School Spending and Performance in Canada and Other High-Income Countries

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Executive Summary

Is Canada spending too much on its schools? This study answers this question by first comparing Canadian and provincial spending on K-12 education to that of other high-income OECD members, and then relating spending to performance on the OECD's Programme for International Student Assessment (PISA). Drawing on recent developments in human capital theory, the study treats performance on large-scale international achievement tests such as PISA as a measure of knowledge capital production, which has been shown to be a robust predictor of future economic growth and prosperity.

The average of 2018 PISA subject scores is used as a single core measure of knowledge capital production. Spending amounts are taken from OECD financial reports of per-student expenditures during the 2018 calendar year, expressed in US dollars adjusted by the 2018 purchasing power parity GDP index.

Canadian 2018 spending on elementary and secondary education ranked 14th among the 34 high-income countries in the study, just above the average of US$11,006, and fourth lowest among G7 members. Spending by the provinces was in the upper-middle range of national expenditures with highest spending Saskatchewan ranking fifth among high-income OECD countries, and lowest-spending British Columbia a little below the high-income OECD average. In the context of these pre-pandemic expenditures, Canadian spending on K-12 education was not excessive, falling comfortably within the mid-range of spending by high-income OECD members.

Canada has long enjoyed an excellent PISA record, achieving high scores on each of the reading, math, and science tests since the triennual assessments began in 2000. Canada's 2018 core score, calculated as the average of the three subject scores, was within the upper quartile of the 33 high-income OECD countries considered (Luxembourg was excluded in this part of the study). Statistical analysis found spending levels accounted for just 14% of the variance in core scores. A scatter plot of PISA core scores against spending shows that of the six nations in the top 25% of average 2018 PISA core scores, only the Republic of Korea was also in the top 25% of K-12 spending.

A separate analysis undertaken to include three non-OECD, strongly performing, high-income, "Asian tiger" economies, found largely similar results. In both analyses of relationships between spending and knowledge production, Canada placed among the highest scoring,

mid-spending countries. A similar, if less variable, pattern was found for the provinces, with top-scoring Alberta, Quebec, and Ontario in the mid-range of spending, while higher-spending Saskatchewan and Manitoba had significantly lower core PISA scores.

In the knowledge-capital model, increasing test scores are linked to economic growth regardless of spending. What matters is whether there is an increase in student knowledge and skill as measured by valid, reliable, and comparable international achievement tests, rather than how much money is spent. Yet if, as shown in this study, higher spending is not associated with higher test scores, it is not obvious how the production of knowledge capital may be increased in well-established legacy school systems given the disappointing record of attempted school improvement across OECD countries in recent decades. Returns from popular yet expensive reforms, such as smaller class sizes, extended teacher education, and consolidated administrative structures, have proven marginal at best, with PISA scores in most OECD countries remaining steady or falling.

Canada's PISA scores have been steadily, if slowly, declining. Canada's core PISA score, for instance, dropped 10 points from 2009 to 2018. In this context, finding effective ways to improve the production of knowledge capital in K-12 schools or, more accurately, in the young people in the age cohorts they enroll, becomes an increasingly pressing problem for education and economic policy.

The study concludes with a discussion of this issue, noting the attractions of distributed, innovation-enabling, and locally adopted alternatives to uniform, centrally directed modifications to established systems. Yet, regardless of the apparent practical or political feasibility of any proposed change to legacy education systems, the study's findings point to the importance of paying at least as much attention to comparative test scores as to comparative spending. This, in turn, points to the desirability of moving toward more PISA-like, competency based, internationally comparable student testing in Canada and the provinces.

In sum, valid, reliable, and comparable measures of student learning are more important than spending over the long term.

Introduction

Canadian students have performed well on international standardized tests, especially the "gold standard" Programme for International Student Assessment (PISA), measuring the performance of 15-year-old students in reading, mathematics, and science. In the 2018 assessment involving 78 countries, Canadian students ranked 6th in reading, 8th in science, and 12th in math, placing ahead of all G7 countries in reading, and second after Japan in math and science. Even more impressively, Alberta students had an average reading score that placed them third highest among the national scores and fourth highest in science, with Quebec students placing fifth highest in math (Allison, 2022).

