and private spending in primary and secondary (including post-secondary non-tertiary) and tertiary education.

2/ The average annual increase in real per capital health public and private spending over 1995–2003.

3/ Excludes Mexico and Turkey (because of outlying data).

The rapid increase in the cost of health care has put pressure on public health budgets in G7 countries. Average public spending on health increased from 6.4 percent of GDP in 1995 to 7.1 percent of GDP in 2003. This increase was highest for France, Italy, and the U.K. (see Table 1). Public spending for education declined slightly in the G7 countries, from an average of 4.8 percent of GDP in 1995 to 4.6 percent of GDP in 2003. This mostly reflected a substantial decline in public education spending in Canada.⁶

⁶ Public education spending in Canada fell from 6.2 percent of GDP in 1995 to 4.6 percent of GDP in 2003. However, because of rapid increases in real GDP, this still allowed for substantial increases in real spending per student in Canada.

Table 2. Trends in Health and Education Outcomes

	Education			Health	
	PISA mathematics scores 1/	Upper secondary graduation rate 2/	Tertiary graduation rate 3/	Standardized death rates 4/	Infant mortality 5/
Canada	1.9	3.4	12.6	-1.6	-1.5
France	1.2	14.3	58.3	-0.9	-2.5
Germany	3.7	-1.2	-14.8	-2.2	-2.9
Italy	2.7	23.1	25.0	-2.5	-4.8
Japan	-1.1	0.0	15.6	-2.8	-4.4
U.K.	...	7.7	20.7	-1.9	-1.9
U.S.	1.2	-1.1	0.0	-1.4	-1.2
G7	1.6	6.6	16.8	-1.9	-2.7
OECD 6/	1.9	8.2	14.8	-2.0	-3.7

Sources: OECD Education at a Glance 2006, www.oecd.org/edu/eag2006; OECD Health Data 2006, www.ecosante.fr; and IMF staff calculations.

1/ Percent difference in scores on comparable components of the PISA mathematics test between the 2000 and 2003 rounds.

2/ Difference in the percent of the population that has attained upper secondary education between the age group 35–44 and 25–34 in 2004.

3/ Percent difference in the percent of the population that has attained tertiary education between the age group 35–44 and 25–34 in 2004.

4/ Annual percent change during 1995–2002.

5/ Annual percent change during 1995–2003.

6/ Excludes Mexico and Turkey (because of outlying data).

Education and health outcomes generally improved in G7 countries in recent years (Table 2).⁷ Except for Japan, all G7 countries posted increases in the average test scores for mathematics proficiency under OECD's Programme for International Student Assessment (PISA) between the 2000 and 2003 rounds.⁸ Improvements in education participation can be gauged from trends in graduation rates of successive cohorts (i.e., if later cohorts have higher graduation rates, education participation has increased over time). The current cohort of 25–34 year olds is generally better educated than the preceding cohort which is presently aged 35–44 years, as indicated by the larger share that attained at least upper secondary and

⁷ See Tables 7 and 8 for levels of education attainment and health status in G7 countries.

⁸ PISA's assessment focuses on the capabilities of 15 year-old students in reading literacy, mathematics literacy, and science literacy. It also includes measures of general or cross-curricular competencies such as learning strategies. The test scores for mathematics are very highly correlated with those for reading and science, and are in many studies interpreted as representative of student test scores in secondary education (including OECD 2006a). But it is important to look at various indicators of achievement in conjunction. For instance, Table 2 shows that Germany achieved relatively large increases in PISA test scores while graduation rates dropped. This raises the question whether improvements in education or the reduced participation in education drives the higher test scores.

tertiary education in the younger of the two cohorts. France, Italy, and the U.K. posted the highest gains, while there was no substantial progress in the U.S. and even a loss of education attainment in Germany. In health, indicators of mortality (standardized death rates and infant mortality) significantly improved in all G7 countries between 1995 and 2003, with the most progress made by Germany, Italy, and Japan.

Trends in education and health outcomes are not closely related to spending trends in G7 countries. A comparison of Tables 1 and 2 shows that the U.K. achieved above-average improvements in education outcomes with relatively modest increases in real spending, while the U.S. achieved less with more additional resources. Similarly, trends in real health expenditure and health status show that Germany has been able to achieve more gains with a smaller increase in real resources than Canada, the U.K., and the U.S.⁹ These issues will be investigated in more depth in the following section.

B. The Relative Efficiency of Education and Health Spending

The relative efficiency of education and health spending is assessed by comparing expenditure levels and associated outcomes in G7 countries and other OECD countries. This is done using the Data Envelopment Analysis (DEA) technique, which was developed for estimating best-practice frontiers and relative efficiency in business applications. In this case, DEA is used to assess the relationship between spending (inputs) and outcomes (production) across countries. The general principle is that countries which achieve the same or better outcomes with lower levels of spending than other countries in the sample are the most efficient and determine the best-practice frontier.¹⁰ The relative spending efficiency of other countries can be measured by how far away they are from the best-practice frontier. This method is intuitively appealing and has the advantage of being flexible and parsimonious in its assumptions. Appendix I provides a detailed discussion of DEA.

⁹ These results for Germany may, in part, reflect developments after the reunification and the impact of reforms of the education and health systems of former East Germany.

¹⁰ The concept of efficiency in this application of DEA to spending is not completely analogous to the concept of technical efficiency in the case of business units engaged in a particular commercial activity (e.g., bank branches). In particular, the heterogeneity of countries needs to be taken into account for the present analysis. Countries differ in many ways, and such differences may have an impact on spending and outcomes. The DEA results mix inefficiencies in spending and sectoral policies with other differences between countries that affect the relationship between spending levels and outcomes. For example, it may be more costly to provide the same education and health services in countries with higher GDP per capita levels. Similarly, education and health outcomes may differ between countries because of variations in the degree of urbanization and demographics. So, in contrast to the more standard application of DEA for production units operating in very similar environments and with clearly defined inputs and outputs, the efficiency results derived here do not provide an accurate measure of the technical efficiency of the use of resources. Rather, they provide a measure of whether the ratio of outcomes over spending is low relative to comparable countries (i.e., countries that achieved at least as much in terms of outcomes) which may be for a variety of reasons including spending inefficiencies.

Education and health spending in the G7 countries are generally not among the most efficient in the OECD (Figures 4–12). Japan is on the best-practice frontier for health-adjusted life expectancy (HALE), standardized death rates, and infant mortality. This means that among the OECD countries with health spending at or below Japan’s level, no country scored better on these health outcomes. Table 3 shows how G7 countries are placed in the ranking of efficiency scores in the sample of OECD countries. G7 countries generally rank in the bottom two quartiles of the rank distribution (particularly France, Germany, the U.K., and the U.S.). Yet, Canada ranks relatively high in education, and Italy and Japan rank relatively high in health.

These initial findings for spending efficiency can be further disentangled by looking at the different stages of the process that links spending and outcomes. In particular, it is useful to separate the impact of spending on intermediate outputs (the first stage of the process from spending to outcomes) and the impact of these intermediate outputs on outcomes (the second

Table 3. Efficiency of Education and Health Spending in G7 Countries Relative to the OECD
(Distribution by quartiles of the ranking of efficiency scores for OECD countries) 1/

	Percentile			
	1–25	26–50	51–75	76–100
Education 2/	Canada		France Germany Italy Japan U.K.	U.S.
Health 3/		Italy Japan	Canada France Germany	U.K. U.S.

Sources: OECD Education at a Glance 2006, www.oecd.org/edu/eag2006; OECD PISA, http://pisaweb.acer.edu.au/oecd_2003/oecd_pisa_data_s1.html; OECD Health Data 2006, www.ecosante.fr; and IMF staff calculations.

1/ Canada’s efficiency scores in education ranked, on average, at the 15th percentile of the overall ranking of efficiency scores in the sample of OECD countries. This places Canada in the top (1–25) quartile of the OECD ranking distribution. The rankings are based on the point estimates of the input-oriented bias-corrected efficiency scores (see Appendix I).

2/ Based on overall (public and private) spending by level of education and associated outcome indicators, including the mean and within-country variation in PISA scores for mathematics and graduation rates for upper-secondary and tertiary education. The OECD countries are ranked by efficiency score for each outcome indicator. Finally, the rankings for all education outcome indicators are averaged to get the average country ranking for education spending.

3/ Based on average rankings of spending efficiency (see previous footnote) based on public health spending and associated outcome indicators, including infant, child, and maternal mortality rates, and healthy life expectancy and standardized death rates.

stage of the process).¹¹ The link between spending and intermediate outputs reflects the cost of procuring and producing the intermediate outputs, that is, issues of cost effectiveness. Countries may also find that their education and health outcomes are low in relation to the available intermediate outputs—in this paper this is referred to as system inefficiency. See Appendix I for more details on these concepts.

For the most part, the relatively low average spending efficiency in G7 countries seems to reflect issues of cost effectiveness, at least in tertiary education and health. Table 4 shows that the majority of G7 countries have better system efficiency in education and health than other OECD countries on average (i.e., the ratio shown for the G7 average is smaller than 1).¹² The results are especially striking for the U.K., which shows very high system

Table 4. Spending and System Efficiency in Education and Health 1/

	Secondary Education		Tertiary Education		Health		
	Total spending efficiency 2/	System efficiency 3/	Total spending efficiency 2/	System efficiency 3/	Public spending efficiency 2/	Total spending efficiency	System efficiency 4/
Canada	0.4	1.2	...	...	1.4	1.6	0.9
France	0.8	1.7	1.1	0.6	1.2	1.3	1.1
Germany	1.0	0.1	1.3	1.5	1.4	1.5	1.6
Italy	1.1	1.6	0.8	0.1	0.6	0.7	0.6
Japan	0.7	1.4	1.2	1.7	0.4	0.4	0.7
U.K.	...	...	1.3	0.4	1.5	1.1	0.1
U.S.	1.2	1.4	1.8	0.8	1.9	2.0	0.8
G7	0.8	1.2	1.2	0.9	1.2	1.2	0.8

Sources: OECD Education at a Glance 2006, www.oecd.org/edu/eag2006; OECD PISA, http://pisaweb.acer.edu.au/oecd_2003/oecd_pisa_data_s1.html; OECD Health Data 2006, www.ecosante.fr; and IMF staff calculations.

1/ Ratio of efficiency rankings of G7 countries and the average ranking in the sample of OECD countries. A ratio of 1 implies that the country ranks at the average of the OECD sample; a lower ratio signifies an above average efficiency and a ratio in excess of 1 implies that the country is less efficient than OECD average. See Appendix I for a more detailed explanation of the underlying calculations.

2/ Based on efficiency rankings from Table 3.

3/ Based on efficiency rankings using as inputs the average of various intermediate education outputs (see Table 9) and as production various outcome indicators (see Table 3 and Table 7).

4/ Based on efficiency rankings using as inputs the average of various intermediate health outputs (see Table 10) and as production various outcome indicators (see Table 3 and Table 8).

