Productivity Measurement in the Education Sector

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Investing in education is a strong priority for governments: OECD countries on average devote around 12 percent of national public expenditures to education (Figure 1), often the second or third largest public expenditure behind health care and social assistance. Since 2000, total spending on education has increased as a share of GDP in most OECD economies and many emerging market economies, reaching 6.4 percent of GDP in the U.S. and 5.6 percent of GDP in Brazil in 2012 (Figure 2). For low- and middle-income countries, UNESCO estimates that spending needs to increase from around 14 percent of their total budgets (Steer and Smith 2015) to 20 percent, or 5.5 percent of GDP, to meet the education Sustainable Development Goal (UNESCO 2014).

Despite this high level of spending on education and its increasing share in national economies, it is not well understood how productive the sector is. Measurement of output and productivity in education presents challenges. Moreover, investments in technology and other improvements expected to drive efficiency appear not to have improved education outcomes (OECD 2015). This note provides a brief review of work to address the challenges of measuring output and productivity in the education sector, with attention also to issues related to the increasing use of technology in the provision of education services.

Human Capital and the National Accounts

With the majority of educational institutions in the government sector (Figure 3), the lack of market pricing presents challenges in measuring the education sector's output and productivity. In the national accounts of most countries, the output of the education sector is measured essentially by the inputs, which include labor costs of teachers and staff, capital inputs, and intermediate inputs (Schreyer 2010). As a result, the ratio of outputs to inputs, the standard concept of productivity, does not provide a measure of the productivity of the sector. Proxy measures of labor productivity in education, such as expenditures per student (Figure 4), are susceptible to Baumol's "cost disease" and fail to capture important outcomes of education such as quality of learning.[1]

Alternative measures of output in education may therefore need to be explored. Some alternative measures have been attempted in research, which present their own challenges. In addition, new issues are arising with advances in information and communication technology (ICT). With the increasing use of ICT, prospects for more efficient education systems improve, but their realization will depend on appropriate application of the new technologies to enhance learning outcomes (OECD 2015).

A definition of education output that has emerged in the literature is the effect of education on the level of knowledge, skills, and competencies of students, or ultimately human capital accumulation (Jorgenson and Fraumeni 1992, Schreyer 2012, OECD 2010, Gu and Wong 2015). Two approaches have

[1] Output in the education sector as measured in the national accounts is a classic example of Baumol's "cost disease", originally applied to the services sector at large (Baumol 1967). It describes how a sector with a labor-intensive structure leads to inevitable increases in spending and costs without any relation to its efficiency.

been developed in the empirical literature to measure the value of investment in human capital (Gu and Wong 2015). One is the income-based approach (Jorgenson and Fraumeni 1989, 1992, 1996), which measures the value of education output as the increase in a student's lifetime income arising from education. Education output under the income-based approach is calculated as a weighted sum of student enrollments using weights based on the value of education, which is calculated as the difference between the lifetime incomes of individuals with higher and lower education levels. The other approach is the cost-based approach (Kendrick 1976), which measures the value of education output as total expenditures on education. Education output under the cost-based approach is calculated as a weighted sum of student enrollments using weights based on total spending per student as the unit price of education.

Different estimates of education output and human capital have emerged in individual studies using the approaches described above. Using the income-based approach, the Human Capital Project at the OECD (Liu 2011) estimates the stock of human capital and its distribution between people of different characteristics, comparing 15 countries over time. While the stock of human capital has increased in every country over time, human capital *per capita* has varied—increasing in Italy, Spain and the U.K., stable in Australia, Canada, and France, and decreasing in the U.S. In countries with significant proportions of the population aging out of the workforce, the volume of human capital per capita is shown to fall. Mahoney and Stevens (2009) build on the income-based approach to estimate the earnings of different qualifications in the labor market in the U.K. and the U.S. When comparing the productivity of an educated-hour worked, they find that the U.S. advantage over the U. K. fell through the 1980s and 1990s until they were nearly equal in the early 2000s.[2]

Schreyer (2010) critiques the human capital approach of using lifetime income, calling out the "tenuous" link between education and future earnings due to influences of labor market trends, on-the-job training, and selection bias of those who choose to complete higher levels of education. He points out that where no market prices exist to indicate consumer valuation, as is the case with much of education, "cost weights emerge as the best way." His estimates comparing input and output measures of education for 32 countries show that a cost-based output approach, based on the number of students and cost of education at different levels, provides more accurate cross-country comparisons of the sector than simply measuring inputs, which vary widely based on salaries of teachers and other staff.[3] He also experiments with controlling for international exam scores, one measure of quality, but finds it has little impact on the cost-based output measure.