Conventional wisdom might suggest this reflects the money Canada spends on schools. Could this be so? Has Canada been spending more on its schools than similar countries that performed less well on the PISA tests? What about the provinces? Have Alberta and Quebec been outspending other provinces? More broadly, do jurisdictions that spend more on education have higher levels of student achievement?

Education policy decisions often appear to assume this is the case, especially policy initiatives with expensive price tags, such as reducing average class sizes or raising teacher qualifications. The literature is notoriously divided on both the merits of such policies and the underlying issue of whether spending matters. As Lafortune, Rothstein and Schanzenbach put it: "The literature regarding whether 'money matters' in education … is contentious and does not offer clear guidance" (2018: 2). Moreover, research findings are dominated by studies from the United States where wide variations in funding mechanisms, school operations, and court-ordered state and local reforms limits applicability to other jurisdictions.[1]

To place results in a broader comparative context this study compares school spending in Canada to spending in other high-income countries and relates spending to test performance. Because education policy in Canada is decided by provincial governments, specific attention is also given to spending and performance in the provinces. The balance of this introduction provides a brief overview of education spending in higher- and lower-income countries,

1 A notable exception is the Canadian study by Mou, Atkinson, and Marshall (2019), which builds on a valuable historical consideration of provincial PISA scores and spending as part of a more extended analysis of budgeting efficiency in the provinces.

followed by a review of the returns associated with education spending with emphasis on the nature and role of knowledge capital in economic growth, concluding with notes on the methodology adopted in this study.

Spending

In a full sense, education is a broad, diffuse, inherently complex, interactive, ongoing, and cumulative process producing a rich range of valued personal, social and economic outcomes. Even so, conventional measures of spending on education focus more narrowly on the operational and capital costs of schools and other instructional systems. Modern societies spend considerable amounts on education in this sense of instructional systems, although there are sharp and substantial differences between richer and poorer nations. Total global expenditures on education[2] increased steadily from US$4 trillion in 2010 to US$4.9 trillion in 2018, before stalling and remaining around that level over the following two years as the COVID-19 disruptions took their toll (World Bank and UNESCO 2022; figure 6a). Countries in the World Bank's high-income category—which includes Canada—accounted for some two-thirds of total global spending on education over the past decade, with only small average increases in real spending. In contrast, real education spending in low- and middle-income countries rose on the order of 6% annually to increase by 77% from 2009 to 2019 (World Bank and UNESCO 2021: 3).

A shade more than three-quarters (76%) of global education spending is funded by governments, with higher shares deriving from private sources in poorer countries. In countries in the lower-middle income range, households contribute around 40% of total education costs compared to an average of 16% in higher-income nations (World Bank and UNESCO 2021: 11). Among OECD members, an average of 82% of total education spending came from governments in 2018, with governments funding an average of 90% of elementary and secondary education (OECD, 2021: table C3.1).

Expressed in relation to national income, education spending by governments averaged 4.2% of global GDP over the previous two decades. Although low-income countries have been slowly increasing education spending, in 2018 they spent an average of just 3.2% of GDP on education, compared to 3.9% in middle-income countries and 4.8% in high-income countries (World Bank, 2023a).

Markedly higher education spending in high-income countries is attributable not only to higher input costs, but also to more extensive and complex instructional systems with considerably higher levels of participation. Three major levels of age and curriculum-differentiated

2 Defined as expenditure on education services by governments, households and donors in accord with UNESCO Institute of Statistics definitions.

instruction are conventionally recognized: primary, secondary, and tertiary.[3] Primary level instruction which, in Canadian usage is commonly viewed as taking place in elementary rather than primary schools, typically begins between ages five and seven, extends over six years or so, and aims to inculcate basic literacy and numeracy while introducing young minds to other subjects. Secondary-level education is conventionally divided into lower and upper levels, each typically providing increasingly specialized instruction over periods of three years, usually with branching academic and vocational programs. In North American jurisdictions, elementary and secondary education are delivered within what is often referred to as a "K-12" system, comprising one or two pre-school Kindergarten years followed by progression through a 6-3-3 structure of elementary, junior high, and senior high schools.[4] Tertiary-level education is provided by colleges and universities through a variety of post-secondary programs ranging from short-cycle vocational qualifications, through general, specialized, and professional undergraduate and graduate degrees.