¹¹ Intermediate outputs are defined here as goods and services (e.g., school instruction hours and patient-doctor consultations) procured with education and health spending and that are used to achieve outcomes (see Appendix I). Indicators and data for key intermediate outputs are listed in Tables 9 and 10.

¹² See Appendix I for more detail.

efficiency in both tertiary education and health, although spending efficiency in the U.K. is well behind the OECD average. The average results for the G7 imply that lack of cost effectiveness is a major driver of spending inefficiencies in the G7 in tertiary education and health. This may be addressed by increasing competition between suppliers of goods and services to education and health institutions and tackling overspending on specific spending items (e.g., due to overstaffing). In secondary education, the situation is reversed, and G7 countries (except Germany) score worse on system efficiency than on overall spending efficiency. This suggests that for secondary education, options for reducing public spending may be found by assessing whether the mix of intermediate outputs is optimal for achieving improved outcomes, or whether incentives for an effective use of intermediate outputs are adequate.

The efficiency findings are reasonably robust and in line with results from similar assessments of spending efficiency. The rankings of G7 countries do not change very much if overall health spending is used in the efficiency analysis instead of public spending (see Table 4). The findings also do not seem substantially affected by outliers or choice of outcome indicator.¹³ Furthermore, the findings of this paper are broadly consistent with findings from other research on the efficiency in education and health, although some results differ due to variations in methodology, choice of measures for spending and outcomes, and the selection of sample countries.¹⁴

C. Achieving Better Outcomes with Lower Spending

Strengthening the link between spending and outcomes would allow countries to achieve the same outcomes at lower levels of spending or achieve better outcomes at the same level of spending. In order to understand how countries can do this, it is important to determine

¹³ Without Mexico and Turkey in the dataset, the results are not driven by outlying observations. In addition, the efficiency results are similar for different measures of outcomes in education and health (with the exception of the education results for Germany, which are quite varied across outcome indicators).

¹⁴ For example, OECD (2006b) assesses the relationship between education spending and PISA test scores (both the average and the distribution) in a framework that is very similar to that of this paper. Japan does better than in the analysis of this paper, but otherwise the results are similar. Afonso and St. Aubyn (2004) find results that are comparable to this paper (although relatively more favorable for Germany) for spending as the input item and PISA test scores as the outcome indicator. Wilson (2005) considers school level data, and uses various measures of input and production in his analysis of education. He finds more favorable results than this paper for Italy, France, and the U.S. WHO (2000) and Greene (2004) use a stochastic approach to assess the link between public health spending and HALE on the basis of a wide sample that covers low-income as well as OECD countries. The main difference from our results is that G7 countries rank more highly, in particular France. Afonso and St. Aubyn's (2004) results are similar to this paper's for health, although they show a better rank for the U.K.

whether the DEA results are policy-related or reflect factors outside of the direct influence of policy makers. This is done below through a statistical analysis of the efficiency results.¹⁵

Cross-country differences in efficiency results are associated with expenditure composition and institutional arrangements in education and health. In particular, wage spending is negatively associated with efficiency in education, while health efficiency tends to be lower in countries with more health workers (Tables 11 and 12).¹⁶ This finding indicates that reduced compensation spending may increase efficiency. However, it could also reflect the possibility that countries with poor past education and health outcomes are spending more on staffing. The mix of intermediate outputs is also important: lowering student-teacher ratios in education is associated with lower efficiency, while immunizations seem to be a cost-effective way of boosting health status, and thereby is associated with higher efficiency.¹⁷ Greater autonomy for schools and emphasis on academic ability in student selection for schools seems to raise efficiency in secondary education, while decentralization and large out-of-pocket payments are associated with lower efficiency in the health sector. In tertiary education, efficiency is negatively associated with decentralization and private spending. Finally, exogenous factors, such as GDP,¹⁸ urbanization,¹⁹ socioeconomic background, and lifestyle also affect efficiency.

¹⁵ The results presented here are based on simple correlations and the results should be interpreted with caution. For example, the analysis does not allow for firm conclusions on the direction of causality. As a robustness check, we also employed an innovative strategy for regression analysis of efficiency outcomes on associated factors. The regression findings are very similar to the correlation findings but are affected by problems of serial correlation. Appendix I discusses this second-stage analysis in more detail.

¹⁶ These results are based on correlations for OECD countries and should therefore not be generalized to other countries. In fact, it is likely that the relationship between efficiency and many of the associated factors identified here is not linear. That is, if spending on compensation is low, an increase in such spending could result in increased efficiency as benefits exceed costs. But, at current levels of spending prevailing in the OECD, the marginal cost of raising wage payments is more likely to exceed the benefits in most cases.

¹⁷ In addition, efficiency in secondary education is higher in countries where more schools report shortages in supplies and library materials. This may reflect an emphasis on cost containment and effectiveness in countries where many schools report such shortages, rather than that spending on school supplies and libraries is inefficient.

¹⁸ Efficiency in education and health, as well as spending levels and outcomes, are highly correlated with GDP. There are two possible main channels through which GDP can affect spending efficiency. First, a higher GDP is associated with a higher cost of service provision (e.g., through the impact on teacher salaries), whereas there are only limited options for productivity increases, especially in primary and secondary education (this is Baumol's disease—for a discussion and evidence for the U.S., see Nordhaus, 2006). Second, as populations grow wealthier, they are likely to consume a larger and more varied package of education and health services, which would include items that do not contribute to education attainment and health status as measured here (e.g., medical care which is not directed at reducing mortality, including many types of cosmetic surgery).

¹⁹ Urbanization poses additional challenges in education and health, which likely accounts for the negative impact on efficiency in education and health (e.g., see Bennett, 2003). This result is robust to the exclusion of

(continued)

For G7 countries looking to enhance the efficiency of their education and health spending, the findings could have several implications:

- The composition of spending in G7 countries tends to be tilted toward compensation, which seems to hamper efficiency in both education and health.

For education, the evidence for a negative association between overspending on compensation and efficiency is quite strong (see Table 11). The negative association between efficiency in achieving PISA test scores and student-teacher ratios suggest that overstaffing may play a role. In addition, the literature suggests that salary levels may also contribute to inefficiencies.²⁰ In particular, it has been found that although the quality of teachers is an important driver of educational attainment, higher compensation does not in itself increase teacher quality (Blau, 1996, and Rivkin, Hanushek, and Kain, 2005). Among the G7 countries, Japan, Germany, and Italy have high wage bills in education. In Italy, a relatively low student-teacher ratio seems a key driver for the relatively high costs of compensation. In Germany, on the other hand, classroom sizes are relatively large and salary levels may be more of a factor in inefficiencies.²¹

For health, the data strongly suggest that overstaffing is associated with efficiency problems. Health employment density as well as general practitioner density are negatively correlated with efficiency for all health outcome indicators. At the same time, numbers of doctors' consultations and hospital beds have a positive association with the efficiency of spending for infant, child, and maternal mortality. It seems, therefore, that how (and how often) health workers interact with patients matters for improving health outcomes in a cost-effective manner.²² Several of the G7 countries (Canada, France, Germany, and the U.S.) have a substantially higher number of health practitioners than the OECD on average, pointing to a potential source of inefficiency in these countries. The U.S. not only has a relatively high number of health practitioners, but also markedly fewer doctors' consultations per capita than other G7 and OECD countries.

highly urbanized Luxembourg. Somewhat surprisingly, the data do not provide evidence for a higher cost of service delivery in countries with large areas which are relatively sparsely populated.

²⁰ This is difficult to verify through our analysis as salary levels are highly correlated with GDP, which makes it hard to distinguish between the effect on efficiency of salary levels, GDP, and other factors that are highly correlated with GDP (Table 13).

²¹ Figure 13 shows that teacher salaries in secondary education in Germany are relatively high in relation to GDP per capita while salaries are lower in Italy.

²² Only partial data are available on salaries and wage payments in the health sector, which was not adequate to draw conclusions on the nominal part of wage spending.

- Policies at the school level is positively associated with the efficiency of education spending, while the relation with decentralization is ambiguous. The devolution of responsibility to the school level is positively correlated with efficiency scores: in countries where more school principals have hiring authority, the efficiency scores of PISA mathematics test scores and the distribution of scores are higher (see also Woessmann, 2000). In Japan, Germany, and Italy—where efficiency scores for education are relatively low—principal autonomy in hiring teachers is substantially lower than in the OECD on average. Moreover, relying on student records for admission to secondary school appears to be a cost-effective practice which boosts efficiency scores of upper-secondary graduation rates. However, decentralization of spending is not associated with higher or lower efficiency of spending in secondary education, while it is negatively correlated with efficiency in tertiary education. This echoes findings from the literature that the link between performance and decentralization in education is ambiguous (see Table 5). This may reflect the need to balance school autonomy and decentralization with accountability for results (e.g., Woessmann, 2006), which may be a complicated task in the context of fiscal decentralization.
- The increasing cost of health care has prompted countries to institute reforms, including by increasing out-of-pocket payments for users of health services. It is therefore unsurprising that out-of-pocket payments are associated with lower efficiency—countries where efficiency problems are large have raised out-of-pocket payments to reduce inefficiencies and the fiscal burden posed by the health sector (see Cutler, 2002). But it also suggests that such measures have only achieved limited success and those countries remain relatively inefficient. Aside from the effect of out-of-pocket payments, the share of private spending does not have an impact on efficiency in health. This may reflect adverse selection issues related to private health insurance and incentives for insured persons to overconsume health services.²³ The negative correlation between decentralization and health spending efficiency we find

²³ Other factors do not appear to play a role in differences in inefficiencies across countries, although it seems plausible that they would have an impact. For example, the share of health spending funded through social security schemes and private health insurance does not help to explain differences in spending inefficiencies in health. Similarly, the relative share of personal versus collective health care as a percent of public health expenditures does not matter. Also, differences in population age structure and income inequality (as measured by the Gini coefficient) does not affect the relationship between health and education spending and outcomes. Finally, although there is strong evidence of the effects of education attainment on health outcomes and health status on education outcomes, we cannot distinguish these cross-sectoral effects from the correlation of GDP with education and health efficiency. However, the statistical analysis shows no impact of education attainment on health efficiency and health status on education efficiency after controlling for GDP.

for the OECD does not have a clear implication for the G7. It reflects the relatively high efficiency of EU new member states, where a relatively small share of health spending is allocated at the subnational level.

