NOVEMBER 2019

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SVENSKT NÄRINGSLIV
SWEDISH ENTERPRISE

Knowledge-based Schooling for Prosperity

The Impact of Education Reforms on Swedish Economic Growth

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Foreword[1]

There is a connection between knowledge and prosperity. This may seem like an obvious statement, but the link between countries' education systems and their economic well-being is rarely discussed in the policy debate.

To remedy this situation, the Confederation of Swedish Enterprise has commissioned Gabriel Heller-Sahlgren of the London School of Economics and the Research Institute of Industrial Economics, and Henrik Jordahl of Örebro University and the Research Institute of Industrial Economics, to review and update the literature analysing the relationship between education quality and economic growth.

The authors also review research analysing how different factors, including school competition, central exit exams, instructional time, and pedagogical methods, affect student achievement in international tests. Furthermore, they simulate different scenarios in order to show how Sweden's growth rate could be affected by hypothetical education reforms.

Of course, increasing economic growth is not the only goal of education systems. Yet their link to prosperity is a key dimension that should not be ignored. Indeed, Heller-Sahlgren and Jordahl's results clearly display the important role sensible education reforms may play for society at large. We hope that their conclusions will contribute to a constructive debate about which education policies and interventions should be prioritised in the coming years.

Anders Morin
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[1] This report was originally published in Swedish as "En kunskapsskola för tillväxt" on 10th May 2019.

Executive summary

- In 2018, Sweden had one of the lowest per-capita GDP growth rates in the EU. Forecasts suggest that growth will continue to be weak in the future.
- Research indicates that education quality – measured by test scores in international student surveys, such as the Programme for International Student Assessment (PISA) and the Trends in International Mathematics and Science Study (TIMSS) – consistently predicts economic growth.
- If Sweden had performed at the level of Singapore in international surveys, its average annual per-capita growth would have been 0.42 percent higher in the period 1960–2016, which in turn would have raised the country's current purchasing-power adjusted GDP per capita by about $11,400.
- The above results are obtained using average test scores in primary and secondary school as measures of education quality. Test scores among upper-secondary school students in TIMSS 1995 independently predict economic growth as well.
- The share of top-performing students appears more important than the share of students reaching basic literacy for the purposes of increasing economic growth.
- Based on research analysing variables that affect international test scores, we highlight five important policy-relevant factors: (1) independent-school competition, (2) central exit exams, (3) instructional time, (4) homework, and (5) pedagogical methods.
- A 10 percentage-point increase in the independent-school enrolment share among 15-year olds would have raised Sweden's annual per-capita growth rate by roughly 0.16 percentage points in the period 1960–2016. This, in turn, would have boosted the country's GDP per capita by about $4,000 at the end of the period.
- Central exit exams would have increased the growth rate in the same period by 0.18 percentage points, thereby raising Sweden's current GDP per capita by about $5,000.
- Three hours additional instructional per week in mathematics, science, and Swedish respectively would have increased average annual economic growth by 0.23 percentage points, and therefore upped today's GDP per-capita by about $6,000.
- Assigning homework in all mathematics and science lessons – compared with the baseline scenario – would have increased Sweden's growth rate by 0.03 percentage points, corresponding to a $600 higher GDP per capita today.
- Making instruction one standard deviation less student centred would have improved the growth rate by 0.4 percentage points, thereby increasing today's GDP per-capita by $9,000.
- Making instruction one standard deviation more teacher directed would have raised growth by 0.17 percentage points, translating into a $4,000 higher GDP per capita today.
- Based on our findings, we recommend that policymakers seek to improve Sweden's international test scores by supporting and expanding independent-school competition via the voucher system, introducing central exit exams, and encouraging more traditional teaching styles.

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1. Introduction

In the long-term perspective, countries' prosperity depends on how fast their economies grow. Historically, Sweden has enjoyed long periods of rapid economic growth, which have been key for the country's contemporary success. Economic growth enabled it to escape poverty and starvation in the 19th century and reach exceptionally high living standards in the 1950s and 60s.

Unfortunately, the current outlook for the Swedish economy is gloomy. Indeed, in 2018, Sweden's growth rate of GDP per capita, a key indicator of prosperity, ranked at the bottom of the EU league table. Meanwhile, recent IMF estimates suggest that its GDP growth will fall in 2019, leading to the poorest economic performance of all Nordic countries. Several other forecasts paint a similarly bleak picture of Sweden's growth prospects in the coming years.

It is important to note that GDP per capita is a better measure of prosperity than GDP, since the former takes population size into account. With a population of 1.4 billion, China naturally has a larger GDP than Sweden, but this does not mean that the average Chinese is better off than the average Swede. Similarly, rapid GDP growth may be misleading as an indicator of economic performance, if it is primarily driven by a growing population.

Overall, the wealth of nations depends significantly on the levels of human capital in their populations. Through education, it is possible to generate economic growth that acts as "a rising tide that lifts all boats". Education reform is therefore bound to be an important ingredient in any long-term growth strategy, evident by research finding a strong relationship between countries' performances in international student surveys, such as PISA and TIMSS, and their per-capita growth rates (Hanushek and Woessmann 2015). In this sense, the East Asian growth miracle – in countries such as South Korea, Singapore, and Taiwan – was not a fluke, but instead intimately connected to the fact that students in the region have had high levels of knowledge and skills, as captured by international test scores.

We emphasise that education is an attractive growth strategy, since it is not dependent on increasing the number of working hours overall. Instead, the idea is that improving human capital in the population increases the value added created during each working hour – thereby, in other words, raising productivity levels.

This reports highlights the relationship between Sweden's economic growth and its education system. It shows that Sweden could have had higher per-capita growth if its students had performed at the same level in international tests as students in countries such as Singapore, Japan, and Switzerland. At the same time, it could also have had lower growth if its results had been comparable to those in Greece, Bulgaria, and Turkey.

We also highlight the importance of both ensuring a high minimum level of knowledge and skills as well as maximising the share of top-performing students. In fact, the impact of top-performing students on economic growth is five times as strong as the impact of students reaching basic literacy. Since top-performing students appear key for growth, education policy should ensure that gifted children are allowed to reach their potential, rather than merely focus on improving the results of low-performing students.

Given our findings, the question is: how can and should policymakers improve Sweden's education quality? To answer this question, we review research analysing factors that predict countries' performances in international tests. Since research uses international-test scores to link education quality with growth, we limit the review to factors that have been found to affect scores in international tests specifically, such as PISA and TIMMS, and that are relevant for the Swedish education-policy debate.

We highlight research suggesting that independent-school competition, central exit exams, instructional time, homework, and pedagogical methods affect student performance in international tests. We estimate each factor's effect size from the most rigorous research available, which we use to simulate several scenarios that show how Sweden's growth rate could be affected by hypothetical changes in each factor.

Of course, apart from boosting economic performance, there are many other goals of education, including self-realisation and the instilment of liberal-democratic values. Yet our calculations show that the economic consequences of investments in knowledge and skills are too large to be ignored when crafting education policy.

Overall, our findings therefore highlight the desirability of education reforms that improve students' knowledge and skills. We especially recommend supporting and expanding independent-school competition, the introduction of central exit exams, and the encouragement of more traditional teaching styles to raise Sweden's knowledge capital and, in so doing, its economic performance.

Before discussing the empirical literature analysing the relationship between education quality and economic growth, Section 2 begins with a brief theoretical discussion of why and how education is thought to impact development.

2. Previous research on the impact of education on growth

Using economic terminology, education is supposed to affect growth by increasing the human capital of the labour force. The concept of human capital reflects the idea that employees' economic value to their employers, and the economy as a whole, varies partly depending on their education and experience.

Human capital may be seen as a factor of production, as in Mankiw et al.'s (1992) influential model, with similar properties to physical capital, such as machinery, roads, and other tangible property. Yet such models risk underestimating the importance of human capital since it is assumed, just like other factors of production, to be subject to diminishing returns, which means that it does not affect the long-term growth rate. The so-called neo-classical model therefore provides a very simplified picture of growth, in which technological change – the only factor that drives long-term development – is seen as a residual that is explained by factors outside the model.

However, according to more recent economic models, human capital affects technological development and therefore also the long-term growth rate of an economy. An example of such models includes the research for which Paul Romer received the 2018 Nobel Prize in economics (e.g. Romer 1994). In such "endogenous" growth models, human capital is assumed to affect the long-term growth rate by contributing to ideas and innovation. In addition, human capital can increase the speed with which existing technology is spread and adopted throughout the economy (Nelson and Phelps 1966). In other words, endogenous growth theory gives human capital, and therefore education, a prominent theoretical role in the production of long-term economic growth.

What, then, does the empirical literature say? For long, research analysing the relationship between human capital and economic growth focused on measures of education quantity, such as school-enrolment rates and average years of schooling (e.g. Barro 1991; Krueger and Lindahl 2001; Gennaioli et al. 2013; Sala-i-Martin et al. 2004). However, studies find that such indicators neither have a robust nor causal relationship with growth. Also, in developed countries, such as Sweden, essentially all children already attend school; studies analysing the effect of increasing school-enrolment rates on growth are mostly relevant for developing countries. Furthermore, enrolment rates are poor measures of human capital, since enrolment itself is likely to be affected by the growth rate – thereby leading to reverse causality – and because today's students have not yet joined the labour force (Woessmann 2003). Meanwhile, the relationship between years of schooling and growth appears to be sensitive to the data utilised, and only appears to be significant among developing countries (e.g. Castelló-Climent and Hidalgo-Cabrillana 2012; Delgado et al. 2013).