Gu and Wong (2015) compare estimates of the education sector's output using the national accounts approach to those using both the income-based and cost-based approaches in Canada. The national accounts estimated that education output increased 1.2 percent annually from 1976 to 2005, while the

[2] Accounting for quality by including PISA scores implies that quality may have a large impact, but the authors emphasize the "speculative nature" of such an adjustment.

[3] Inputs are based on labor compensation to teachers and administrative staff, capital, and intermediate inputs, consistent with the traditional national accounting measure. Outputs in this estimation are based on the number of students by education level, weighted by the cost per student at each level, i.e. the cost-based approach to measuring education output.

income-based approach and the cost-based approach yielded growth rates of 0.8 percent and 0.6 percent over the same period, respectively.[4] After 1990, the growth in total hours worked in the education sector was slow at 0.4 percent per year, but economic output of the sector increased 0.8 percent per year from both income-based and cost-based approaches. In addition, while other studies have tended to shy away from hedonic methods that account for quality through price changes (Schreyer 2010), these authors extend their analysis to employ such methods using student test scores to account for changes in quality. They find that using this methodology that includes quality adjustments raises the growth of education output by 0.2 percentage points per year from 1976 to 2005.

While alternative measures of education output are being developed in the literature, such as those based on income, they are constrained by the difficulties in establishing comparable and accurate measures over time and across countries. In the System of National Accounts (SNA), the "treatment of education costs is consistent with the production and asset boundaries of the SNA" but encourages using satellite accounts for an alternative treatment in the recording and measurement of human capital (SNA 2009).

Turning to the increasing use and application of technology in education, *prima facie* the promise of more efficient delivery of quality education and more productive investments in human capital is strong. Yet, the challenges of measurement remain, as well as the challenge to properly apply technology to improve the sector.

Technology in the Education Sector

Using technology in the classroom is not a new phenomenon. New technologies have long promised transformations in the education sector (Cuban 1986). Overhead projectors, typewriters, radio, television, interactive whiteboards and tablets are all examples of educational technologies used throughout the 20th and into the 21st century. And yet, despite the claims of technology enthusiasts, the actual gains from these technologies to make education more productive or efficient are unclear.

The long history of educational technology shows that throughout time it seems to have perpetuated essentially the same educational model: blackboards to whiteboards to smartboards and textbooks to laptops to tablets. This is certainly true of the "first wave" of digital technologies, which brought desktop and laptop computers to classrooms around the world in the 1990s and early 2000s. While many expected access to the internet and digital information to revolutionize education, computers were largely used for students to passively absorb information and practice problems as generations had done with textbooks and workbooks. Research has shown that most computers have been used for drill and practice exercises or to teach basic computer skills like typing and word processing (Reiser 2001, Darling-Hammond et al. 2016).

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[4] The growth in the *nominal value* of education output by the national accounts (based on inputs) and cost-based measures is similar, while the *volume* of output differs due to the cost-based approach's methodology of using a weighted sum of student enrollment as an estimate of output volume.

There are two ways to see the relative lack of success of technology to make education more productive. On the one hand, it appears to have been unable to substantially drive down costs. While innovations that put televisions or video lectures into classrooms have been seen by some as ways to replace teachers, overall technology has complemented the teacher-centered model (Reiser 2001). As the previous section showed, measuring productivity and growth in education has largely relied on the inputs to education, predominantly teachers' salaries. The OECD has found that countries that spend more on education also invest more heavily in ICT for schools, but the relationship is complicated by the fact that spending on ICT competes with other priorities such as hiring teachers and purchasing other materials like textbooks (OECD 2015).