Enrollments and input prices are the main cost drivers within these hierarchical, increasingly differentiated, and branching instructional structures. Most countries mandate at least ten years of schooling, which typically equates to the completion of lower secondary school. In low-income countries an average of only 40% of young people had attained this level of schooling in 2018, compared to 95% in high-income countries (World Bank, 2023b).

Returns

National spending on education is primarily justified as an investment in human capital, understood as the accumulation and renewal of knowledge and skills in populations that can facilitate economic growth (Becker, 2009; Schultz, 1961; Valero, 2022). In broader scope, investing in education is viewed as developing a rich set of interconnected variables associated with individual, social, and technological development fostering prosperity, crime reduction, health, and civic engagement (Lochner, 2011). As sharply illustrated by the effects of school closures during the recent pandemic, dependable access to elementary and secondary schools also provides real-time economic and social benefits to families and firms, aiding stable parental participation in the labour force.

3 Or lower, middle, and upper schools in some jurisdictions. The International Standard Classification of Education (ISCED) scheme recognizes Levels 1 (primary), 2–4 (secondary) and 5–8 (tertiary), where Level 2 is lower secondary, 3 upper secondary and 4 post-secondary but non-tertiary (UNESCO, 2012).

4 Conventions vary, but in some jurisdictions the six years of elementary school are subdivided into primary and junior curriculum levels to yield a 3-3-3-3 structure. Because of the possible confusion between the meaning of "primary" in this usage and the six years of level-1 primary education in the ISCED classification scheme, the term "primary" is generally avoided in this report in favour of referring to the initial six years of schooling as the elementary level to conform with Canadian usage.

"Human capital is nonetheless a latent variable that is not directly observed" (Hanushek and Woessmann, 2012: 271). As a result, investment in human capital is usually estimated indirectly using enrollment rates, years of completed education, and/or the attainment of certificates and degrees. This approach assumes a year of education at a given level in one system is equivalent to that in others. Moreover, years of completed schooling may not account for knowledge acquired outside of schools, through family resources, tutoring, or by individual learning through books and the internet, for example. Recent work by Eric Hanushek, Ludger Woessmann and their colleagues (*e.g.*, Hanushek, Jamison, Jamison, and Woessmann, 2008; Hanushek and Kimko, 2000; Hanushek and Woessmann, 2012, 2015, 2022) has sought to avoid these limitations by replacing measures of education attainment with measures of cognitive skill obtained by averaging and re-scaling scores from large-scale international assessments of student achievement, especially PISA, TIMSS, and PIRLS.[5]

By directly considering variation in demonstrated knowledge and skill as measured on these tests, the Hanushek-Woessmann approach substantially improves the predictive power of studies modelling the effect of education on economic growth. Whereas years of schooling account for around only 25% of the variance in subsequent growth in per-capita GDP in Hanushek and Woessmann's regression analyses, adding their test-based measure increases this to 73% (2012: table 1). Additional modelling of a range of cultural and institutional differences among nations, including differences in how schools are organized and operated and the influence of family effects, has shown the relationship between test scores and economic growth to be "extraordinarily robust" (2012: 270). Consistently strong relationships between test scores and economic growth in some 50 countries at varying stages of development is indicative of a causal rather than a merely associative relationship. "The simple conclusion from the combined evidence is that differences in cognitive skills *lead to* economically significant differences in prosperity (Hanushek and Woessmann, 2015: 107, emphasis added).

In more recent work, Hanushek and Woessmann (2015) adopt the term "knowledge capital" (2015: 2)[6] as an alternative to "cognitive skills". Both terms refer to student achievement

5 TIMSS is the acronym for Trends in International Mathematics and Science Studies (as well as the earlier Third International Mathematics and Science Study, which evolved from prior international mathematics studies); PIRLS is the acronym for the Progress in International Reading Literacy Studies. See table 10 in Hanushek & Woessmann, 2015 for a complete list of the test results used.