Importantly, more recent research instead finds that it is education quality – as measured by test scores in international student surveys – that matter for economic growth. Indeed, when including test scores in the analysis, years of schooling has essentially no explanatory power at all.

To understand growth among developed countries, the shift in focus from measures of education quantity to quality has been crucial. One additional year of schooling is unlikely to have an equal impact on knowledge and skills in vastly different education systems; an important reason for utilising international test scores as a measure of human capital is precisely that they better reflect education output. Indeed, results from surveys such as PISA and TIMSS explain more of the variation between developed countries, and better reflect the average human-capital level in the labour forces cross-nationally.

In one analysis including 50 countries in the period 1960–2000, Hanushek and Woessmann (2008) find a strong impact of education quality on growth: a one standard deviation increase in test scores, corresponding to about 100 PISA points, raises growth by up to 2 percentage points.[2] Broadly speaking, 100 PISA points are equivalent to the progress students make in about three years of schooling, corresponding to the average performance difference in the PISA 2015 mathematics test between students in Sweden (494 points) and Lebanon (396 points). Note that the large effect size means that the impact of test scores is considerable even if it would turn out to be exaggerated. A similar analysis by Hanushek and Woessmann (2011a) show that varying education quality is an important explanation for growth differences across OECD countries: initial GDP per capita and years of schooling together explain 25 percent of the variation in countries' growth rates in the period 1960–2000, a figure that increases to 73 percent when the authors add test scores to the model. The impact of test scores also remains when adjusting for various economic institutions, such as the security of property rights.

Of course, it is difficult to determine whether the relationship between education quality and growth is causal. Yet researchers have used several techniques to investigate whether the findings reflect a causal relationship, concluding that education quality does in fact cause higher growth.

One such technique is to utilise so-called instrumental-variable models. By exploiting features in countries' education systems – independent-school enrolment rates, the existence of central exit exams, and the degree of centralisation in decision-making – it is possible to isolate the variation in test scores that can only be explained by institutional differences. This enables researchers to circumvent the problem that test scores are affected by other factors apart from formal schooling – such as culture – and allow them to focus only on the variation in performance that can be explained by differences in education policy. Interestingly, research exploiting instrumental variables finds essentially identical effects compared to research using simpler methods, thus supporting a causal interpretation of the relationship between education quality and growth overall (Hanushek and Woessmann 2009, 2012a, 2012b).

[2] The standard deviation measures the dispersion of observations in the data analysed. Larger standard deviations indicate that the observations are more spread out, whereas smaller standard deviations indicate that the observations are closer to the mean. In normally distributed data, 68 percent of all observations are within one standard deviation of the mean.

Another approach to investigate whether it is reasonable to draw causal inferences from the research is to analyse the relationship between changes in test scores and changes in growth. Hanushek and Woessmann (2012b) show that within-country time trends in test scores predict time trends in growth, which means that variables that vary across countries but do not change much over time, such as culture and language, do not bias the results. Similarly, it is encouraging that changes in test scores after the growth period analysed do not correlate with growth in the period analysed. The authors' analysis of time trends therefore suggests that education quality causes growth, although this approach also has a weakness: it cannot capture the effect of the level of, rather than trend in, education quality.

While international test scores appear to cause growth, it is important to note that such scores do not merely pick up students' cognitive skills. Indeed, research suggests that they also capture important non-cognitive skills, such as conscientiousness, and that this variation boosts growth to the same extent as the variation explained by cognitive skills (see Balart et al. 2018). In other words, international test scores appear to be a good measure of both cognitive and non-cognitive skills of importance for economic development.

Overall, therefore, research strongly suggests that higher education quality – as measured by international test scores – pays off in the form of higher economic growth. In the next section, we investigate this relationship using a longer growth period than the one analysed in previous research, and discuss the implications for Swedish economic growth specifically.

3. The relationship between international test scores and per-capita GDP growth

Between 1960 and 2016, Sweden had an average annual per-capita growth rate of 2.04 percent. How much higher or lower would growth have been if Swedish students had performed better or worse in international tests? To answer this question, we use test scores obtained from Hanushek and Woessmann (2012b) for 50 countries – constructed from international tests in mathematics and science, conducted in primary and secondary school between 1963 and 2003 – and per-capita GDP data in 2011 US dollars, adjusted for purchasing power, between 1960 and 2016 from the latest update of the Maddison Project Database (Bolt et al. 2018). In the analysis, we adjust for differences in the GDP per capita and years of schooling in 1960.[3] In other words, our research extends Hanushek and Woessmann's (2012b) analysis to also include the years after the 2008 financial crisis. We then use the results to simulate Swedish counterfactual growth rates and GDP per capita over time.[4]

Figure 1 displays a strong relationship between test scores and growth, when holding constant average years of schooling and initial GDP per capita. The results suggest that a one standard deviation increase in test scores – equivalent to about 100 PISA points – raises growth by 1.3 percentage points. At the same time, Figure 2 shows that there is no relationship whatsoever between years of schooling and growth, in support of previous findings. According to the results in Table A1 in the Appendix, initial GDP per capita and years of schooling together explain 46 percent of the variation in growth – a figure that increases to 80 percent once we add test scores to the model. Overall, our results broadly correspond to Hanushek and Woessmann's findings, despite the fact that we analyse a growth period ending in 2016.[5]

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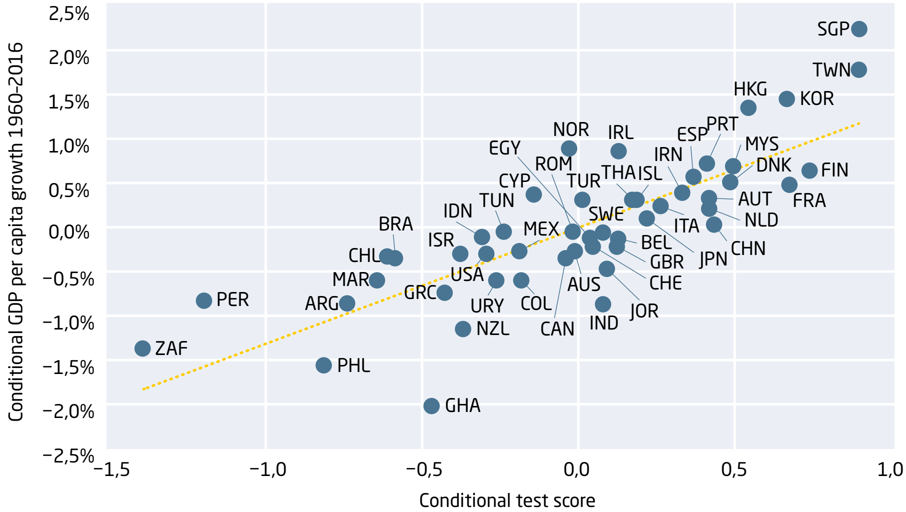
[3] More specifically, we adjust for the natural logarithm of GDP per capita and the average years of schooling in the populations in 1960. The first variable is obtained from Bolt et al. (2018) and the latter from Barro and Lee (2013).

[4] In our main analysis, Zimbabwe is excluded because it is an extreme outlier. In the Appendix, we report results from robustness tests in which we include Zimbabwe, and the results are very similar.

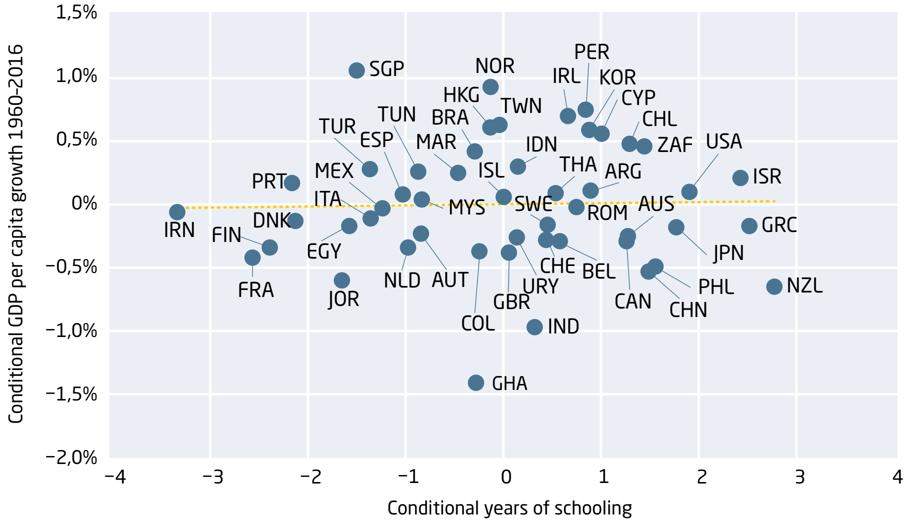
[5] If anything, our results are slightly weaker, which appears to be largely explained by differences in the growth period analysed. If we instead use the average annual growth rate in the period 1960–2000 as dependent variable, we find that a one standard deviation increase in test scores raises growth by 1.9 percentage points.