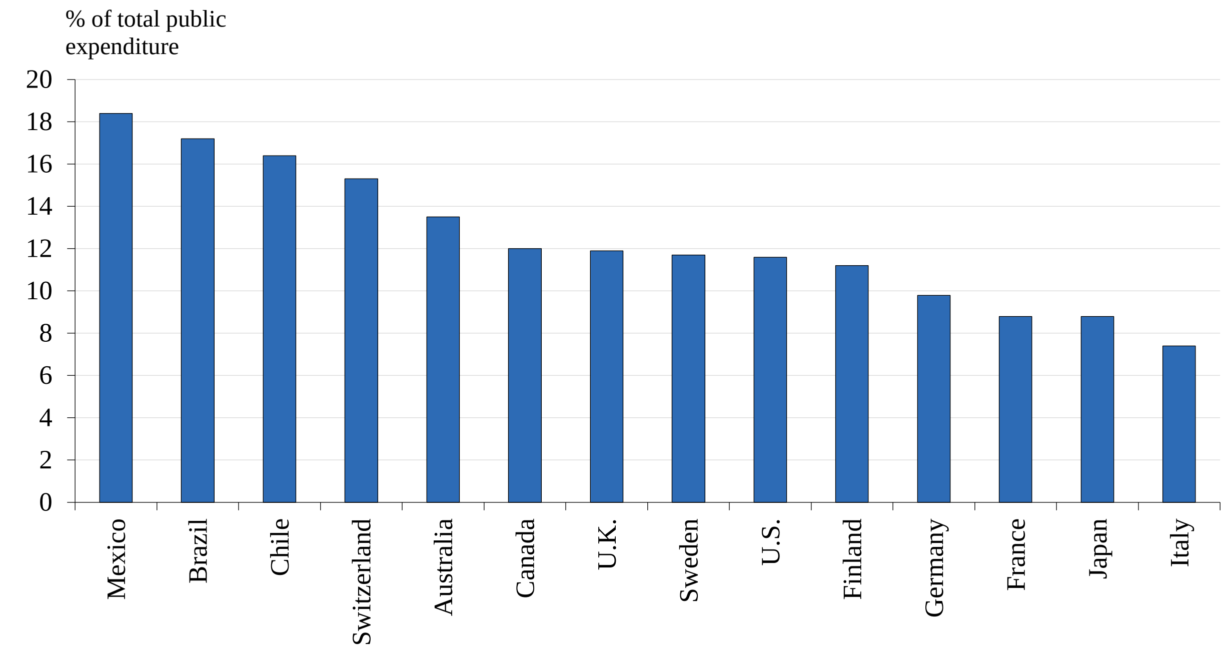
Second, technology also appears to have been unable to substantially improve the outcomes of education in terms of student learning. While the discussion above focuses on economic inputs and outputs of education like spending and income of graduates, schools and systems themselves increasingly measure their success in terms of student performance on achievement tests. The OECD's analysis of high- and middle-income countries that participate in the PISA exam shows that countries that invested more in computers between 2003 and 2012 saw a sharper decline in mathematics performance (Figure 5). They also find that students' access to computers in school or at home does not have an impact on student performance, and those students who use computers at school more intensively than average actually have poorer performance on the exam. The lack of a relationship between technology and learning has been found elsewhere, for example, the high-profile *One Laptop per-Child* program which did not show learning gains from distributing laptops to children (Cristia et al. 2012).

The inability of technology to improve learning outcomes, as found in these studies, may be due to the fact that it has not changed the teaching and learning environment much. Recent work from scholars at Stanford University found that in the U.S., education technology for low-income students in particular has been used to reinforce the passive teacher-centered model, rather than promoting active and creative engagement with technology (Darling-Hammond et al. 2016).