IV. CONCLUDING REMARKS

The analysis of this paper breaks new ground by assessing the relationship of spending efficiency in education and health with policies and institutions. The question of how better outcomes can be achieved at a lower cost is central to the concept of efficiency. This is also a critical question for fiscal policy, and a better understanding of what drives efficiency allows a more rational approach to balancing needs in education and health with limits imposed by fiscal affordability and sustainability. In particular, the analysis of this paper suggests directions for education and health policies that could raise efficiency, including:

- Education and health reforms need to pay close attention to issues of staffing and wages. Countries where the education and health sectors are overstaffed and compensation payments account for a relatively high share of spending may pay a price in the form of reduced efficiency. This seems to be a relevant issue for all G7 countries, perhaps with the exception of the U.K. In this context, policy making should take into account that a larger education and health workforce will not automatically lead to an increase in education and health service delivery. This suggests that policy makers should carefully monitor indicators of capacity utilization (e.g., average class size and hospital bed occupation rates).
- Spending efficiency can be enhanced by gearing the composition of spending toward cost-effective intermediate outputs. For instance, immunizations yield large benefits in terms of health status at a relatively low cost, and countries should ensure that public spending is not a constraint to achieving better immunization rates. Reducing student-teacher ratios, on the other hand, tends to be a relatively inefficient way of improving education outcomes.
- Reforms aimed at increasing efficiency need to take into account the stage of the spending process at which inefficiencies arise. In particular, it is important to distinguish lack of cost effectiveness (mostly a problem in health and tertiary education) from system inefficiency (a frequent problem in secondary education). Issues of cost effectiveness may be tackled by increasing competition between suppliers of goods and services to education and health institutions, as well as addressing any bias in the composition of spending toward wages and salaries (e.g., by moderating salaries and tackling overstaffing). System efficiency can be improved by reforms that promote competition between education and health institutions in a framework of appropriate accountability for the quality of service delivery.

- Effective education and health reforms need to balance increased devolution of responsibility and resources with enhanced market competition and regulatory frameworks that ensure accountability for results. Shifting responsibility for education and health to the private sector and subnational governments is unlikely to achieve efficiency gains alone, but may be part of a balanced reform strategy. In education, such a reform strategy could include enhanced autonomy for schools to hire teachers and selecting students on merit. In health, progress may be made by providing incentives for cost savings. With cost-increasing technological progress and aging driving up the cost of health care, reducing inefficiencies in the health sector will be key for achieving sustainable fiscal policies and overcoming obstacles to international competition in G7 countries. However, it is critical for reforms aimed at increasing efficiency to address concerns about accountability that may arise from an increased role for competition. In addition, concerns about equity need to be taken into account. In particular, disadvantaged groups are often dependent on public spending for access to basic education and health services. Reforms should be designed to balance equity concerns (and the related risk of reversal of reforms in the future) with the need to increase spending efficiency.

APPENDIX I. DATA, DATA ENVELOPMENT ANALYSIS, AND SECOND-STAGE ANALYSIS

In this paper, the DEA technique is used to assess the relationship between spending and outcomes. This method allows us to identify countries where the ratio of outcomes over spending is relatively high in comparison with other countries where it is comparatively low. A second-stage statistical analysis is used to assess whether differences between countries can be accounted for by factors out of the control of policy makers, or whether changes in expenditure and sectoral policies may make a difference. This appendix explains key technical aspects of the data used in the paper, the DEA methodology and the second-stage analysis.

A. Some Data Issues

The paper uses PPP deflated spending that eliminates unit cost differences across countries in the education and health sector. The idea is to use a measure of spending that is comparable across countries in the sense that, assuming equal cost efficiency, a similar package of education and health services could be bought at the same level of spending.²⁴ Expressed as a ratio of GDP, the spending measure will be biased against countries with lower levels of GDP—at a given level of spending as a share of GDP, richer countries will be able to procure more education and health services than poorer countries. In PPP terms this bias will likely be closer to zero than with the alternatives, although some bias against richer countries may remain. In any event, such bias should be limited within the relatively homogeneous group of OECD countries.

The DEA exercise benchmarks the relationship between spending and outcomes in G7 countries against the OECD. The sample of G7 countries is too small for a meaningful comparison of spending levels and outcomes, so the sample was expanded to the OECD (excluding the outliers Mexico and Turkey). The DEA exercise links spending and outcomes as follows:²⁵

²⁴ Since relative prices of non-tradable goods, including many education services and key health services, tend to rise with per capita income (the Balassa-Samuelson effect), conventional spending measures such as converting spending in a common currency using market exchange rates will tend to be biased against richer countries (i.e., this measure of spending will overestimate what richer countries can buy in comparison with poorer countries). This is one likely explanation for the finding that richer countries tend to have higher levels of spending at lower levels of education and health attainment (see also Gupta and Verhoeven, 2001). PPPs for household final consumption expenditure and for GDP are very similar (OECD, 2006b)—here GDP PPPs are used. Ideally, one would like to use sector-specific national unit costs in the education and health sectors, but these are not available.

²⁵ With enrollment rates near 100 percent in G7 countries and in the absence of internationally comparable test results at the primary school level, no indicators are available that can meaningfully capture differences in primary education attainment for a sufficiently large sample of countries.

- Total spending per student in **secondary education** is related to average PISA mathematics test scores, the distribution of those test scores (measured as the ratio of the score at the 25th percentile in the country to the score at the 75th percentile), and secondary education graduation rates.²⁶
- Total spending per student in **tertiary education** is related to tertiary education graduation rates.
- Public spending per capita on **health** is related to infant, child, and maternal mortality rates, as well as HALE and population standardized death rates.²⁷

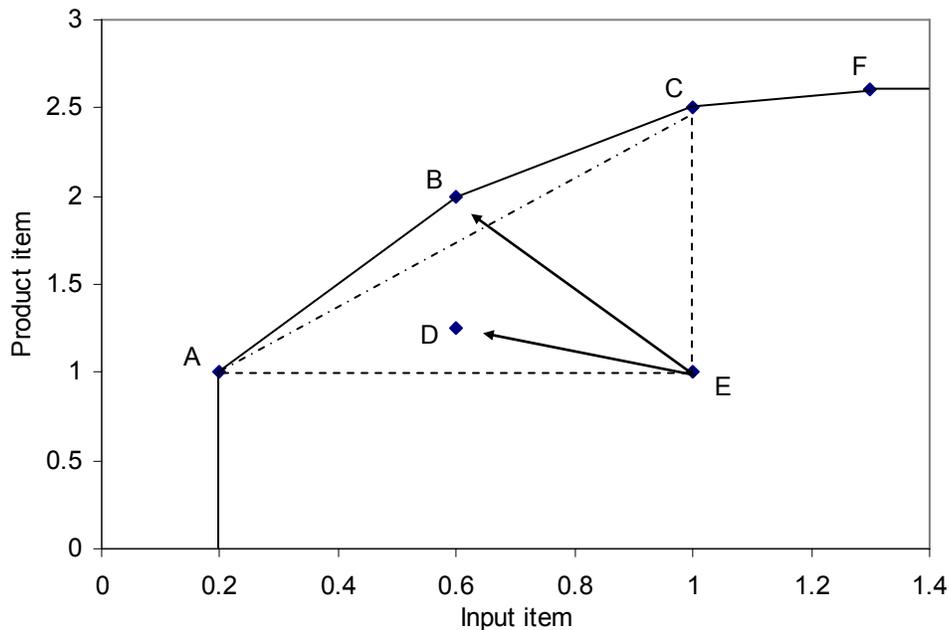
The choice of these outcome indicators is driven by data availability and reflects the variables that have been used in other studies of education attainment and health status (e.g., WHO, 2000, and OECD, 2005 and 2006b). These are also the outcome indicators of choice in many of the studies that have assessed the link between education and health outcomes and economic growth. A limitation of these variables is that they may not capture the full range of outcomes pursued with education and health spending.

B. Data Envelopment Analysis

The framework for analyzing the relationship between spending and outcomes derives from the empirical analysis of production efficiency. This framework provides a method for assessing the relative efficiency with which production units convert input items into product items (i.e., technical efficiency). It is based on a straightforward concept of dominance (see Figure 3): as unit A achieves the same number or more product items than unit E with fewer input items, unit A is more efficient than (i.e., dominates) unit E. By the same token, unit E is also less efficient than units B, C, and D. The difference between the input items used by unit

²⁶ Alternatively (see OECD, 2006b), one could define the relevant spending measure for PISA test scores and secondary graduation rates as the cumulative spending through secondary education, including primary education. This has the advantage of taking into account all education spending that may be relevant for outcomes in secondary education. However, this measure also has drawbacks. It seems reasonable to assume that some type of discount factor should be applied to the education enjoyed longer ago—but it is unclear how one would estimate such a discount factor. The cumulative spending measure is also more complicated, thereby increasing the risk of measurement error (and DEA is sensitive to measurement error). Fortunately, the measures of cumulative spending and current annual spending in secondary education are very highly correlated, which suggests that the findings are not much influenced by the choice between those alternatives.

²⁷ Since the emphasis is on public policy, we consider public spending when data are available (which is for health, but not education). Moreover, the DEA results are very similar when using public health spending as the input item and when considering public and private spending as the input item. Finally, in the second-stage regressions below, an attempt is made to separate out the effect of private spending.

Figure 3. Efficiency and the Best-Practice Frontier

A and E can be used as a measure of the inefficiency of unit E relative to unit A. (Alternatively, this could be measured by the difference in production items.)

The most efficient units in a sample provide the parameters for an initial estimate of the best-practice frontier. One of the most common ways for determining the best-practice (or production possibility) frontier is DEA (a more detailed discussion of DEA can be found in Zhu, 2003). The best-practice frontier is illustrated in Figure 3 by the solid line that connects the best-practice units A, B, C, and F. Because these are the most efficient units in the sample, they are assigned an efficiency score of 1. The efficiency scores of the less efficient units (D and E) depend on their distance to the best-practice frontier (the lower the efficiency score, the less efficient the unit). Several measures of the distance to the frontier can be used. Here we adopt the Farrell input-oriented efficiency score and we only assess cases with one input and one production item. In this simple case, it is straightforward to calculate the efficiency score for unit E as the ratio of the number of inputs needed *at a minimum* (i.e., at the best-practice frontier) to achieve its level of production (this is 0.2, see Figure 3) and the number of inputs actually used by unit E (1.0). In other words, the efficiency score of unit E is 0.2. This can be interpreted as an indicator of the cost savings that could be achieved from efficiency enhancement. That is, if unit E was fully efficient, it would only need 20 percent of the inputs it is using to achieve the same production level.

Simple DEA estimation produces upward-biased estimates of the efficiency scores which need to be corrected. In this paper, spending is taken as the input, measures of education achievement and health status are used to measure production, and OECD countries are the

production units. However, estimating the best-practice frontier for the OECD countries from the observations of education and health spending and outcomes is subject to bias, for which a correction needs to be made. This bias stems from the fact that since we only observe a sub-sample of the possible outcomes representing all feasible combinations of spending and outcomes, we do not know the exact position of the best-practice frontier. Suppose, for example, that the inputs in Figure 3 represent education spending and the product item PISA test scores. Also, suppose that education spending or PISA test scores were initially not observed for country B. Then the best-practice frontier would be drawn through the countries A, C, and F, following the dashed line between the observations for countries A and C. However, suppose the observation for country B becomes available. Then, the best-practice frontier would shift outward to the line that connects countries A, B, C, and F. It is straightforward to see that, as a general principle, as more information becomes available about the feasible production combinations, the best-practice frontier may shift *outward* but cannot move inward. This one-sided error means that estimating the best-practice frontier with a finite sample is subject to a bias. Since efficiency scores are measured in relation to the frontier, the estimation of scores is subject to the same bias in finite samples (i.e., efficiency is overestimated unless a correction is made for the bias).