Figure 1. The relationship between international test scores and per-capita GDP growth



Note: Added variable plot showing the relationship between test scores and the average annual per-capita growth in the period 1960-2016, adjusted for (log) GDP per capita and years of schooling in 1960. The values on the x and y axes correspond to the differences between the countries' actual values on the variables and the values predicted by the control variables.

Figure 2. The relationship between years of schooling and per-capita GDP growth



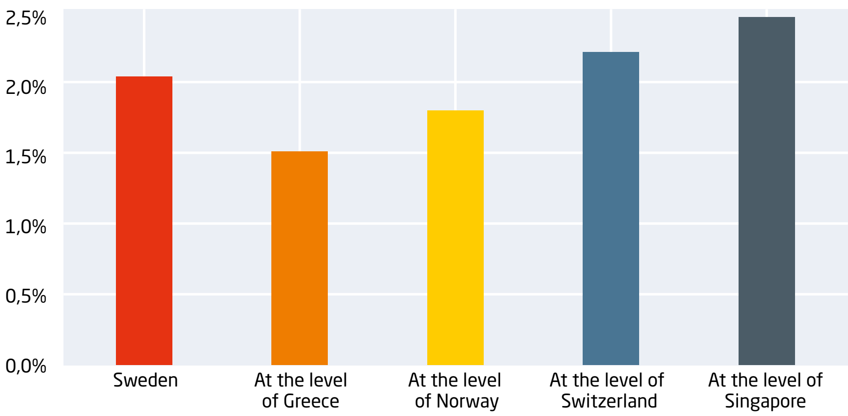
Note: Added variable plot showing the relationship between years of schooling in 1960 and the average annual per-capita growth in the period 1960-2016, adjusted for (log) GDP per capita and international test scores. The values on the x and y axes correspond to the differences between the countries' actual values on the variables and the values predicted by the control variables.

In turn, Figure 3 displays differences between Sweden's actual and counterfactual average annual growth rates in the period 1960–2016, at different levels of test-score performance. The actual growth rate in the period was 2.04 percent, which could have been higher or lower had Swedish pupils performed as well or as poorly as pupils in the four comparison countries. If Sweden had performed on a par with Switzerland, its growth rate would have been 2.21 percent annually, and if it had performed on a par with Singapore its growth would have been 2.46 percent annually. If Sweden instead had performed on a par with Greece or Norway, its growth would on the other hand have been weaker: Sweden's average annual growth rate would have been 1.51 percent had it performed at the level of Greece in international test, and 1.80 percent had it performed at the level of Norway.

At a first glance, the growth differences may appear relatively small. Yet the fascinating property of growth is that also small differences translate into large differences in per capita GDP over time. This is shown in Figure 4, which displays Sweden's actual per-capita GDP over time as well as its counterfactual GDP per capita at different levels of education performance, using the same benchmark countries as in Figure 3. Sweden's actual per-capita GDP, adjusted for purchasing power, increased from $14,677 in 1960 to $44,659 in 2016. Figure 4 shows that the country's 2016 per-capita GDP would instead have increased to $56,085 had it performed at the level of Singapore in international tests, or to $48,980 had it performed on a par with Switzerland in these tests.

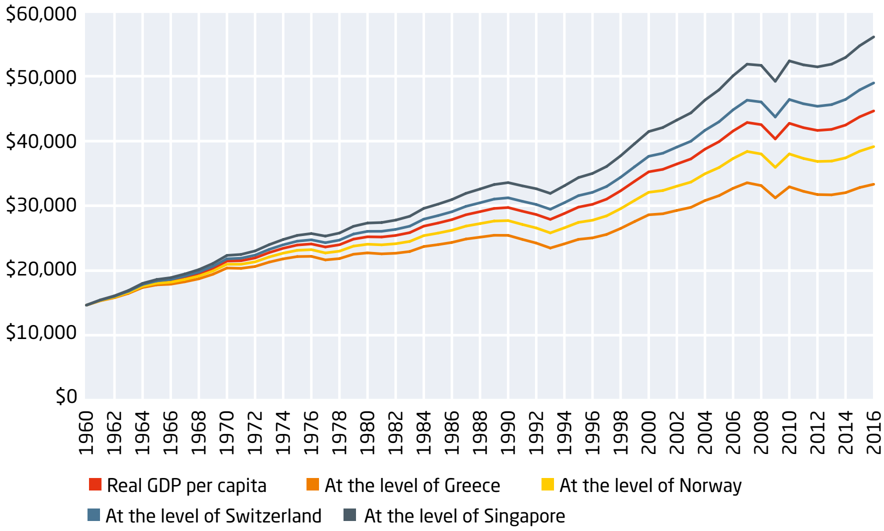
In other words, the average Swede would have been $11,426 better off if Swedish students had performed at the level of Singaporean students, while test scores on a par with Swiss students would have increased the purchasing power of the average Swede by $4,321. Education reforms that improve Swedish students' performance levels in international tests therefore appear important from an economic perspective.

Figure 3. Sweden's annual average per-capita growth 1960-2016 at different levels of international test score performance



Note: The calculations are based on the results reported in Table A1, which show that a one standard deviation increase in test scores (equivalent to 100 PISA points) raises annual average per-capita growth by 1.3 percentage points. The blue bar displays Sweden's actual growth rate, while the other bars have been calculated by adding the predicted increase (or decrease) in growth that would arise at the different performance levels to Sweden's actual growth rate.

Figure 4. Simulations of Sweden's GDP per capita in 1960-2016 at different levels of international test score performance

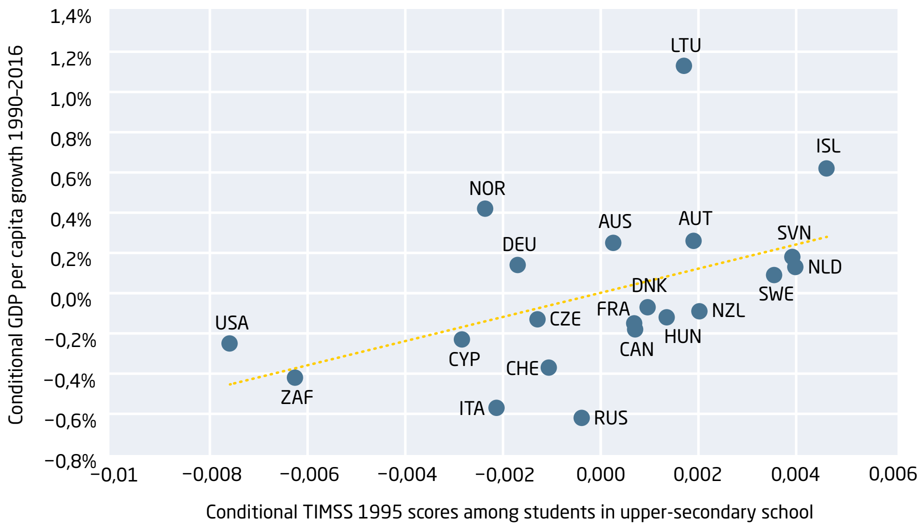


Note: The calculations are based on the results reported in Table A1, which show that a one standard deviation increase in test scores (equivalent to 100 PISA points) raises annual average per-capita growth by 1.3 percentage points. The different scenarios have been calculated by adding the difference between the counterfactual and actual annual average growth rates to the actual growth rate in each year.

3.1. The impact of scores in tests conducted in upper-secondary school

In this section, we display the relationship between results in TIMSS 1995 among students in the final year of upper-secondary school and average annual growth in the period 1990–2016. These data are only available for 21 countries, but the results indicate that upper-secondary school quality is indeed related to per-capita growth. While the impact is smaller compared with the one in Figure 1, which is obtained using scores from tests conducted in primary, lower-secondary, and upper-secondary school, it is important to note the shorter growth period analysed and that the number of countries included is fewer than half compared with Hanushek and Woessmann's dataset. The relationship in Figure 5 suggests that countries scoring 100 points higher in TIMSS 1995 had 0.61 percentage points higher growth annually between 1990 and 2016. Given the shorter growth period, and the fact that the impact is included in the simulations in Figures 3 and 4, we do not report further simulations for upper-secondary school only.[6]

Figure 5. The relationship between upper-secondary school quality and per-capita GDP growth



Note: Added variable plot showing the relationship between TIMSS 1995 scores among students in the final year of upper-secondary school and the average annual per-capita growth in the period 1990-2016, adjusted for (log) GDP per capita in 1990 and years of schooling in 1995. The values on the x and y axes correspond to the differences between the countries' actual values on the variables and the values predicted by the control variables.