However, we are seeing a new wave of education technology that may have the potential to better incorporate a "hands-on, minds-on" approach to teaching and learning (Winthrop et al. 2016). New digital technologies are focusing on active learning strategies that personalize learning and give students the tools to ask and answer their own inquiries. Innovators are focused more on tools that can help teachers rather than trying to replace them, and are putting more of a premium on teacher training and engagement. These strategies hold promise for education to get better results and improve its productivity by better fostering skills from literacy and numeracy to communication and teamwork.

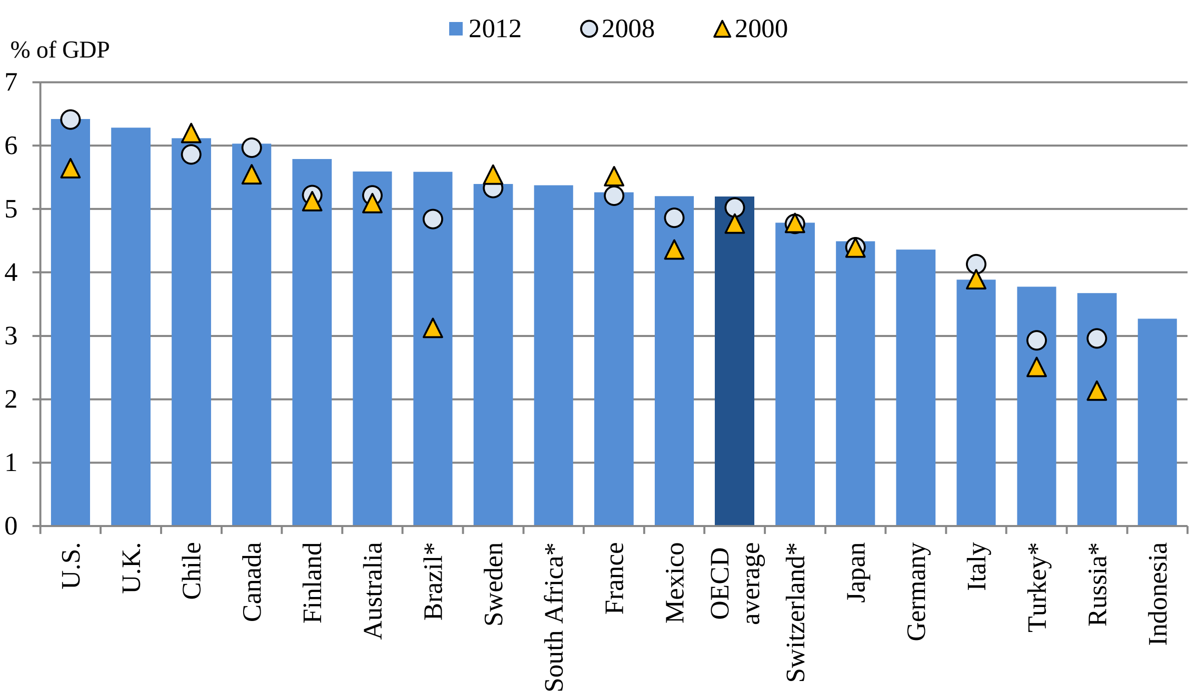
Along with better measurements of growth within the sector, these innovations could lead to a better understanding of what drives improvements in education as well as improve its productivity.

Figure 1. Public Spending on Education, 2012



Source: OECD Education Finance Indicators.