Corrections are made for the estimation bias in the best-practice frontier and efficiency scores through bootstrapping. This paper uses a method proposed by Simar and Wilson (2000), and is based on the assumption that the frontier that envelops all possible production combinations of input and product items is smooth. A key issue is how quickly the estimated efficiency scores converge to their unbiased true values if the sample of observations is expanded.²⁸ In the case of one input and one product item the convergence rate is fast enough to yield acceptable estimates of efficiency scores and build confidence intervals. Table 3 in the main text presents rankings for the G7 countries relative to the OECD based on the point estimates of the input-oriented bias-corrected efficiency scores.

As an alternative to DEA, efficiency scores could be estimated using stochastic estimation methods (e.g., WHO, 2000, and Greene, 2004). The main advantage of DEA is that it is parsimonious in its assumptions for deriving the best-practice frontier—the key assumptions are that all units have access to the same set of production technologies, free disposal of inputs and outputs, and convexity of the set of production possibilities. Drawbacks of DEA

²⁸ This convergence speed is $n^{-2/(p+q+1)}$, where p is the number of inputs and q is the number of product items. In the 1 input/1 product cases of this paper, the convergence speed is $n^{-2/3}$. This is faster than the convergence speed for a standard parametric regression of $n^{-1/2}$, suggesting that reasonable estimates of efficiency scores and confidence intervals can be reached with a lower number of observations than would be needed for standard regression analysis. However, the convergence speed declines exponentially as the number of inputs and product items is increased, and already at two inputs and two product items, the speed of convergence is markedly slower than for parametric regressions. This implies that such an expansion in numbers of inputs and product items comes at great cost in terms of the ability to draw conclusions on efficiency from a limited number of observations.

include sensitivity to measurement error and to sample selection bias. These drawbacks are less pronounced in stochastic estimation methods, but these may be more sensitive to misspecification as the efficiency estimates are obtained from a model that describes the production process. This model needs to capture variations in efficiency between countries as well as other sources of heterogeneity that may explain differences in the relationship between spending and outcomes across countries (e.g., Greene, 2004). When assessing the impact of spending on outcomes across countries, the dilemma faced with stochastic frontier estimation is that a large number of observations is needed for a reasonable estimation of the various model parameters and efficiency, but that as the number of countries in the sample is expanded, they also become more heterogeneous (especially when low-income countries are mixed with OECD countries) which leads to further challenges in the specification of the model. Specification of the model is also complicated by a lack of understanding about what drives differences across countries in their relationship between spending and outcomes. Taking this into account, DEA seems most suited for the undertaking of the analysis of this paper.

The analysis of the link between spending and outcomes in education and health is complicated by the fact that this relationship is indirect. Spending has no direct impact on outcomes. Rather, spending translates into intermediate inputs (e.g., school buildings and service delivery contracts with physicians) which are combined to produce intermediate outputs (e.g., school instruction hours and patient-doctor consultations). These intermediate outputs in turn are used to promote better outcomes.

The DEA results can be disaggregated to determine at which stage of the spending process inefficiencies arise. In particular, the paper attempts to disaggregate what happens in the stage from spending to intermediate outputs (cost effectiveness) and from intermediate outputs to outcomes (system efficiency). This is done by comparing overall spending efficiency (the overall measure of efficiency from spending to outcomes as discussed above) and system efficiency (see Table 4) as follows. First, an index of intermediate outputs in health and education (by level) is created. For secondary education, the intermediate output indicator is the index of countries' average ranks for the levels of student-teacher ratios, number of computers per student, and average hours of compulsory instruction time in secondary education. For tertiary education, the intermediary output indicator is the countries' rank for the level of the student-teacher ratio. For health, the intermediate output indicator is the index of the countries' average ranks for number of hospital beds, physicians per capita, health workers per capita, immunizations, and doctors' consultations. Countries are indexed such that the lower the rank (the higher the number) of a country's index, the more intermediate outputs the country uses. Second, efficiency scores are calculated, using the intermediate output index as an input and associated outcomes (mean and within-country variation in PISA mathematics scores and graduation rates for secondary education; graduation rates for tertiary education; and infant, child, and maternal mortality rates, as well as HALE and standardized death rates for health). Third, the resulting system efficiency

rankings are averaged, expressed as a ratio of the average OECD ranking, and compared with similar ratios for spending efficiency.

C. Second-Stage Analysis with Efficiency Scores

The second-stage analysis attempts to explain observed differences in the relationship between spending and outcomes. This will allow us to answer the question of how countries can strengthen the link between spending and outcomes. The second stage uses correlations and regressions of efficiency scores and associated factors to explain observed differences in the relationship between spending and outcomes.

Given the close relationship of spending and outcomes with income levels, correlations of efficiency scores and associated factors are conditional on GDP. GDP per capita has a very strong negative impact on efficiency scores (see footnote 22). Many of the factors that are associated with efficiency are also closely related to income level. In order to avoid attribution of factors whose effects on the variation in efficiency cannot be separated from the effect of GDP, only GDP per capita and factors unrelated to GDP per capita are considered in the second-stage analysis of this paper.

Regression analysis provides insight into the relative importance of factors that are associated with efficiency. The standard approach for the second stage is to regress the DEA efficiency scores on a set of explanatory variables (e.g., see Afonso and St. Aubyn, 2006). Since the Farrell input-oriented efficiency scores are limited to between 0 and 1, sometimes a truncated regression framework is used. However, this yields biased coefficient estimates due to serial correlation between the observations (the source of this is the same as the bias in the estimation of efficiency scores discussed above—see Simar and Wilson, 2007). Instead, Simar and Wilson (2007) propose another set of bootstrap procedures. However, these still require a larger sample size than we have available (less than 28 observations, given that some countries for which we have efficiency scores will drop out of the regressions because of nonavailability of data for the independent variables).

To circumvent the problem of small sample size, the regression model is reformulated in differences. Instead of estimating the DEA efficiency scores for each country, the model proposed here estimates *differences* in efficiency scores between countries. The model only considers differences in efficiency scores between countries where one country has a higher level of outcomes and lower spending than the other country (i.e., one country dominates the other under DEA). This can be illustrated in Figure 3. Country E is dominated by countries A, B, C, and D, but not by country F. Achieving better results would mean for country E that it moves in a left-and-upward direction, into the area outlined by the dotted vertical and horizontal lines. For country E to achieve such an improvement, it would be important to

know what drives the differences in its efficiency score from the scores of countries A–D.²⁹ The difference with country F, on the other hand, is not very relevant for country E in its quest for better outcomes with lower spending, because moving toward country F would imply an increase in spending. Writing the model in differences in efficiency scores instead of levels of the scores boosts the sample size considerably.³⁰ For the example illustrated in Figure 3, country E is represented by four observations in the new data set (the differences in efficiency scores with countries A, B, C, and D). Separate regressions are estimated for the various education and health spending and outcome indicator combinations.

The regression coefficients are estimated using a bootstrap method to address serial correlation. The difference regression is susceptible to the same type of bias and related serial correlation as the level regressions, although the bias may now be positive as well as negative depending on which country in the pair has the larger bias. The method used here is equivalent to algorithm 1 of Simar and Wilson (2007), which they developed to address the effects of serial correlation on coefficient estimates in second-stage regressions of efficiency score levels. It makes use of Monte Carlo draws of error terms in the regression for the bootstrap. Their algorithm was adjusted to the regression model in differences by making a straightforward change to ensure that the Monte Carlo draws of the error terms were taken from a distribution with the correct truncation for our regression model in differences.³¹

Cluster correction further helps reduce the correlation problem, but the model still suffers from incorrect standard errors due to serial correlation. The cluster correction relaxes the independence assumption and allows dependence within clusters (all differences with the dominated country for each dominated country) but not across clusters. Specifying cluster correction affects the estimated standard errors and variance-covariance matrix of the estimators, but not the estimated coefficients. However, because of the difference specification the sample-wide serial correlation remains and limits inference due to inaccurate standard errors.

The regression results are presented in Tables 13 and 14. They are very similar to the findings from the correlation analysis in Tables 11 and 12 (although it is striking to see spending on in-patient care emerge with a negative sign across the board in the regressions of

²⁹ The difference in the efficiency score between a pair of countries where one dominates the other in DEA is equivalent to the expenditure savings that the dominated country would realize if it were to achieve the same relation between spending and outcomes as the dominating country.

³⁰ The model is formulated in differences (both the explanatory and explained variables) without a constant. Adding a constant would imply that there is a fixed wedge between the efficiency scores of countries, which is counterintuitive.

³¹ The results of a straightforward truncated regression (without bootstrapping) and the outcomes using the bootstrapping procedure are very similar. This indeed suggests that the difference model is not much affected by the bias in estimating efficiency score levels.

health efficiency while in the pairwise correlations it is not highly associated with efficiency). However, because of the limitations of the regression due to inaccurate standard errors, the analysis of the paper focuses on the second-stage correlations.