3.2. The relative effects of students reaching basic literacy and top-performing students

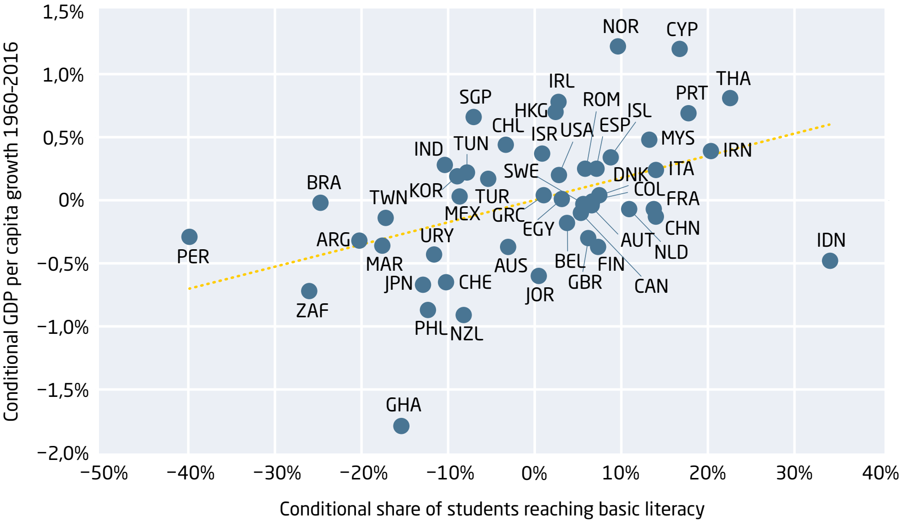
In this section, we analyse the relationship between economic growth and (1) the share of students reaching basic literacy as well as (2) the share of top-performing students in international tests. The share of students reaching basic literacy is defined as the share who score at least 400 points – equivalent to one standard deviation below the OECD average – in Hanushek and Woessmann's dataset, while the share of top-performing students is defined as the share who score at least 600 points – equivalent to one standard deviation above the OECD average – in this dataset.

The results in Figures 6 and 7 show that both groups of students are important for growth, but that top-performing students are considerably more important than

[6] As displayed in Table A1, years of schooling in 1995 is only weakly positively related to growth in this model. Since we have already displayed the relationship between this measure and growth in Figure 2 – which is based on a regression that includes a much larger number of countries and analyses a longer growth period than the regression on which Figure 5 is based – we do not display these findings graphically.

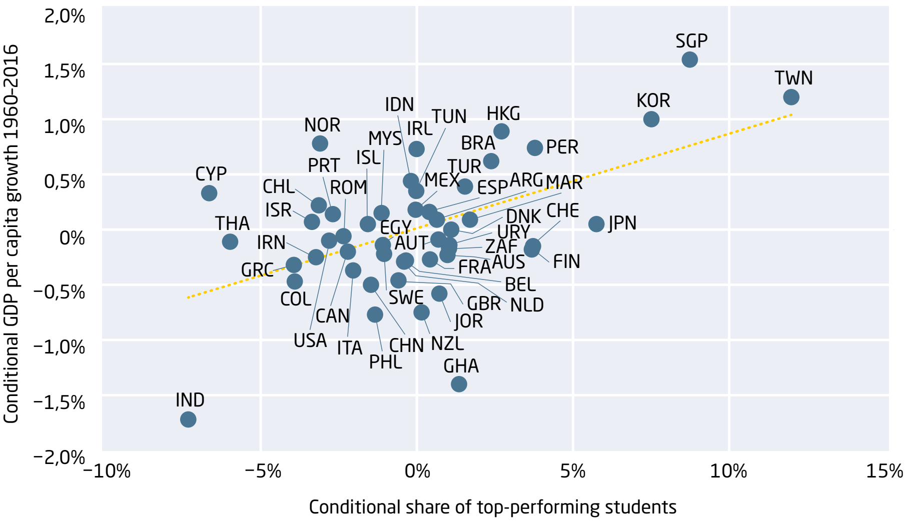
students reaching basic literacy. While a 10 percentage point increase in the share of students reaching basic literacy raises the annual growth rate by 0.18 percentage points, an equivalent increase in the share of top-performing students raises the annual growth rate by 0.87 percentage points.[7]

Figure 6. The relationship between the share of students reaching basic literacy and per-capita GDP growth



Note: Added variable plot showing the relationship between the share of students reaching basic literacy and the average annual per-capita growth in the period 1960-2016, adjusted for (log) GDP per capita and years of schooling in 1960 as well as the share of top-performing students. The values on the x and y axes correspond to the differences between the countries' actual values on the variables and the values predicted by the control variables.

Figure 7. The relationship between the share of top-performing students and per-capita GDP growth



Note: Added variable plot showing the relationship between the share of top-performing students and the average annual per-capita growth in the period 1960-2016, adjusted for (log) GDP per capita and years of schooling in 1960 as well as the share of students reaching basic literacy. The values on the x and y axes correspond to the differences between the countries' actual values on the variables and the values predicted by the control variables.

According to Hanushek and Woessmann's aggregated scores from tests conducted between 1963 and 2003, Sweden has historically had a high share of students reaching basic literacy – but at the same time relatively few top-performing students.

[7] We analysed the potential interaction between the share of students reaching basic literacy and the share of top-performing students, but found little evidence of any interaction effects.

About 9 percent of Swedish students were top performing on average, while fully 94 percent reached the threshold for basic literacy. This should be compared with Singapore, in which 95 percent of students reached basic literacy and 18 percent of students were top performing. In the period analysed, therefore, there was little scope to increase growth by raising the share of students reaching basic literacy, but there was considerable scope to increase growth by increasing the share of top-performing students.

To calculate the share of students reaching basic literacy and the share of top-performing students today, we use the thresholds used by the OECD in PISA 2015, which roughly correspond to those used by Hanushek and Woessmann. Students reaching basic literacy are defined as those who attain at least level 2, which corresponds to 407–420 PISA points depending on subject, while top-performing students are defined as those who attain at least level 5, which corresponds to 607–633 PISA points depending on subject. On average, 80 percent of students in Sweden reached basic literacy in PISA 2015, compared with 91 percent of students in Singapore. At the same time, only 10 percent of students in Sweden were top performing in PISA 2015, a considerably smaller figure than in Singapore where 26 percent of students were top performing.

There is therefore more scope to increase Swedish economic growth by raising the share of students reaching basic literacy today, compared with the growth period analysed in the report. Still, the growth potential of doing so is considerably smaller than if the country managed to increase the share of top-performing students. Indeed, if the share of Swedish students reaching basic literacy were to increase to Singapore's levels, one would expect Sweden's growth rate to rise by roughly 0.20 percentage points. On the other hand, if the share of top-performing students in Sweden were to increase to Singapore's levels, one would expect Sweden's growth rate to rise by roughly 1.39 percentage points.

Overall, since top-performing students appear so important for growth, Swedish education policy should ensure that gifted children are able to reach their true potential, rather than merely focusing on improving the results of low-performing students.

4. Factors affecting international test scores

Since countries' scores in international tests are strongly linked to their economic performance, an important question is: how can a country improve its results in such tests? In this section, we discuss factors that research finds affect international test scores. We are especially interested in cost-effective policies and practices. We limit the review to factors that have been found to affect international test scores specifically, such as PISA and TIMMS scores, and that are relevant for the Swedish education-policy debate.

We focus on the following five factors:

- Independent-school competition
- Central exit exams
- Instructional time
- Homework
- Pedagogical methods

However, we do not discuss different types of resource-based factors (such as class size), information about education quality, school league tables, or school inspections. This is either because there are no studies analysing the effects of these factors on international test scores, or because such studies do not find any significant effects in general. In some cases, there is research finding effects of the factors on other outcomes, as in the case of class size, but it is difficult to extrapolate them to cross-national differences in international surveys. This is partly because (1) the alternative outcomes analysed are often high stakes, whereas international test scores are low stakes, for students, (2) such research tends to analyse relatively small variation in some of the factors of interest compared with the variation that exists between countries, as in the case of independent-school competition, and (3) cross-national variation is often necessary to analyse the factors' system-level impact. For example, it is difficult to say much about the potential effects of doubling independent-school competition, if one has merely analysed the impact of increasing it by 10 percent.

4.1. Independent-school competition

There are various theoretical mechanisms linking school choice and independent schools to higher achievement (see Heller-Sahlgren 2013). For example, school choice may ensure that more students are able to find a school that fits them specifically. It may also lead to a re-allocation of students from low- to high-quality schools, which may expand by increasing the number of classes in existing schools or by opening new campuses. Also, independent schools may be better than government schools on average, and, if so, increasing independent-school enrolment shares should improve education quality by itself. However, the most important mechanism is likely that school choice and independent schools increase competition, which forces all schools, including those run by the government, to step up their game in order to attract students.

Research analysing international test scores finds that independent-school competition improves student performance in both PISA and TIMSS (Hanushek and Woessmann 2011b).[8] According to the most reliable studies, competition increases results both among students in independent and government schools, while also decreasing per-student expenditure. The possible productivity improvement is relatively large and does not depend on whether independent schools are publicly or privately funded (Heller-Sahlgren 2018; West and Woessmann 2010). Overall, the findings suggest that an increase in independent-school enrolment shares by 10 percentage points improves student performance by about 13 PISA points.

Overall, therefore, research suggests that independent schools – by generating competition – are an efficient tool for increasing growth via higher international test scores. This finding is also broadly in line with a Swedish study on the subject, which shows that independent-school competition improves outcomes in TIMSS without affecting expenditures (Böhlmark and Lindahl 2015).[9]

4.2. Central exit exams

The lack of reliable outcome measures in Swedish education is frequently criticised in the policy debate.[10] Since student grades are decided entirely by individual teachers, and because those grades are a key admissions tool in upper-secondary and tertiary education, the system is fundamentally unfair: students in schools with lax grading practices benefit at the expense of students in schools with stricter grading practices. Average outcomes may also decline, as motivation to work hard is likely to decrease if diligence and persistence do not give students a competitive advantage. Additionally, the lack of reliable grades makes it difficult for parents and authorities to assess school quality, while decreasing the informational value of grades and therefore worsening the matching process between individuals and further education and jobs. Indeed, if there were nationally comparable achievement measures, it would likely be easier to match the right person to the right education or job.