6 Their use of the fuller phrase "knowledge capital of a nation" in the text and as the title for their 2015 book reviewing their research and distilling insights appears to be a deliberate echo of Adam Smith's *The Wealth of Nations*, given their early quotation (2015: 2) of the following passage from Smith's landmark work: "A man educated at the expence [sic] of much labor and time to any of those employments which require extraordinary dexterity and skill, may be compared to [an] expensive

as measured by standardized international tests such as PISA. Yet, "knowledge capital" has the semantic advantage of directing attention to the learned content of the broader notion of human capital. In doing so, it directs attention to the outcomes of schooling and other learning, rather than the indirect metrics of enrollment and attainment previously used to estimate stocks of human capital.

The main policy message is that schools can boost economic growth by improving average test scores. The initial effect of increased test scores on GDP will be small at first but, if maintained, will steadily accumulate as successive cohorts of higher-achieving graduates join the workforce. In a low-end scenario, Hanushek and Woessmann (2015: 161–163, figure 7.1) discuss how education reforms that yield a sustained 25-point increase (0.25 of a standard deviation) in PISA scores could plausibly produce a 3% gain in GDP over 20 years, with growth continuing to increase if the higher average test scores are maintained and new graduates replace retirees, further increasing the stock of knowledge capital. They point out a 25-point increase in PISA scores is quite feasible; similar gains having been achieved in their historical data between 1975 and 2000 by Finland and Canada (2015: 161, figure 4.1).

This is consistent with established thinking on human capital, but the central importance of intentionally investing in knowledge capital rather than just time in school is vital. Conventional reasoning holds that improvements in publicly funded activities can be realized through expansion, which typically requires spending more. But it is not sufficient to just spend more. In the knowledge capital model, higher spending that does not produce increased test scores cannot be expected produce economic growth. What matters is whether there is an increase in student knowledge and skill as measured by valid, reliable, and comparable achievement tests, rather than just larger budgets.

In lower-income countries with room for school expansion, progress may be made on both fronts simultaneously: getting more children into functioning schools can be expected to boost knowledge capital. In developed countries, with mature, well-developed, and well-resourced education systems and universal or near-universal levels of school enrollment there is less opportunity for expansion. Furthermore, spending decisions will be made within a more complex and fractured policy environment where the pursuit of popular social, ideological, or political goals may take precedence over improving average test scores.

Indeed, production of knowledge capital appears to plateau in well-developed countries despite increased spending. As demonstrated in a recent Fraser Institute study by John Krieg, "as poor countries get richer, their PISA results rise. As rich countries get richer, their PISA results remain relatively stable" (2019: 26). An OECD study endorses this pattern, showing

machin[e]. The work which he learns to perform, it must be expected, over and above the usual wages of common labor, will replace to him the whole expence of his education, with at least the ordinary profits of an equally valuable capital" (Smith, 1776/1979: 118).

that in countries above a per-capita GDP threshold of $20,000 in constant 2007 US dollars, "national wealth is no longer a predictor of a country's mean performance in PISA" (2012: 2).

Canada has performed well on the PISA assessments, but how does this relate to comparative levels of school spending and achievement in other high-income countries?

Method

The aim of the study is to compare and analyze education spending and performance at elementary and secondary levels in Canada and other high-income countries and in the provinces. In line with the theoretical considerations reviewed above, education performance was conceptualized as the production of knowledge capital as estimated by comparable international test scores. The OECD's Programme for International Student Assessment (PISA), which tests the reading, math, and science performance of 15-year-old students, was used as an appropriate measure of knowledge production. While students to be tested are routinely described as "15-year-olds", PISA aims to test students toward the end of lower secondary school to assess knowledge acquired during a common span of basic, typically compulsory, schooling. Participants are randomly selected from within randomly selected schools that can be of any type, academic or vocational, public or private, rural, urban, or suburban.[7]

Until the disruptions associated with the recent pandemic, PISA assessments were held every three years since 2000. This study draws on the 2018 results, which provide pre-pandemic average scores for the 78 participating nations, including all OECD members and the ten Canadian provinces (OECD, 2019).