APPENDIX II. TABLES AND FIGURES

Table 5. Links Between Economic Growth and Spending and Outcomes in Education and Health

I. The Relationship Between Education Attainment and Economic Growth		Reference
Issue	Context provided in literature	
Modern growth theory suggests that education attainment is a key driver for economic growth.	Education produces human capital, which yields sustainable economic growth.	Lucas (1988) and Romer (1990)
Empirical evidence from cross-country studies provides support for such a positive link.	Because of its effect on the quality of the work force, education also encourages private investment. In recent studies of developed countries, higher economic growth is associated with measures of human capital formation due to education (e.g., scores on science tests, literacy scores, and number of years of schooling).	Milesi-Ferretti and Roubini (1998) Coulombe, Tremblay, and Marchand (2004), de la Fuente and Doménech (2006), and Poot (2000)
Economic theory suggests that the impact of education attainment on growth varies by level of education.	Tertiary education allows a faster incorporation of new technologies and larger spillover effects on economic growth. At low levels of spending, public education spending should focus on achieving basic education achievement at primary and secondary levels. But as education spending increases, the impact on growth is maximized by raising the share devoted to higher education. The focus on vocational training in a number of European countries may have promoted high growth rates in the 1960s and 1970s, but contributed to an increased growth gap with the U.S. in the 1980s and 1990s when technological change was more rapid.	Papagni (2006) Blankenau (2005) Krueger and Kumar (2004)
Empirical research suggests that the level of education that matters for growth may vary across countries and time.	In OECD economies, economic growth is associated mostly with improvements in higher education. In East Asian countries where universal primary education was realized early, the subsequent growth of secondary education was an important enabling factor for achieving high rates of investment and exports.	McMahon (1998) Petraakis and Stamatakis (2002)
There are synergies and trade-offs between the impact of education on economic growth and equity.	Returns to educational investment are highest for disadvantaged families for pre-primary and primary education and highest for the well-off for tertiary education. This creates complementarities between efficiency and equity at lower levels of education and trade-offs at higher levels.	Woessmann (2006)

Table 5. Links Between Economic Growth and Spending and Outcomes in Education and Health (continued)

II. The Relationship Between Education Spending and Attainment	
Issue	Context provided in literature Reference
The empirical evidence for a direct and positive relationship between the level of education spending and education attainment is mixed.	Microeconomic and cross-country studies for developed countries have found mixed evidence for a statistically significant relationship between the level of education spending and student performance in developed countries. Greenwald, Hedges, and Laine (1996), Hanushek and Kimko (2000), and Hanushek (2002)
Policy, institutions, and environmental factors influence education outcomes.	The evidence for developing countries is also mixed. Baldacci and others (2004) and Pritchett (2001) Family background and teacher quality have been identified as important explanatory variables for student achievement. Greenwald, Hedges, and Laine (1996) and Rivkin, Hanushek, and Kain (2005) In a U.S. study, unionization of teachers is associated with increased cost of education (through teacher wages and lower student-teacher ratios) and lower student achievement. Hoxby (1996)
On some key policy questions (public versus private education and decentralization) the evidence is mixed.	In a cross-country analysis of 39 (mostly developed) countries, mathematics and science test scores are found to positively depend on parents' education, school autonomy, class size, and emphasis on assessing student performance, while test scores depend negatively on teacher unions' influence. Woessmann (2000) Microeconomic studies for the U.S. do not permit the conclusion that private primary and secondary education achieves better results than public education. Grogger and Neal (2000) Evidence for the U.S. suggests that public universities, as well as universities that are more dependent on public subsidies, have lower graduation rates. Lowry (2004) The impact of voucher systems financing depends on the specifics of funding, targeting, and discretion in their use. Neal (2002) Education spending efficiency may also be affected by the degree of centralization of policy, although it is not clear if efficiency tends to be higher under centralized or decentralized systems. Gradstein and Justman (2002) and Woessmann (2006)

Table 5. Links Between Economic Growth and Spending and Outcomes in Education and Health (continued)

III. The Relationship Between Health Status and Economic Growth		
Issue	Context provided in literature	Reference
Modern growth theory suggests an ambiguous relationship between health status and economic growth.	<p>Improved health status has a positive effect on years of schooling and raises the age at which workers choose to retire; but due to aging, the net impact of improved health status on economic growth may be negative.</p> <p>The rising cost of health care raises concerns about competitiveness because of the potential impact on national savings and worker compensation, but there is widespread disagreement on the validity of these concerns. Rising public spending on health care may present obstacles for competitiveness and economic growth to the extent that it results in higher fiscal deficits and taxation, or a reduction in other spending that contributes to economic growth.</p>	Boucekkine, de la Croix, and Licandro (2002) Pauly (1995) and Reinhardt, Hussey, and Anderson (2004)
The empirical evidence points to a positive relationship between health outcomes and economic growth.	<p>Large sample cross-country studies consistently find a positive and statistically significant contribution to growth from health status (measured as life expectancy or adult survival rates):</p> <ul style="list-style-type: none"> ● 30 percent of the growth rate of per capita income over a 20-year period can be attributed to improvement in health attainment in OECD countries, implying that health outcomes are as important for economic growth as physical investment. ● A 1 year improvement in a population's life expectancy yields an estimated 4 percent increase in economic output in a study of developing countries. ● A 1 percent increase in the adult survival rate increases worker productivity by an estimated 1.7 percent. 	Barro and Sala-i-Martin (1995) and Doppelhofer, Miller, and Sala-i-Martin (2004) Gyimah-Brempong and Wilson (2004)
The trade-off between equity and efficiency is strong in health care.	Improving equity in health care (e.g., by providing universal insurance coverage) is at odds with strengthening incentives for cost efficiency (e.g., increasing the share of medical cost directly borne by the patient).	Bloom, Canning, and Sevilla (2003) Bloom and Canning (2005) Cutler (2002)

Table 5. Links Between Economic Growth and Spending and Outcomes in Education and Health (continued)

IV. The Relationship Between Health Spending and Status		Reference
Issue	Context provided in literature	
The evidence for a relationship between health spending levels and health outcomes is limited.	Cross-country studies for OECD countries provide limited evidence on whether health spending contributes significantly to health outcomes. For example, Or (2000) finds in a study of industrialized countries that health spending lowers premature mortality among women but not among men. Nixon and Ulmann (2006) find that health care expenditure is significantly associated with large improvements in infant mortality but is only marginally important to life expectancy.	Or (2000) and Nixon and Ulmann (2006)
	Health expenditure is found to be a determinant of economic growth in a study of 22 developed countries from 1970–95.	Kneller, Bleaney, and Norman (1999)
Policy and institutions influence health outcomes.	For developing countries, the evidence for a link between health spending levels and outcomes is mixed.	Baldacci and others (2004) and Filmer, Hammer, and Pritchett (2000)
	There is also no widely accepted evidence that a private supply of health care would be more efficient than a public one.	Besley, Gouveia, and Dréze (1994)
Environmental factors have a critical impact on health outcomes.	Private insurance may reduce incentive to choose cost-effective treatment options, which could lead to increased use of costly new technologies.	Gilied (2003)
	Lifestyle (e.g., alcohol and tobacco consumption and diet), the level of income, occupational and socioeconomic status, urbanization, and medical technology are key factors for explaining health status. Environmental factors—in the wide sense of the term—might be even more important than medical inputs in explaining variations in health outcomes in industrialized countries (Or, 2000).	Bennett (2003), Färe and others (1997), and Or (2000)
	Income inequalities and social inequities also seem linked with health status in developed economies.	Deaton (2003)

Table 5. Links Between Economic Growth and Spending and Outcomes in Education and Health (concluded)

IV. Cross-Linkages Between Education and Health		
Issue	Context provided in literature	Reference
Education attainment is an important explanatory factor for health outcomes.	Life expectancy and infant mortality are dependent on the level of schooling and other measures of education attainment.	Barro and Lee (1994), Glewwe and Jacoby (2004), and Jamison, Jamison, and Hanushek (2006)
The question of whether education or health is more important in determining economic growth has not been answered definitively.	Barro and Lee (1994) find that life expectancy is more important than schooling in explaining economic growth, while Doppelhofer, Miller, and Sala-i-Martin (2004) find that primary schooling is more important than health status.	Barro and Lee (1994) and Doppelhofer, Miller, and Sala-i-Martin (2004)

**Table 6. Education and Health Spending
(PPP dollars)**

	Total education spending primary per student 1/	Total education spending secondary per student 1/	Total education spending tertiary per student 1/	Total health spending per capita 2/	Public health spending per capita 2/
Canada 3/		6,482	19,992	2,483	1,743
France	4,939	8,653	10,704	2,401	1,824
Germany	4,624	7,173	11,594	2,624	2,060
Italy	7,366	7,938	8,764	1,958	1,436
Japan	6,350	7,283	11,556	1,906	1,548
U.K.	5,851	7,290	11,866	1,799	1,462
U.S.	8,305	9,590	24,074	4,497	1,989
G7	6,239	7,773	14,078	2,524	1,723
OECD 4/	5,761	7,340	11,457	2,012	1,454

Sources: OECD Education at a Glance 2006, www.oecd.org/edu/eag2006; and OECD Health Data 2006, www.ecosante.fr.

1/ Data are for 2003.

2/ Data are the average for 1998–2001.

3/ Only average spending is available for primary and secondary education.

4/ Excluding Mexico and Turkey (because of outlying data).

Table 7. Outcome Indicators in Education 1/

	PISA mathematics scores average	PISA mathematics score distribution 2/	Upper secondary graduation rate	Tertiary graduation rate
Canada	532.5	0.80	...	...
France	510.8	0.78	81.2	26.0
Germany	503.0	0.75	98.9	20.6
Italy	465.7	0.76	81.4	36.8
Japan	534.1	0.77	91.4	36.1
U.K.	...	...	...	39.3
U.S.	482.9	0.76	75.4	33.6
G7	504.8	0.77	85.7	32.1
OECD 3/	506.8	0.77	84.7	35.8

Sources: OECD Education at a Glance 2006, www.oecd.org/edu/eag2006; and OECD PISA, http://pisaweb.acer.edu.au/oecd_2003/oecd_pisa_data_s1.html.

1/ The PISA test was given in 2003, upper secondary graduation rate data are for 2004, and the tertiary graduation rate is averaged for available years during 1999–2004. The graduation rate is calculated in gross terms as the number of graduates over the total population of the age group representing the typical age at graduation.

2/ Ratio of the test score at the 25th percentile of the score ranking by student and the 75th percentile.

3/ Excluding Mexico and Turkey (because of outlying data).

Table 8. Outcome Indicators in Health 1/

	Healthy life expectancy (years)	Standardized death rate (per 100,000)	Infant mortality rate (per 1,000)	Child mortality rate (per 1,000)	Maternal mortality rate (per 100,000)
Canada	70.5	561	5.3	5.7	5.8
France	71.5	567	4.0	4.6	8.8
Germany	70.7	622	4.2	4.7	3.6
Italy	71.6	549	4.2	4.6	3.4
Japan	74.0	455	2.9	3.8	6.7
U.K.	69.8	647	5.2	5.8	7.0
U.S.	68.1	670	6.9	7.6	10.5
G7	70.9	582	4.7	5.3	6.5
OECD 2/	69.8	651	4.6	5.3	6.5

Source: OECD Health Data 2006, www.ecosante.fr.

1/ Data for healthy life expectancy are the average for 2001–02, standardized death rates are the average for 2000–02, infant mortality are the average for 2003–04, child mortality are for 2004, and maternal mortality are the average for 2002–03.

2/ Excluding Mexico and Turkey (because of outlying data).

Table 9. Intermediate Output Indicators in Education 1/

	Primary			Secondary			Primary and Secondary		Tertiary
	Student-teacher ratio	Net teaching hours per teacher (yearly)	Net school enrollment (in percent)	Student-teacher ratio	Net teaching hours per teacher (yearly) 2/	Computers per student	Average hours of compulsory instruction time (yearly) 3/	Student-teacher ratio	
Canada	...	...	94.1	...	...	0.2	...	...
France	19.4	918	94.0	12.1	627	...	943	17.8	
Germany	18.8	793	...	15.1	728	0.1	781	12.7	
Italy	10.7	726	88.5	11.0	594	0.1	980	21.6	
Japan	19.6	648	99.6	14.1	500	0.2	795	11.0	
U.K.	21.1	950	95.0	14.4	893	0.2	909	17.8	
U.S.	15.0	1080	87.4	15.5	1080	0.3	...	15.8	
G7	17.4	853	93.1	13.7	737	0.2	882	16.1	
OECD 4/	16.0	813	89.9	12.4	674	0.2	850	15.5	

Source: OECD Education at a Glance 2006, www.oecd.org/edu/eag2006.