Research in education economics has empirically analysed the effects of central exit exams, which all students in some countries – or regions within countries – take, normally at the end of secondary school. However, in contrast to the situation in France, Japan, the Netherlands, Singapore, and the UK, students in Sweden do not take such exams. This is important since research frequently shows a robust positive relationship between the existence of central exit exams and student performance in international tests (see Bishop 1997; Woessmann 2018). And this relationship appears to be causal. For example, Jürges et al. (2005) compare student achievement in

[8] In a recent report, the OECD (2019, p. 91) claims that "the systemic effects of competition are more unclear. PISA shows no relationship between competition and results in cross-country comparisons". Yet this is because the OECD analyses the simple cross-national relationship between competition and performance, without adjusting for other variables; there are many cross-national differences that must be held constant when analysing the effects of school competition using international data. The academic research referenced above analyses student-level data and exploits methods with which it is more reasonable to draw causal inferences. And, as noted, this research finds positive effects on PISA results and negative effects on per-student expenditure.

[9] Hennerdal et al. (2018) question Böhlmark and Lindahl's (2015) results, finding little support for the idea that independent schools improve outcomes in compulsory education. Yet their study suffers from several problems, which make it considerably less reliable than Böhlmark and Lindah's research. This is because Hennerdal et al. (2018) utilise a method that does not capture the causal impact of independent-school competition. The authors simply study the cross-sectional correlation between independent-school enrolment shares at the municipal level and student achievement. This differs from Böhlmark and Lindahl's research design, which focuses on whether changes in independent-school enrolment shares generate changes in outcomes over time. This approach adjusts for all constant differences – observable and unobservable – between municipalities, which affect both independent-school enrolment shares and outcomes. Also, they adjust for changes in several observable factors at the municipal level, which may be related to changes in independent-school competition.

[10] For example, see Heller-Sahlgren and Jordahl (2016), Henrekson (2017), and Henrekson and Vlachos (2009).

TIMSS across German states with and without central exit exams, exploiting the fact that students who take such an exam do it in mathematics but not in science, both of which are tested in TIMSS. The idea is that central exit exams should improve results only in the subject that is tested in those exams. The authors therefore investigate whether German students in states with central exit exams perform better in TIMSS mathematics than in TIMSS science, compared with students in states without such exams. The results suggest that this is indeed the case: central exit exams improve student mathematics scores by 0.13 standard deviations, which is equivalent to about 13 TIMSS points, and equivalent to the performance difference between Sweden (501 points) and Hungary (514 points) in TIMSS 2015.

More recently, Jürges and Schneider (2010) use the same methodology and find a similar effect size: central exit exams raise achievement in TIMSS mathematics by 0.11 standard deviations, which is equivalent to about 11 TIMSS points. They also investigate potential mechanisms explaining the effects and show that teachers in states with central exit exams give more homework as well as check and discuss homework more often in the classroom. Students also experience increased learning pressure and consider mathematics more difficult and boring, indicating that central exit exams may also have downsides.

In a further contribution, Federičová and Münich (2017) analyse the effects of a reform in Slovakia, which shifted the timing of a central admissions exam from grade 4 to grade 5 in primary school. In robustness tests, they also use students in Czechia as a control group. The findings show that central exams improve average results among 10-year old students in TIMSS by between 0.14 and 0.19 standard deviations, equivalent to 14 and 19 TIMSS points respectively. We calculate the unweighted average of all four reported estimates and obtain an impact of about 0.14 standard deviations, or 14 TIMSS points.

4.3. Instructional time

Compared with students in other countries, Swedish students do not spend much time in the classroom. Indeed, a 2004 comparison of 23 OECD countries showed that Swedish 15-year old students received less instructional time than students in all other countries included in the comparison. Students in Sweden received 741 instructional hours per year, which may be compared with 855 hours in Norway, 892 hours in Germany, 978 hours in Spain, and 1,042 hours in France (see OECD 2006). The question is whether Swedish students are harmed as a result of receiving less instructional time.

Intuitively, it would make sense that more instructional time generates higher student achievement, since it allows teachers (1) to teach more material and go more in-depth into specific subjects, and (2) to vary and individualise instruction, while (3) having more time to answer students' questions (Farbman 2015). Indeed, several studies indicate that more instructional time improves student achievement. For example, Dobbie and Fryer (2013) show that instructional time is positively associated with student performance among New York charter schools. And in a study analysing PISA results, Rivkin and Shiman (2015) find that more instructional time improves student performance. Meanwhile, Pischke (2007) investigates the effects of an unusually short school year in West Germany, which arose when the start of the school year was changed from spring to autumn in 1966–67, finding that a shorter school year led to increased grade repetition and a decreasing number of students attending higher secondary school tracks.

In this report, we focus on a study by Lavy (2015), which compares PISA results in 22 OECD countries. Instructional time is measured in hours per week separately in mathematics, science, and test language. By exploiting the fact that instructional hours vary across subjects for the same students, the study is likely able to separate causation from correlation. Merely comparing instructional time and average results across schools risks either exaggerating the effect, if, for example, high-performing students actively choose resource-rich schools with more instructional time, or underestimating the effect, if, for example, schools with low-performing students choose to have more instructional time to help their students catch up. Lavy circumvents this problem by comparing the performance of the same student in different subjects. That is, he analyses whether a student performs better in one subject than in the other subjects, if they receive more instructional time in the former. The results show that one more instructional hour per week in mathematics, science, or the test language improves achievement in these subjects by about 6 points. The impact is certainly not insignificant, but increasing instructional time is expensive since teacher salaries must increase commensurately.

4.4. Homework

The impact of homework is a much-debated topic, in Sweden and elsewhere. How does it affect international test scores? There are a few studies that seek to answer this question. For example, Gustafsson (2013) analyses data from several countries participating in TIMSS 2003 and 2007, and finds a positive impact of homework among students in grade 8. In perhaps the most reliable study available, Falch and Rønning (2012) analyse data from TIMSS 2007 and also find positive effects on achievement. Yet the effect size is small: the results suggest that assigning homework in all or almost all lessons, compared with assigning no homework at all, improves TIMSS performance by about 3 points only.

One possible reason explaining the small effect size is that the impact depends on the quality of the homework assigned, which is also likely to vary across countries. Indeed, it is noteworthy that the effect of homework in Sweden, according to Falch and Rønning's (2012) results, in fact is negative, in contrast to other countries included in the analysis. Meanwhile, the effects in Australia, Austria, and the US are about three times as large as the average impact.

Overall, we therefore note that the average effect of homework on international test scores is positive, but that the quality of homework is probably important. In our simulations in Section 5.4, we assume that the hypothetical increase in assigned homework would be of a quality comparable to the international average.

4.5. Pedagogical methods

Whether traditional or modern pedagogical styles are best for improving achievement is subject to considerable debate. From a scientific standpoint, the issue is challenging to study since pedagogical styles are difficult to observe and cannot readily be approximated by observable teacher characteristics such as gender, age, education, and experience. Overall, in Sweden and in several other countries, there is little doubt that "traditional", teacher-directed instructional styles have increasingly been replaced with "modern", student-centred practices. While teacher-directed instruction is based on features such as whole-class teaching, practice, and repetition, student-centred instruction involves more project work, group work, and increased use of ICT.[11]

[11] For a more detailed discussion about traditional and modern teaching strategies, see Le Donné et al. (2015).

Available research generally indicates that traditional, teacher-led instructional methods improve achievement, while student-centred methods are less effective or may even decrease achievement. Most of this research analyses within-country variation (e.g. Kirschner et al. 2006; Machin and McNally 2008; Schwerdt and Wuppermann 2011).

For our purposes, Cordero and Gil-Izquierdo's (2018) study is of particular interest. The study exploits PISA data that have been linked to the Teaching and Learning International Survey (TALIS) at the school level in eight countries. This enables the authors to study the relationship between teacher methods, as measured in TALIS, and student performance in PISA. The authors focus on the Spanish dataset, using two indices of teaching styles: an index of teacher-directed instruction and an index of active learning practices, which indicate more student-oriented instruction.[12] The authors use PISA mathematic scores as outcome variable, exploiting instructional practices among teachers in other subjects at the same school to predict instructional practices among mathematics teachers. This is in order to avoid the fact that instructional practices may be the result, rather than cause, of student achievement. The results show that one standard deviation more teacher-directed instruction raises PISA results by 13 points, while one standard deviation more active learning practices lowers PISA results by 31 points.[13]

These effects are large, especially considering that it is not necessarily expensive to switch instructional styles. Certainly, it is important to note that instructional styles are not policy variables that easily can be modified through political decisions. Yet it would be possible to reform curriculums, education laws, and teacher education, to encourage teachers to use more teacher-led instruction, which is likely to have an impact on practices over time.