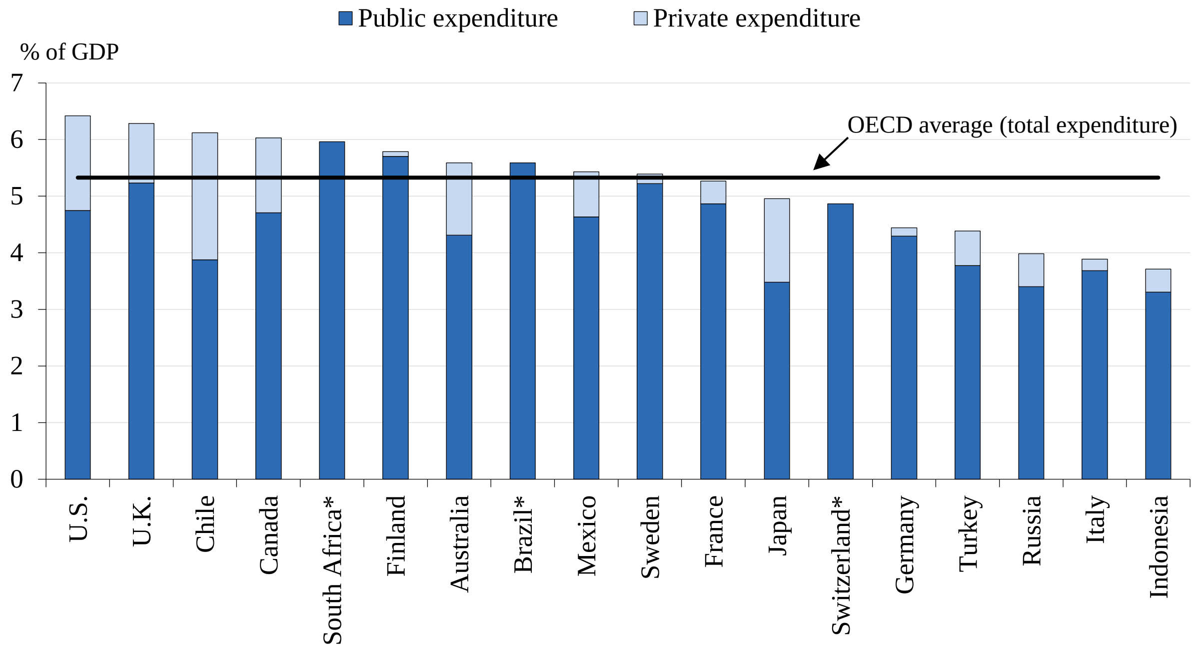
Figure 2. Expenditure on primary to tertiary education institutions as a percentage of GDP



Source: OECD Education at a Glance 2015.

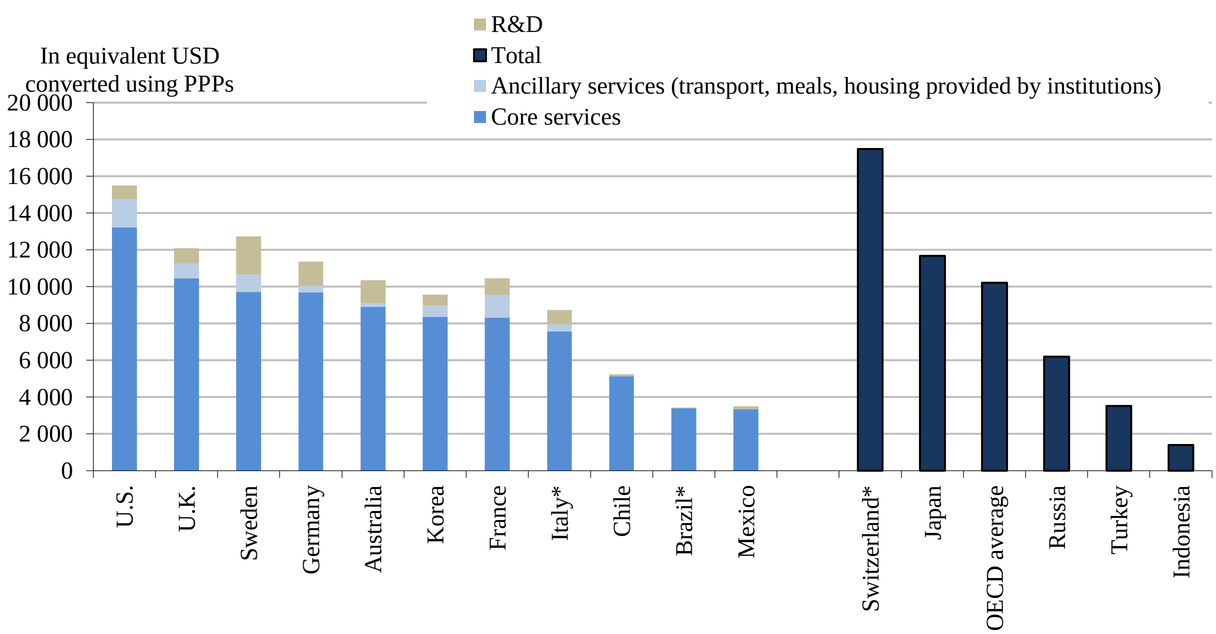
Note: Public and private expenditures on education institutions. *Public expenditures only.