1/ Intermediary output data are from 2004, except secondary school enrollment which is the average for 1999–2003 and the number of computers per student in secondary education which is for 2003.

2/ Average of lower and upper secondary.

3/ For students aged 7–14 years.

4/ Excluding Mexico and Turkey (because of outlying data).

Table 10. Intermediate Output Indicators in Health 1/

	Total hospital beds (per 1,000)	Health worker density index (per 1,000) 2/	Physicians (per capita)	General practitioner density (per 1,000)	Immunization for measles (percent of children 1–2 years old)	Number of doctors' consultations (per capita)
Canada	3.7	12.2	2.1	1.0	94.5	6.1
France	8.0	10.2	3.3	1.6	86.8	6.8
Germany	9.0	13.2	3.3	1.1	92.9	7.3
Italy	4.6	10.5	2.3	0.9	84.3	6.1
Japan	14.6	10.4	2.0	...	100.0	14.0
U.K.	4.2	...	2.1	0.7	81.5	5.5
U.S.	3.5	13.2	2.3	1.0	93.0	4.0
G7	6.8	11.6	2.5	1.0	90.4	7.1
OECD 3/	6.2	12.5	3.0	0.8	91.1	6.9

Source: OECD Health Data 2006, www.ecosante.fr.

1/ Intermediary output data are the average of available data for 2001–04, except for hospital beds which is the average for 2000–02, health worker density which is the average for 2000–03, immunization which is the average for 2003–04, and doctors' consultations which is the average for 2002–03.

2/ Physicians, nurses, and midwives.

3/ Excluding Mexico and Turkey (because of outlying data).

Table 11. Correlations of Bias-Corrected Efficiency Scores and Associated Factors for Secondary and Tertiary Overall Education Spending 1/

	PISA mathematics score average	PISA mathematics score distribution	Upper secondary graduation rate	Tertiary graduation rate
Expenditure policy variables				
Compensation (percent of non-tertiary education expenditure)	--	--		n.a.
Compensation (percent of tertiary education expenditure)	n.a.	n.a.	n.a.	-
Teacher compensation (percent of non-tertiary education expenditure)	-			n.a.
Salaries (percent of total expenditure on public institutions)	--	-		
Subnational expenditure (percent of total expenditure)				--
Student-teacher ratio in secondary education	++	+		
Schools reporting shortages in school supplies (percent)		++		n.a.
Schools reporting shortages in library material (percent)		++	++	n.a.
Institutional factors				
Schools using student records for admission (percent)			+	n.a.
Schools where principal is responsible for hiring (percent)	++	+		n.a.
Exogenous factors				
GDP (PPP dollars per capita)	--	--	--	--
Students with mother's education of ISCED 3C or higher (percent)	+	+		n.a.
Urban population (percent of total)		-	--	-

Sources: OECD Education at a Glance 2006, www.oecd.org/edu/eag2006; the World Bank's World Development Indicators, <http://devdata.worldbank.org/wdi2006/contents/index2.htm>; OECD PISA, http://pisaweb.acer.edu.au/oecd_2003/oecd_pisa_data_s1.html; UNESCO Institute for Statistics, <http://stats.uis.unesco.org>; and IMF staff calculations.

1/ Includes only pairwise correlations between efficiency scores and factors that are not significantly correlated with GDP (and GDP itself). Double ++ (- -) indicates that the efficiency score is positively (negatively) correlated with the associated factor at the 5 percent significance level. Single + (-) indicates that the efficiency score is positively (negatively) correlated with the associated factor at the 10 percent significance level. N.a. signifies that the associated factor is not available.

Table 12. Correlations of Bias-Corrected Efficiency Scores and Associated Factors for Public Health Education 1/

	Healthy life expectancy	Standardized death rate	Infant mortality rate	Child mortality rate	Maternal mortality rate
Expenditure policy variables					
Out-of-pocket payments (PPP per capita)	–	–	--	--	–
Subnational expenditure (percent of total expenditure)	--	–	–	–	--
Total health employment density (per capita)	--	–	–	–	–
General practitioner density (per capita)	–	–	--	--	--
Number of hospital beds (per capita)			++	++	
Number of doctors' consultations (per capita)	+		++	++	++
Measles immunization (percent of children 1–2 years old)				++	
Exogenous factors					
GDP (PPP dollars per capita)	--	--	--	--	--
Population 64 years or older (percent of total population)					–
Diet (calories per day)	--	--	--	--	--
Urban population (percent of total)			–	–	–

Sources: OECD Health Data 2006, www.ecosante.fr; the World Bank's World Development Indicators, <http://devdata.worldbank.org/wdi2006/contents/index2.htm>; and IMF staff calculations.

1/ Includes only pairwise correlations between efficiency scores and factors that are not significantly correlated with GDP (and GDP itself). Double ++ (--) indicates that the efficiency score is positively (negatively) correlated with the associated factor at the 5 percent significance level. Single + (–) indicates that the efficiency score is positively (negatively) correlated with the associated factor at the 10 percent significance level. N.a. signifies that the associated factor is not available.

Table 13. Regression Results for Overall Education Spending Efficiency Scores 1/

	PISA mathematics score average	PISA mathematics score distribution	Upper secondary graduation rate	Tertiary graduation rate
Compensation (percent of total non-tertiary education spending)	-0.011**	-0.013**	-0.016**	
Private expenditure on education (percent of total non-tertiary education spending)			2.149**	
Private expenditure on education (percent of total tertiary education spending)				-0.287**
Subnational expenditure (percent of total expenditure)	-0.005**			
Schools where principal is responsible for hiring (percent)	0.002**	0.002**		
GDP (1,000s PPP dollars per capita)	-0.016**	-0.012**	-0.014**	-0.030**
Urban population (percent of total)		-0.009**	-0.019**	
N	124	154	46	103
R ² 2/	0.59	0.47	0.59	0.48

Sources: OECD Education at a Glance 2006, www.oecd.org/edu/eag2006; the World Bank's World Development Indicators, <http://devdata.worldbank.org/wdi2006/contents/index2.htm>; OECD PISA, http://pisaweb.acer.edu.au/oecd_2003/oecd_pisa_data_s1.html; UNESCO Institute for Statistics, <http://stats.uis.unesco.org>; and IMF staff calculations.

1/ Bootstrapped truncated regressions with lower bound 0 and upper bound 1 suppressing the constant term and with robust standard errors (in parenthesis) and clustering on each dominated country. The model is formulated in differences in the efficiency scores of pairs of countries where one country has a higher level of outcomes and lower spending than the other country (i.e., one country dominates the other in DEA). ** denotes significance at the 5 percent confidence level.

2/ In regression without intercept, R² measures the proportion of the variability in the dependent variable about the origin explained by the regression.

Table 14. Regression Results for Public Health Spending Efficiency Scores 1/

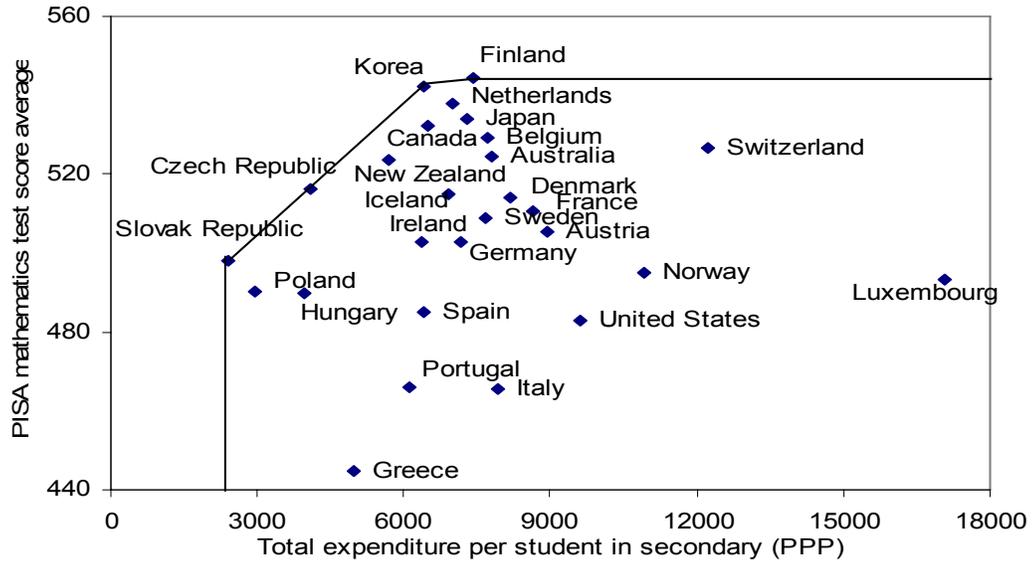
	Healthy life expectancy	Standardized death rate	Infant mortality rate	Child mortality rate	Maternal mortality rate
Expenditures on inpatient care (percent of public health spending)	-0.006**	-0.011**	-0.004**	-0.061**	-0.006**
Private expenditure on health (percent of total health spending)					-0.358**
Density of general practitioners (per 1,000)	-0.177**	-0.197**	-0.122**	-0.115**	-0.131**
GDP (1,000s PPP dollars per capita)	-0.017**	-0.018**	-0.039**	-0.033**	-0.010**
Caloric intake per day (1,000s)			-0.398**	-0.150**	
Urban population (percent of total)			-0.009**	-0.010**	-0.006**
N	74	82	72	86	117
R ² 2/	0.39	0.44	0.76	0.58	0.79

Sources: OECD Health Data 2006; www.ecosante.fr; the World Bank's World Development Indicators, <http://devdata.worldbank.org/wdi2006/contents/index2.htm>; and IMF staff calculations.

1/ Bootstrapped truncated regressions with lower bound 0 and upper bound 1 suppressing the constant term and with robust standard errors (in parenthesis) and clustering on each dominated country. The model is formulated in differences in the efficiency scores of pairs of countries where one country has a higher level of outcomes and lower spending than the other country (i.e., one country dominates the other in DEA). ** denotes significance at the 5 percent confidence level.