[12] Note that high scores on one index do not necessarily lead to low scores on the other. There are other teaching styles, including "cognitive activation", which is used to motivate students as well as stimulate critical thinking and problem solving (see Le Donné et al. 2015).

[13] See Columns 1–2 in Cordero and Gil-Izquierdo's (2018) Table 3. Since teachers in all schools in the study to some extent use both teaching styles, the findings cannot technically be extrapolated to situations in which schools would stop using teacher-directed or active learning practices entirely.

5. Simulating the effects on Sweden's per-capita GDP growth

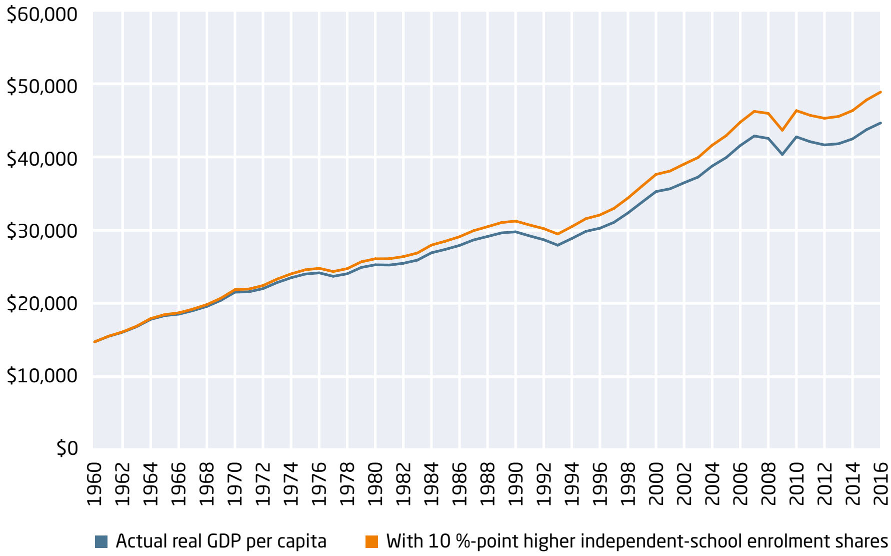
In this section, we simulate the indirect effects of the factors discussed in Section 4 on Sweden's growth rate and per-capita GDP over time. However, since the factors may act as complements or substitutes, we only study them separately and do not attempt to calculate their aggregate impact.

5.1. Independent-school competition

To what extent may independent schools affect growth by improving student performance in international surveys? It is possible to estimate the answer to this question by combining West and Woessmann's (2010) findings with the results from our analysis of the relationship between international test scores and growth in the period 1960–2016. Doing so suggests that an increase in the independent-school enrolment share among 15-year old students by 10 percentage points would raise growth by about 0.16 percentage points.[14]

We then use this estimate to simulate the counterfactual change in the average annual per-capita GDP growth in the period 1960–2016, under the assumption that Sweden would have had a 10 percentage point larger independent-school enrolment share throughout this period, compared with the actual enrolment share each year. Sweden's per-capita GDP growth was 2.04 percent per year in the period 1960–2016; if the country would have had a 10 percentage point larger independent-school enrolment share throughout the period, average annual growth would instead have reached 2.22 percent.

Figure 8. Simulation of Sweden's GDP per capita 1960-2016 with higher independent-school competition



Note: The calculations are based on West and Woessmann's (2010) findings regarding the impact of independent-school competition on PISA scores and our results regarding the impact of test scores on growth.

[14] This calculation is based on West and Woessmann's (2010) Column 3 in Table 2, which shows that the impact of a 10 percentage-point increase in the independent-school enrolment share generates 12.6 points higher PISA scores. According to our results, an improvement by 100 PISA points generates 1.3 percentage points faster growth = 0.126*0.013 = 0.00164.

Finally, Figure 8 shows the simulation of Sweden's per-capita GDP in the period 1960–2016, based on the above calculations. Instead of the country's actual GDP per capita of $44,659 in 2016, it would have been able to reach a GDP per capita of $48,889; if the independent-school enrolment share had been 10 percentage point larger since 1960. Since independent-school competition also appears to lower per-student expenditures, as noted in Section 4.1, this clearly highlights the economic benefits of independent-school competition.

5.2. Central exit exams

As discussed in Section 4.2, central exits exams appear to have a robust positive impact on international test scores. Here, we calculate the indirect effect on growth by combining the results in studies by Jürges et al. (2005), Jürges and Schneider (2010), and Federičová and Münich (2017), which analyse TIMSS data in Germany and Slovakia respectively, with the results from our analysis of the relationship between international test scores and growth in the period 1960–2016. Our findings suggests that if Swedish students were to take central exit exams, annual average GDP per capita growth would increase by 0.18 percentage points.[15]

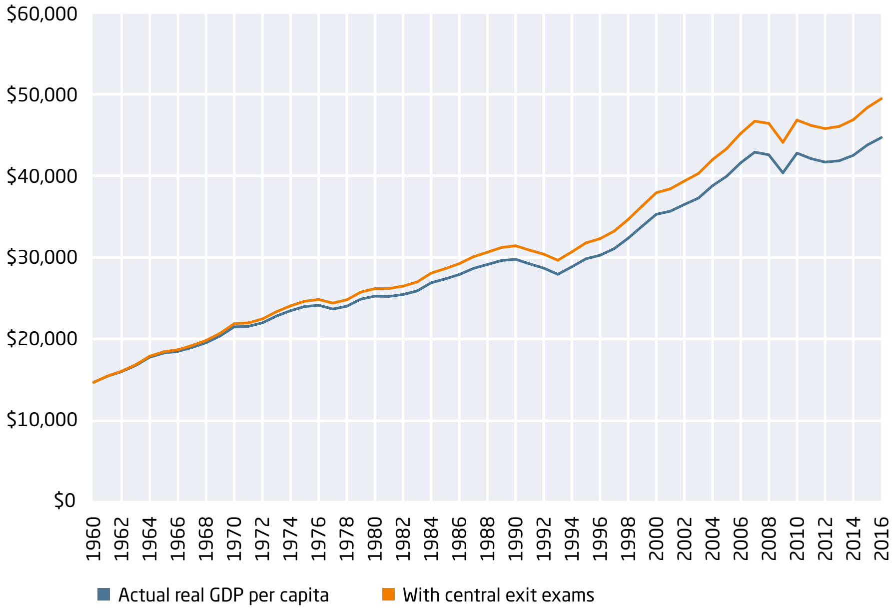
We then use this estimate to simulate the counterfactual change in the average annual per-capita GDP growth in the period 1960–2016, under the assumption that Sweden would have had central exit exams throughout this period. Sweden's per-capita GDP growth was 2.04 percent per year in the period 1960–2016; if the country would have had central exit exams, average annual growth would instead have reached 2.23 percent.

Finally, Figure 9 shows the simulation of Sweden's per-capita GDP in the period 1960–2016, based on the above calculations. Instead of the country's actual GDP per capita of $44,659 in 2016, it would have been able to reach a GDP per capita of $49,420; if students had been taking central exit exams.

The cost of introducing such exams in Sweden would be relatively low, since they could replace the national proficiency tests that are currently taken in the last years of lower- and upper-secondary school. By anonymising and digitising the exams, and having teachers mark exams taken by students in other schools, the cost of marking would also be minimised. Overall, therefore, introducing central exit exams could be of great economic importance in a longer-term perspective.

[15] This calculation is based on the average of the estimates in Jürges et al.'s (2005) Column 4 in Table 3, Jürges and Schneider's (2010) Panel 1 in Table 5, and Federičová and Münich's (2017) Column 1, Panel 1 in Table 4 as well as Column 4 in Table 5. These estimates show that central exit exams improve student achievement by about 14.1 TIMSS points on average. According to our results, an improvement by 100 TIMSS points generates 1.3 percentage points faster growth = 0.141*0.013 = 0.00183.

Figure 9. Simulation of Sweden's GDP per capita 1960-2016 with central exit exams



Note: The calculations are based on the findings of Jürges et al's (2005), Jürges and Schneider (2010), and Federičová and Münich (2017) regarding the impact of central exit exams on TIMSS scores and our results regarding the impact of test scores on growth.