Figure 3. Private and Public Expenditure on primary to tertiary education institutions as a percentage of GDP, 2012



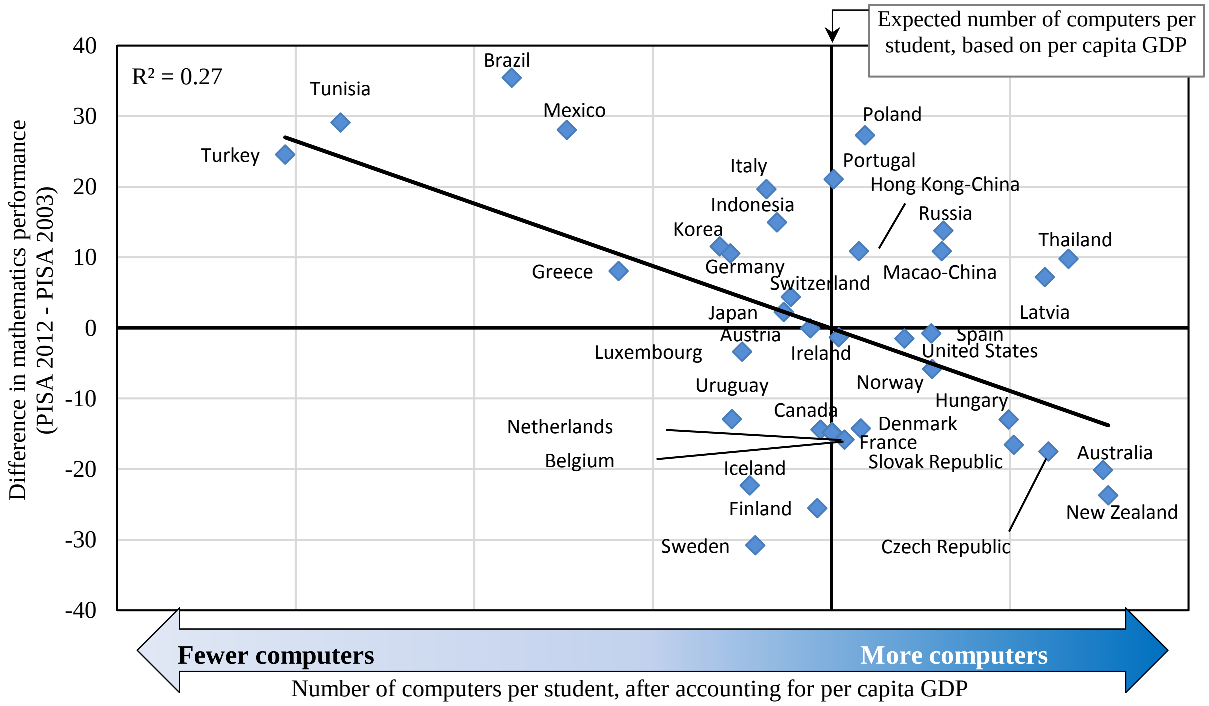
Source: OECD Education at a Glance 2015.
Note: Public and private expenditures on education institutions. *Public expenditures only.

Figure 4. Annual expenditure by educational institutions per student, by types of service, from primary to tertiary education, 2012



Source: OECD Education at a Glance 2015.
Note: *Public institutions only. For countries with only the total shown, a breakdown into the three components is not available.

Figure 5. Trends in Mathematics Performance and Number of Computers in Schools, 2003-2012



Source: OECD Students, Computers and Learning 2015.

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