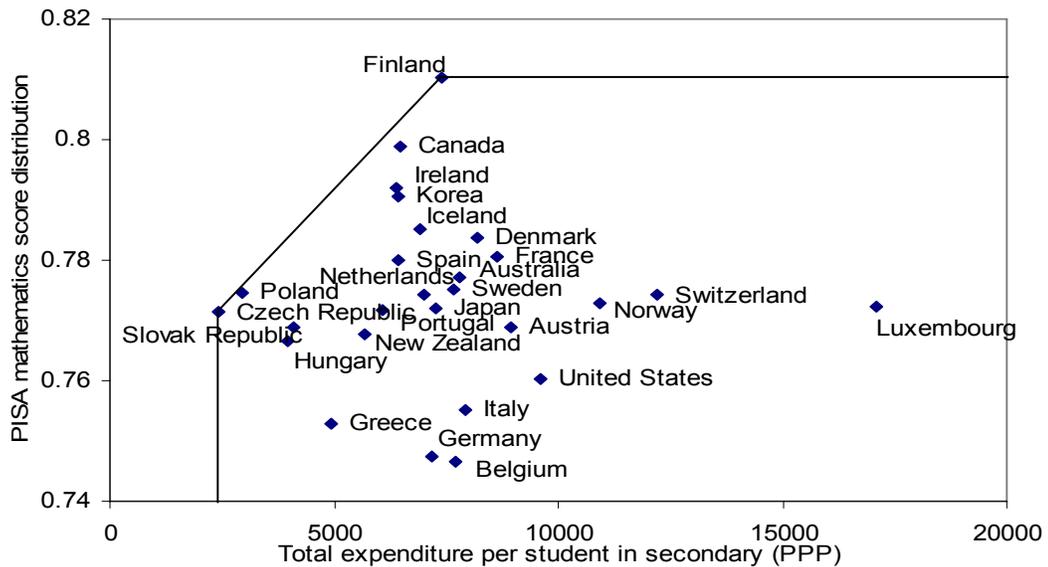
2/ In regression without intercept, R² measures the proportion of the variability in the dependent variable about the origin explained by the regression.

Figure 4. Secondary Education Spending and Average PISA Mathematics Scores 1/



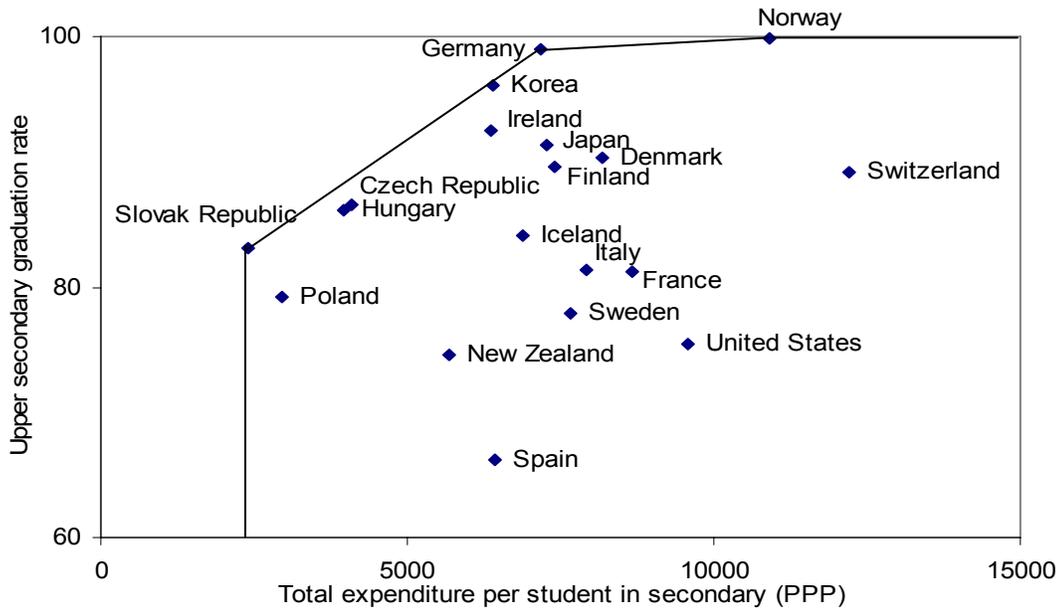
Sources: OECD Education at a Glance 2006, www.oecd.org/edu/eag2006; OECD PISA, http://pisaweb.acer.edu.au/oecd_2003/oecd_pisa_data_s1.html; and IMF staff calculations. 1/ The line connects countries with the highest observed efficiency and depicts the best-practice frontier unadjusted for estimation bias (see Appendix I).

Figure 5. Secondary Education Spending and the Distribution of PISA Mathematics Scores 1/



Sources: OECD Education at a Glance 2006, www.oecd.org/edu/eag2006; OECD PISA, http://pisaweb.acer.edu.au/oecd_2003/oecd_pisa_data_s1.html; and IMF staff calculations. 1/ The distribution of PISA test scores is calculated as the ratio of the average scores for the top quartile and for the bottom quartile of test scores. The line connects countries with the highest observed efficiency and depicts the best-practice frontier unadjusted for estimation bias (see Appendix I).

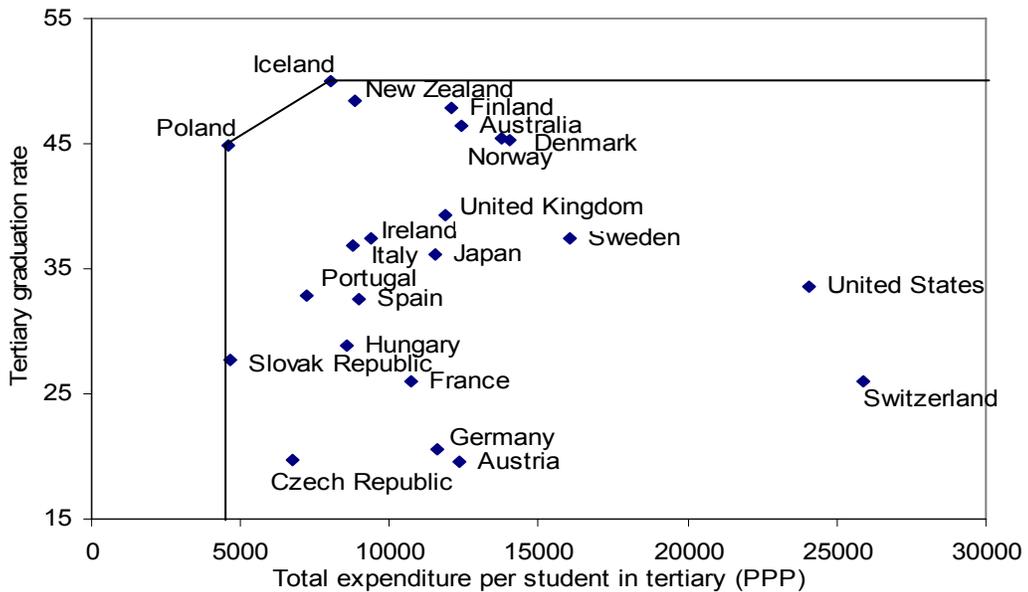
Figure 6. Secondary Education Spending and Upper Secondary Graduation Rates 1/



Sources: OECD Education at a Glance 2006, www.oecd.org/edu/eag2006; and IMF staff calculations.

1/ The line connects countries with the highest observed efficiency and depicts the best-practice frontier unadjusted for estimation bias (see Appendix I).

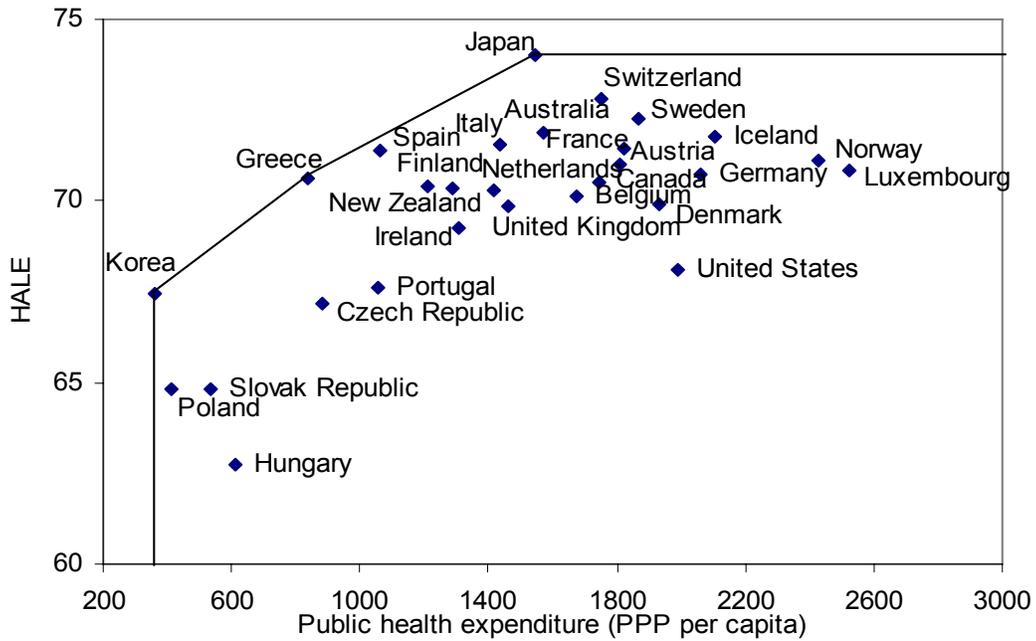
Figure 7. Tertiary Education Spending and Tertiary Graduation Rates 1/



Sources: OECD Education at a Glance 2006, www.oecd.org/edu/eag2006; and IMF staff calculations.

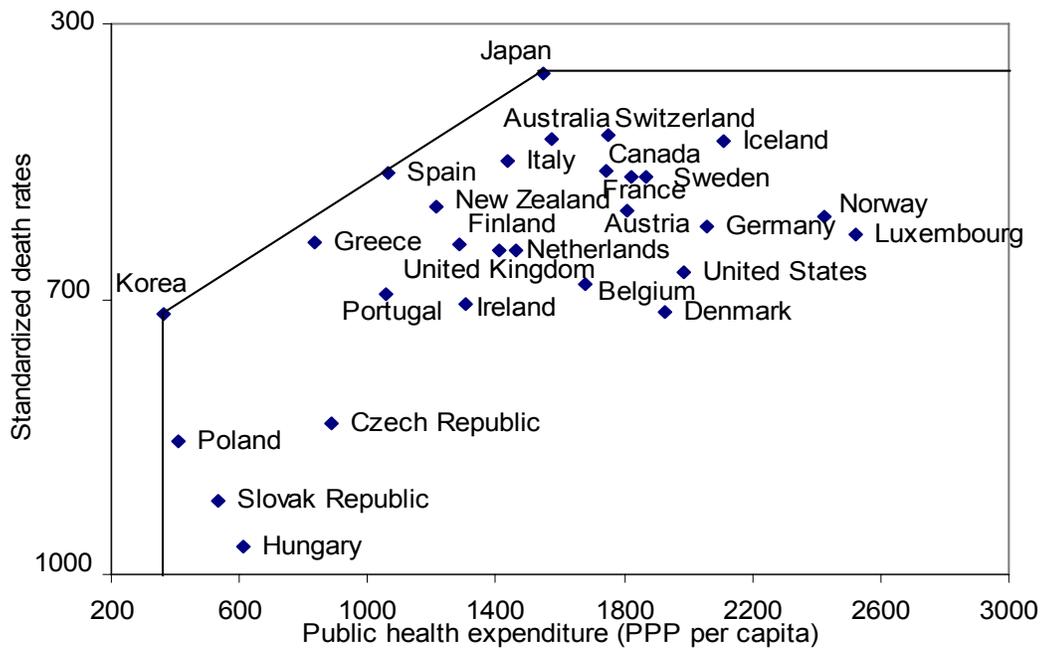
1/ The line connects countries with the highest observed efficiency and depicts the best-practice frontier unadjusted for estimation bias (see Appendix I).