National scores on the three subjects are highly correlated, Pearson coefficients for all 2018 participants exceeding 0.95 (p. <.0001). Given this, the average of the three subject scores is used as a single compact measure of knowledge capital. This average score, also referred to as the core PISA18 score, has Pearson correlations at or above 0.93 with each of the three subject scores for the high-income countries as defined below, and at or above 0.90 for the ten Canadian provinces.[8]

Data on education spending are primarily taken from the 2021 edition of the *Education at a Glance: OECD Indicators,* the publication that reports spending statistics for member nations in 2018 to coincide with the year the PISA data were collected (OECD, 2021). These statistics are complied through the OECD's Indicators of Education Systems (INES) program,[9] which provides the most complete and comprehensive set of comparable measures of education

7 See Allison, 2022 for a more extensive account of the design and administration of the PISA assessments.

8 Probability values were less than .0001 for all pairs of correlations reported.

9 For a description, see Ball, 2016.

spending currently available. An online database (http://stats.oecd.org)[10] provides limited subnational data, which was the preferred source for 2018 provincial spending statistics to provide comparability with national level spending. This online source was also used to update the values published in the *Education at a Glance 2021* tables where adjustments had been made. Statistics Canada's Pan-Canadian Education Indicators Program (PCEIP) (Statistics Canada, 2023) was also consulted.[11]

The main spending measure used is total per-student spending at the primary, secondary, and post-secondary non-tertiary level.[12] This is calculated by dividing total public and private expenditure for instructional, administrative, and other support institutions by the number of full-time equivalent (FTE) students receiving instruction at those levels, adjusted to the financial year (OECD, 2018: 116). Expenditures in national currencies are converted to United States dollars (USD) using the 2018 purchasing power parity [PPP] GDP index to express spending on a common scale.

Four OECD members (Colombia, Costa Rica, Mexico, and Turkey) were not included in the World Bank's 2018 list of high-income countries and consequently excluded from the analysis (World Bank, 2023c). All 34 high-income countries with 2018 PISA core scores and comparable spending data are listed in the **Appendix** together with the abbreviations used in data displays.

10 The Education at a Glance Database is located in the Education and Training theme. At the time of writing, the database was being migrated to a new OECD Data Explorer platform at https://data-explorer.oecd.org/ at the end of March 2024.

11 The citation in the reference list is for the most recent publication in the PCEIP series at the time of writing. A complete list of the PCEIP reports until 2023 is given at <https://www150.statcan.gc.ca/n1/en/catalogue/81-582-X#wb-auto-2>. The 2021 publications reporting 2918/19 data were the primary sources consulted.

12 The primary, secondary, and post-secondary non-tertiary levels include ISCED Level 4 programs, which are primarily apprenticeship and similar trades-qualification programs that do not qualify as tertiary level education. The key distinction lies in the qualification earned rather than the institution providing instruction. The main post-secondary non-tertiary qualification in Canada is a trade certificate or diploma earned through a vocational or community college, but community colleges also offer programs leading to ISCED 5 or above credentials, such as professional diplomas. Such programs are generally viewed as being distinct from upper secondary schooling in Canada, with the exception of Quebec, where there is overlap, but many European countries provide various forms of integrated secondary and post-secondary paths to vocational credentials, rendering it impossible to draw a common dividing line between the end of secondary and subsequent non-tertiary education. Because of this, the primary, secondary and post-secondary indicator provides the most comprehensive and comparable post-preschool/pre-tertiary education measure available. One other point of note with regard to this indicator is that the Canadian data includes enrollment in pre-primary grades. This discrepancy is considered to have a relatively small effect on the overwhelmingly large enrollments across the entire span of the primary, secondary, and post-secondary, non-tertiary indicator (Statistics Canada, 2023: 17). In practical terms, this is also the indicator with the least missing data in the *Education at a Glance* tables. To better conform to Canadian usage, per-student expenditures for these combined levels are referred to as elementary and secondary or K-12 spending.