5.3. Instructional time

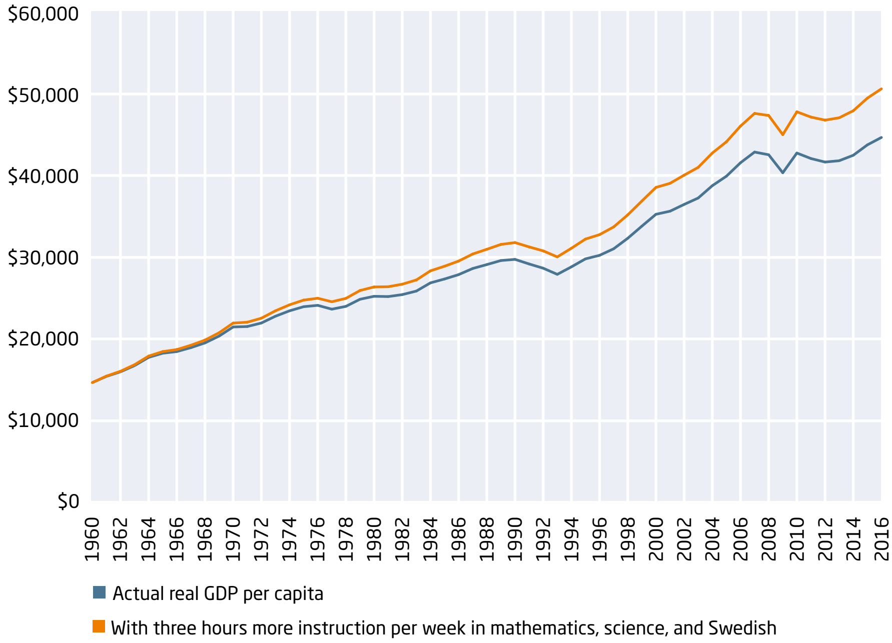
As discussed in Section 4.3, instructional time has positive effects on student achievement in international tests. Here, we calculate the indirect impact on growth by combining the results in Lavy's (2015) study with the results from our analysis of the relationship between international test scores and growth in the period 1960–2016. Our findings suggests that if Swedish students were to receive three hours extra instruction in mathematics, science, and Swedish per week – that is, nine hours additional instruction per week – annual average GDP per capita growth would increase by 0.23 percentage points.[16]

We then use this estimate to simulate the counterfactual change in the average annual per-capita GDP growth in the period 1960–2016, under the assumption that Sweden would have had three hours more instruction per week in each subject continuously in this period. Sweden's per-capita GDP growth was 2.04 percent per year in the period 1960–2016; if the country would have had three hours more instruction per week in each subject in this period, average annual growth would instead have reached 2.27 percent.

Finally, Figure 10 shows the simulation of Sweden's per-capita GDP in the period 1960–2016, based on the above calculations. Instead of the country's actual GDP per capita of $44,659 in 2016, it would have been able to reach a GDP per capita of $50,605; if students had received three hours extra instruction per week in mathematics, science, and Swedish respectively.

[16] This calculation is based on Lavy's (2015) Column 2, Panel 2 in Table 3, which shows that the impact of an additional hour of instruction improves PISA results by 5.8 points. We therefore assume that the impact of instructional time is constant across subjects and that scores in each subjects have the same effect on growth. Increasing the average PISA score by 17.4 (5.8*3) points would therefore require three additional hours in each subject. According to our results, an improvement by 100 PISA points generates 1.3 percentage points faster growth = (0.058*0.013)*3 = 0.00226.

Figure 10. Simulation of Sweden's GDP per capita 1960–2016 with more instructional time



Note: The calculations are based on Lavy's (2015) findings regarding the impact of instructional time on PISA scores and our results regarding the impact of test scores on growth.

Increasing instructional time would therefore likely have a positive impact on Sweden's level of prosperity in a longer-term perspective. However, increasing it by three hours in mathematics, science, and Swedish per week respectively, which appears to be necessary for instructional time to rival independent-school competition and central exit exams in terms of growth effects, would be very expensive. For this reason, improving international test scores by increasing instructional time appears considerably less efficient compared with stimulating more independent-school competition, which both decreases costs and raises achievement, and introducing central exit exams, which probably can be done relatively cheaply.

5.4. Homework

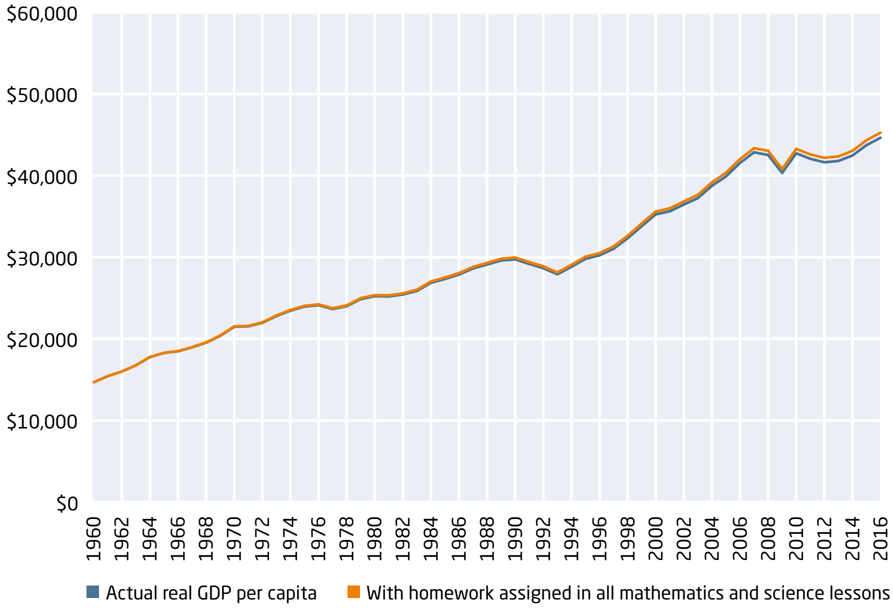
As discussed in Section 4.5, homework in mathematics and science has small but positive effects on achievement in international surveys. Here, we calculate the indirect effect on growth by combining the results in Falch and Rønning's (2012) study with the results from our analysis of the relationship between international test scores and growth in the period 1960–2016. We assume that the hypothetical increase in assigned homework would be of a quality that is comparable to the average effect across the 16 countries analysed by the authors. Our findings suggest that if the Swedish students who were either not assigned any homework at all, or who were not assigned homework in at least half of their mathematics and science lessons, would be assigned homework in all lessons, annual average GDP per capita growth would increase by 0.02 percentage points.[17] This must be considered a small impact, especially since it would require significant pedagogical changes.

[17] This calculation is based on Falch and Rønning's (2012) Column 5 in Table 5, which shows that (1) moving from "Homework not given" to homework in "Every or almost every lesson" raises TIMSS scores by 2.4 points, (2) moving from homework in "Some lessons" to homework in "Every or almost every lesson" raises TIMSS scores by 1.8 points, and (3) moving from homework in "About half of the lessons" to homework in "Every or almost every lesson" improves TIMSS scores by 1.2 points. According to their Table 1, an average of 24.6 percent of Swedish students were not assigned any homework at all, 66.4 percent of students were assigned homework in some lessons, and 6.6 percent of students were assigned homework in about half of the lessons. According to our results, an improvement by 100 TIMSS points generates 1.3 percentage points faster growth = (0,024*0,013)*0,246 + (0,018*0,013)*0,664 + (0,012*0,013)*0,066 = 0,00024.

We then use the estimate to simulate the counterfactual change in the average annual per-capita GDP growth in the period 1960–2016, under the assumption that all Swedish students would have been given homework in all mathematics and science lessons continuously in this period. Sweden's per-capita GDP growth was 2.04 percent per year in the period 1960–2016; if students would have been given homework in all mathematics and science lessons in this period, average annual growth would instead have reached 2.07 percent.

Finally, Figure 11 shows the simulation of Sweden's per-capita GDP in the period 1960–2016, based on the above calculations. Instead of the country's actual GDP per capita of $44,659 in 2016, it would have been able to reach a GDP per capita of $45,262; if students had been assigned homework in all mathematics and science lessons. Compared with independent-school competition, central exit exams, and instructional time, the impact of homework therefore appears to be of marginal importance to Sweden's level of prosperity.

Figure 11. Simulation of Sweden's GDP per capita 1960-2016 with more homework assigned



Note: The calculations are based on Falch and Rønning's (2012) findings regarding the impact of homework on TIMSS scores and our results regarding the impact of test scores on growth.

5.5. Pedagogical methods

As discussed in Section 4.5, more traditional teaching styles appear to improve, and more student-centred teaching styles appear to decrease, international test scores. Here, we calculate the indirect effect of traditional and student-centred methods on growth by combining the results in Cordero and Gil-Izquierdo's (2018) study with the results from our analysis of the relationship between international test scores and growth in the period 1960–2016. If Swedish students would receive one standard deviation more instruction characterised by student-centred, active learning practices, according to the TALIS index, annual average GDP per capita growth would fall by 0.4 percentage point. If they instead would receive one standard deviation more teacher-directed instruction, according to the TALIS index, annual average GDP per capita growth would instead increase by 0.17 percentage point.[18]

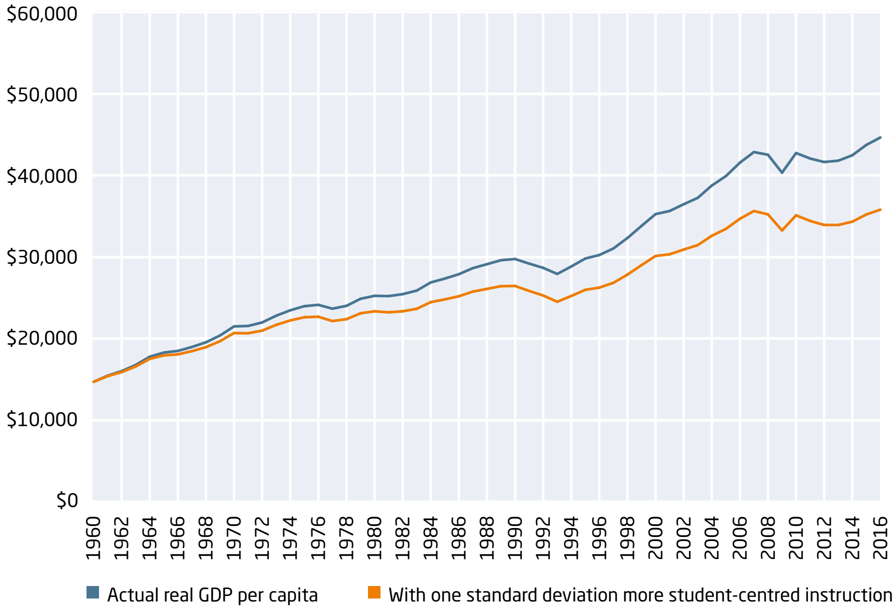
We then use these estimates to simulate the counterfactual changes in the average annual per-capita GDP growth in the period 1960–2016, under the assumption that instruction on average would have been one standard deviation more student centred or teacher directed respectively. Sweden's per-capita GDP growth was 2.04 percent per year in the period 1960–2016. If instruction would have been one standard deviation more student centred, average annual growth would instead have been 1.64 percent. But if instruction would have been one standard deviation more teacher directed, annual average growth would have reached 2.21 percent.