Figure 8. Public Health Spending and HALE 1/



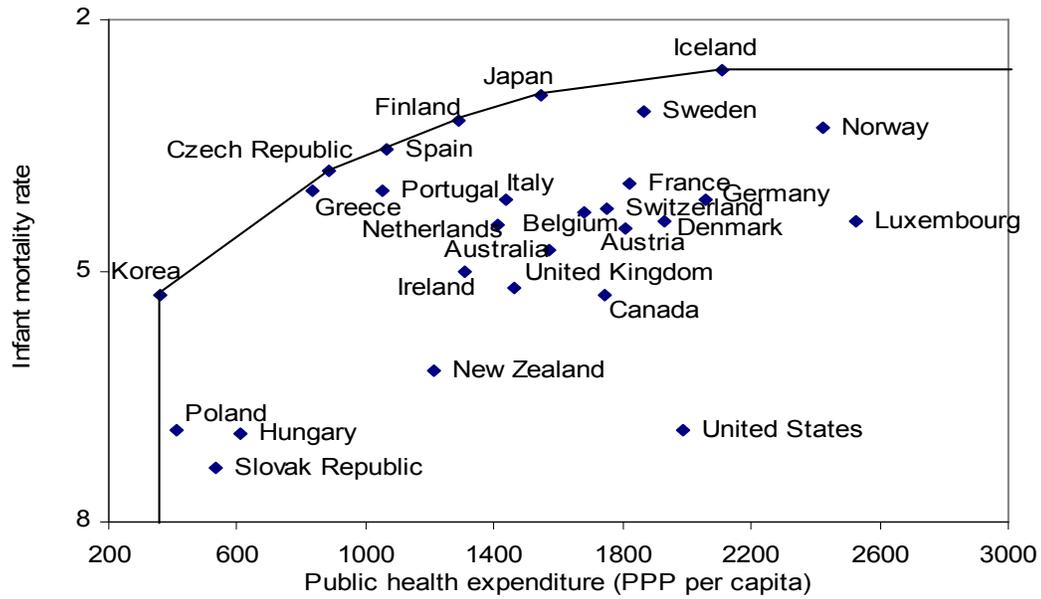
Sources: OECD Health Data 2006, www.ecosante.fr; and IMF staff calculations.
 1/ The line connects countries with the highest observed efficiency and depicts the best-practice frontier unadjusted for estimation bias (see Appendix I).

Figure 9. Public Health Spending and Standardized Death Rates 1/



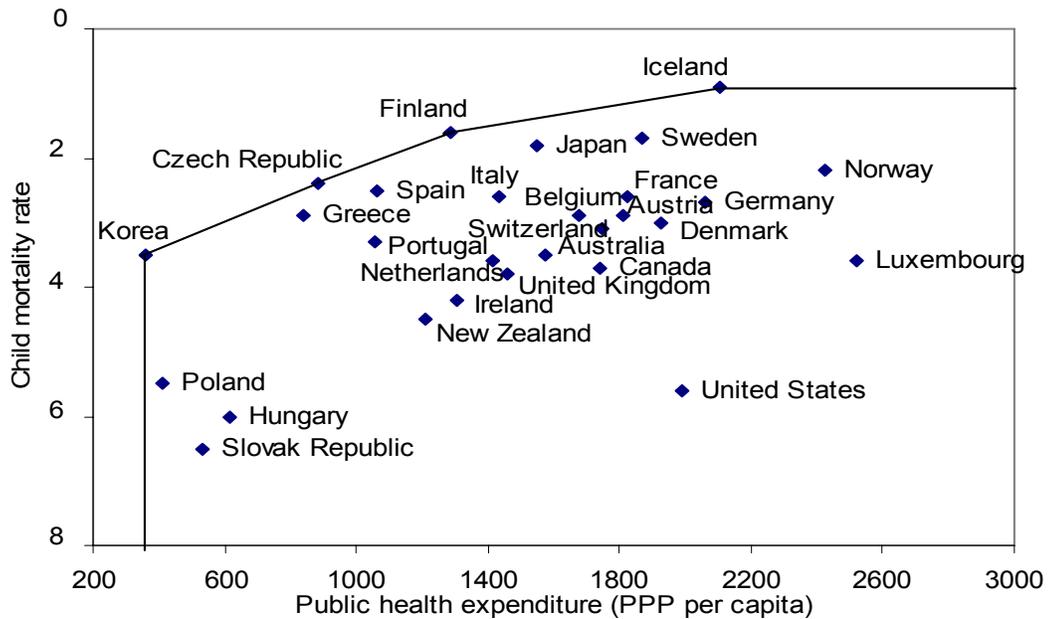
Sources: OECD Health Data 2006, www.ecosante.fr; and IMF staff calculations.
 1/ The line connects countries with the highest observed efficiency and depicts the best-practice frontier unadjusted for estimation bias (see Appendix I).

Figure 10. Public Health Spending and Infant Mortality 1/



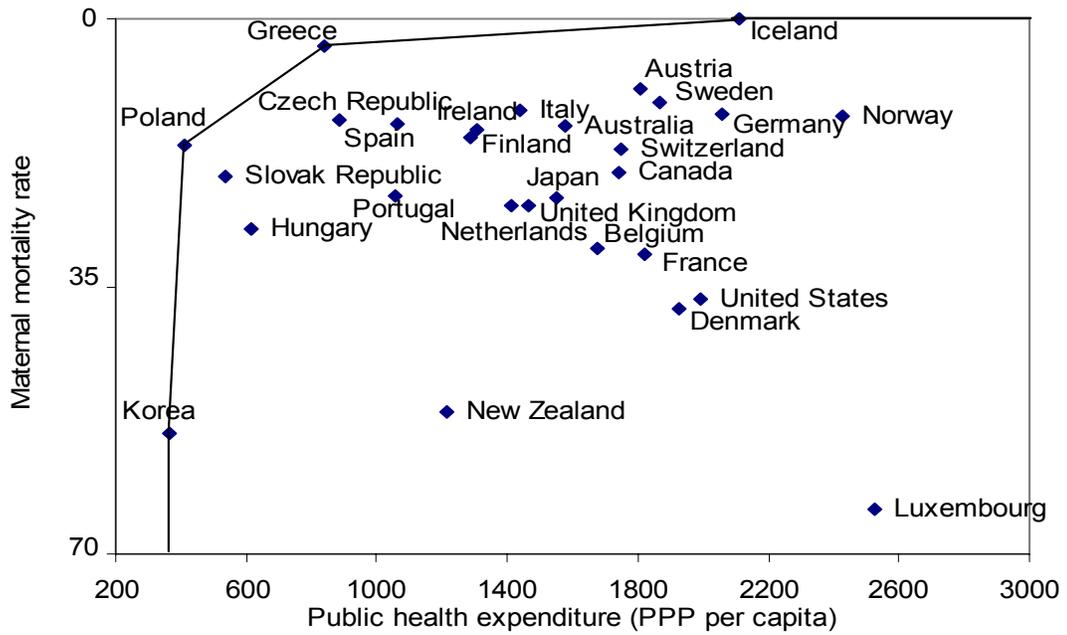
Sources: OECD Health Data 2006, www.ecosante.fr; and IMF staff calculations.
 1/ The line connects countries with the highest observed efficiency and depicts the best-practice frontier unadjusted for estimation bias (see Appendix I).

Figure 11. Public Health Spending and Child Mortality 1/



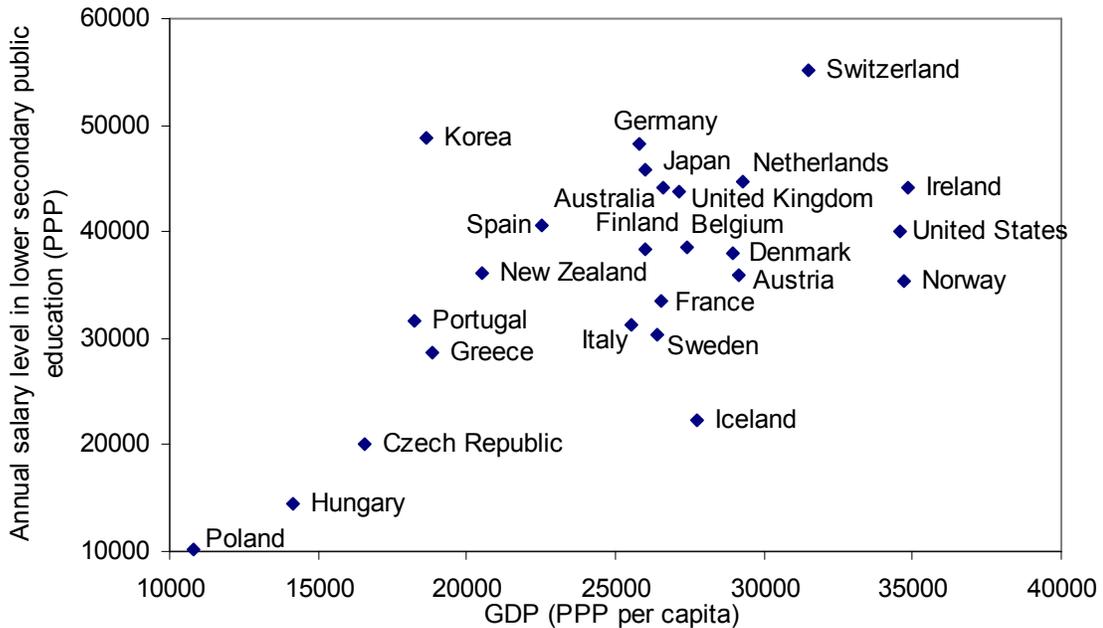
Sources: OECD Health Data 2006, www.ecosante.fr; and IMF staff calculations.
 1/ The line connects countries with the highest observed efficiency and depicts the best-practice frontier unadjusted for estimation bias (see Appendix I).

Figure 12. Public Health Spending and Maternal Mortality 1/



Sources: OECD Health Data 2006, www.ecosante.fr; and IMF staff calculations.
 1/ The line connects countries with the highest observed efficiency and depicts the best-practice frontier unadjusted for estimation bias (see Appendix I).

Figure 13. Teacher Salary in Secondary Education and GDP



Sources: UNESCO Institute for Statistics, <http://stats.uis.unesco.org>; and the World Bank's World Development Indicators, <http://devdata.worldbank.org/wdi2006/contents/index2.htm>

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