The OECD financial data used in the body of the study do not include results from three high-income PISA participants of particular interest, namely, Hong Kong (China), Singapore, and Taiwan. These three, along with Korea, which is an OECD member and thus included in the main body of the study, have been recognized as "Asian Tigers" because of their rapid industrialization and impressive and resilient economic growth since the 1960s (Gulati, 1992; Hanushek and Woessmann, 2015: 45; Toma, 2019). An alternative source of cumulative spending data is used to compare spending and performance in these three non-OECD members with those considered in the main body of the study.

Summary

Governments in higher-income countries such as Canada spend substantial amounts of wealth on education with the expectation that increasing human capital will yield positive economic returns. New approaches replace earlier attainment estimates of human capital with measures of knowledge capital based on international test results. These approaches have shown robust and plausibly causal positive relationships with subsequent economic growth. This implies that high levels of education spending in countries such as Canada are unlikely to yield expected economic gains unless they improve international test scores among young people completing basic schooling.

The balance of this study addresses this issue by first looking at spending at the elementary and secondary level in high-income OECD countries and the Canadian provinces, and then examining the relationship between spending and the production of knowledge capital as measured by PISA test scores.

School Spending

Elementary and secondary spending by high-income OECD countries

Figure 1.1 compares total per-student spending for elementary and secondary education with total per-student spending on all levels of education, from elementary to Ph.D. Total spending includes all expenditures by public and private instructional, administrative, and support institutions for full-time equivalent (FTE) students over the 2018 calendar year. Amounts are in US dollars. Countries are ranked in descending order of elementary and secondary spending.

The figure highlights two points. First, and as discussed more fully later, Canada is positioned in the middle ranks of elementary and secondary spending among high-income OECD countries; second, spending on elementary and secondary education accounts for by far the lion's share of overall education spending in these countries.[13]

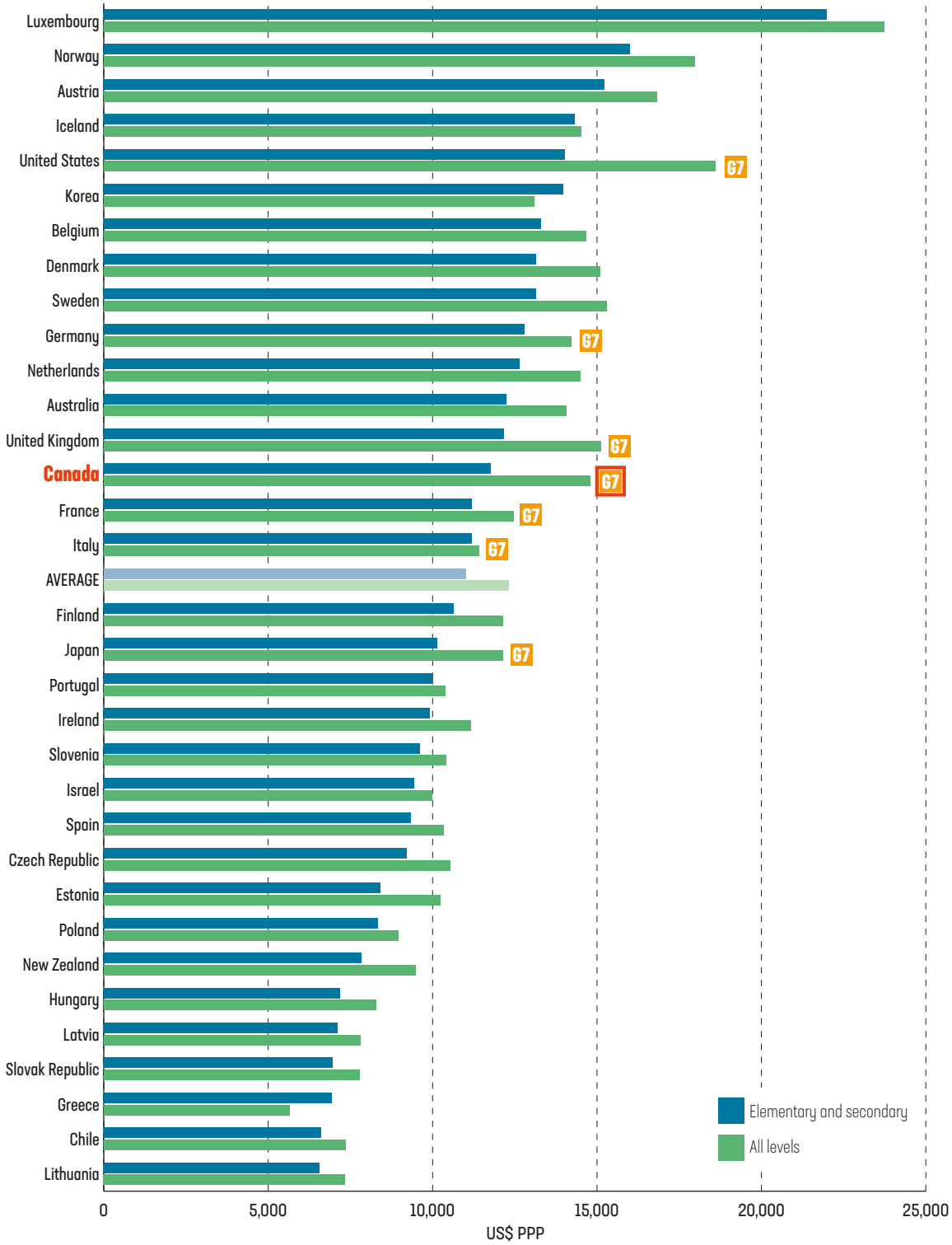
Elementary and secondary spending compared to spending at all levels.