Figures 12 and 13 show the simulation of Sweden's per-capita GDP in the period 1960–2016, based on the above calculations. Instead of the country's actual GDP per capita of $44,659 in 2016, it would have been seen a GDP per capita of just $35,810; if instruction had been one standard deviation more student centred on average. If instruction instead had been one standard deviation more teacher directed, the country's GDP per capita would have reached a GDP per capita of $48,986.

Making instruction less student centred – by decreasing the amount of group work, project work, and ICT usage – and more teacher directed – by increasing whole-class teaching, practice, and repetition – would therefore likely have a positive impact on Sweden's level of prosperity in a longer-term perspective. Certainly, it is difficult to directly affect classroom methods through education policy, but it would be reasonable to start by changing the national curriculum and education law in the right direction. Similarly, it would be desirable to reform teacher education to stimulate the adoption of more effective instructional styles among teacher students. Such changes would not be expensive, since little suggests that more traditional teaching styles are more expensive than student-centred styles – if anything, the opposite is true. Teacher-directed and student-centred instruction merely differ in terms of time-use patterns among teachers. At the same time, it would be difficult to know whether any potential reforms would in the end actually affect classroom practices, which would be necessary for growth to improve via increased student achievement.

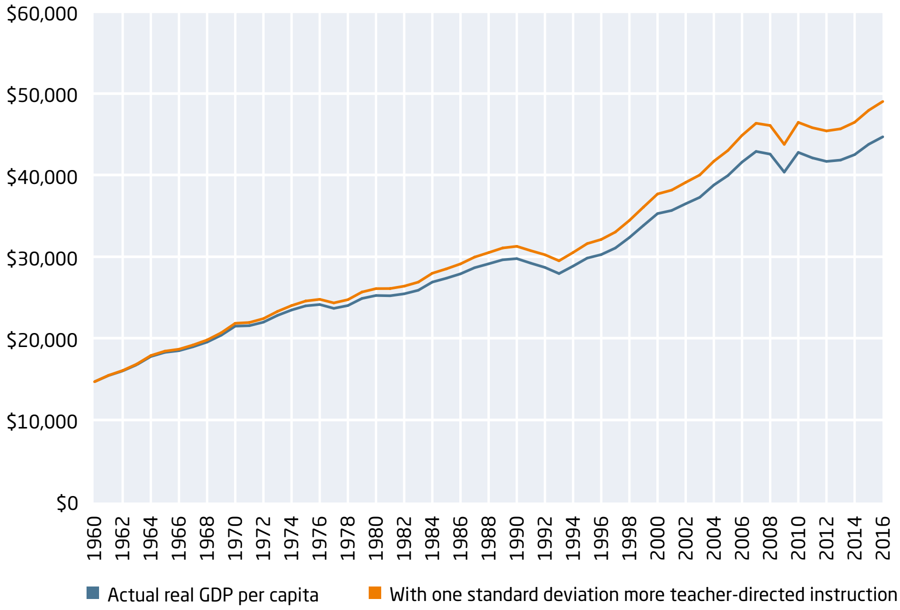
[18] This calculation is based on Cordero and Gil-Izquierdo's (2018) Columns 1 and 2 in Table 3, which show that one teacher-level standard deviation more instruction characterised by student-centred, active learning practices in TALIS decreases PISA results by 31 points, while one standard deviation more teacher-directed instruction in TALIS improves PISA results by 13 points. According to our results, an improvement by 100 PISA points generates 1.3 percentage points faster growth = 0.31*0.013 = 0.00403 and 0.13*0.013 = 0.00169.

Figure 12. Simulation of Sweden's GDP per capita 1960–2016 with more student-centred instruction



Note: The calculations are based on Cordero and Gil-Izquierdo's (2018) findings regarding the impact of student-centred instruction on PISA scores and our results regarding the impact of test scores on growth.

Figure 13. Simulation of Sweden's GDP per capita 1960–2016 with more teacher-directed instruction



Note: The calculations are based on Cordero and Gil-Izquierdo's (2018) findings regarding the impact of teacher-directed instruction on PISA scores and our results regarding the impact of test scores on growth.

6. Conclusion

There are many potential benefits of education, one of which is its positive impact on economic growth. Given Sweden's knowledge-intensive economy, and its large public sector, increasing human capital and economic growth is key. In the long-term perspective, it will otherwise simply be impossible to maintain high public and private consumption levels.

For this reason, the fact that high student achievement in international surveys, such as PISA and TIMSS, translates into more rapid growth is important. If Swedish students had performed at the level of Singaporean students in international surveys in the period 1960–2016, the country's purchasing-power adjusted GDP per capita would have been about $11,400 higher than it is today. While these types of back-of-the-envelope calculations are necessarily tentative, they clearly indicate that education policy can have an important impact on economic development.

At the same time, it is important to note the importance of ensuring a high minimum level of knowledge and skills as well as maximising the share of top-performing students. In fact, the impact of the share of top-performing students on economic growth is five times as strong as the impact of the share of students reaching basic literacy. Since top-performing students appear to be key for growth, education policy should ensure that gifted children are allowed to reach their true potential, rather than merely focusing on improving the results of low-performing students.

Based on research in the economics of education analysing international test scores, we have investigated the potential growth effects of five policy-relevant factors of importance in the Swedish education debate. The results are encouraging: increasing independent-school enrolment shares, introducing central exit exams, decreasing student-centred instruction, and increasing teacher-directed instruction would boost growth and thereby enable higher private consumption and improved public services. If such changes would have occurred already in 1960, Sweden's purchasing-power adjusted GDP per capita would have been between $4,000 and $9,000 higher today. The effects of all factors cannot be aggregated and the effect sizes should therefore be interpreted with some caution. In other words, our back-of-the-envelope calculations merely provide an indication of the economic value of the education-policy actors analysed.

At the same time, assigning more homework to students would only have a small impact on international test scores and economic growth. Admittedly, increasing instructional time by three hours per week in mathematics, science, and Swedish respectively would have a similar effect as increasing independent-school competition by 10 percentage points, introducing central exit exams, and making instruction one standard deviation more teacher directed. Yet increasing instructional time by nine hours in total per week would indubitably be the most expensive reform of those discussed in this report, since teacher salaries must increase commensurately.

Overall, from an economic perspective, we therefore recommend that policymakers seek to improve Sweden's international test scores by supporting and expanding independent-school competition via the voucher system, introducing central exit exams, and encouraging more traditional teaching styles by reforming the national curriculum and education law as well as teacher-education courses.

More generally, a key lesson from our analysis is that the economic consequences of education reform are simply too large to be ignored. Indeed, ignoring them increases the risk of policymakers' crafting policies that neither improve student achievement nor strengthen the economy. Because as our report shows, knowledge is not just power – it also generates prosperity.

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Appendix

Table A1. The relationship between education and per-capita GDP growth

	(1)	(2)	(3)		(4)
		1960-2016			1990-2016
	Excluding Zimbabwe	Excluding Zimbabwe	Including Zimbabwe		Upper-secondary school quality
Average test score		0.013***	0.014***	TIMMS 1995 score	0.006***
		(0.002)	(0.002)		(0.002)
Years of schooling (1960)	0.002***	0.000	−0.000	Years of schooling (1995)	0.001*
	(0.001)	(0.000)	(0.001)		(0.001)
(log) GDP per capita (1960)	−0.013***	−0.011***	−0.010***	(log) GDP per capita (1990)	−0.009***
	(0.002)	(0.001)	(0.002)		(0.0003)
Adjusted R^2	0.46	0.80	0.65		0.37
n	49	49	50		21

	(5)	(6)
	1960-2016	
	Excluding Zimbabwe	Including Zimbabwe
Share of top-performing students	0.087***	0.106***
	(0.024)	(0.030)
Share of students reaching basic literacy	0.018***	0.015**
	(0.006)	(0.006)
Years of schooling (1960)	−0.000	−0.000
	(0.000)	(0.000)
(log) GDP per capita (1960)	−0.011***	−0.009***
	(0.001)	(0.002)
Adjusted R^2	0.79	0.64
n	49	50

Note: Significance levels: *p<0.1; **p<0.05; ***p<0.01. Robust standard errors i parentheses.

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Arkitektkopia AB, Bromma, 2019