Average per-student elementary and secondary spending for the 33 high-income countries with complete data[14] is US$11,006, which is 90% of the average per-student spending on education at all levels (US$12,310). The three countries with the smallest proportions of per-student elementary and secondary spending to spending at all levels are the United States (75.3%), Canada (79.5%), and the United Kingdom (80.5%), all of which have extensive, well-developed tertiary level systems. With the exception of Japan (83.5%), which occupies sixth place in ascending order on this measure after Estonia (82.1%), and New Zealand (82.5%), the proportions of per-student spending at the elementary and secondary level in the remaining G7 countries are notably larger, France ranking 18th (89.9%), followed by Germany ranking 20th (90.1%), and Italy in a distant 30th place (98%).

13 The gaps between the two coloured bars do not represent tertiary spending as there are far fewer students enrolled at the tertiary level. Per-student tertiary spending ranges from highs of US$48,828 in Luxembourg and US$34,036 in the United States, to lows of US$9,160 and US$3,499 in Chile and Greece. (Data extracted on September 17, 2023 from OECD.Stat.)

14 Switzerland is excluded due to missing data. An elementary and secondary per student amount is given in the updated on-line database and is included in subsequent discussion, but no tertiary level amounts were given in either the published or on-line sources consulted.

Figure 1.1: Total education spending (US$ PPP) per-student for high-income OECD countries, 2018



Notes: Countries ranked by descending order of elementary-secondary spending. Switzerland excluded because data are missing.
Sources: OECD, 2021: table C1.1, updated from OECD.Stat Educational finance indicators database, as of September 17, 2023.

In two countries, per-student spending at all levels exceeds per-student elementary and secondary spending, by US$891 in Korea and US$1,285 in Greece. Given the differences between the two economies, this commonality is likely attributable to quite disparate circumstances. Korea (the only Asian tiger in the dataset), has the sixth highest level of per-student elementary and secondary spending (US$13,969), slightly less than the United States (US$14,009), whereas Greece is at the other end of the distribution with the fourth lowest level of elementary and secondary spending per student (US$6,935), almost half as much. The structural profile of the education system shown on Korea's Ministry of Education website allows for extensive vocational and trades education in upper secondary and post-secondary, non-tertiary institutions, which likely accounts for the high levels of elementary and secondary spending.[15]

The high shares of elementary and secondary per-student spending are driven by almost universal levels of student participation undergirded by compulsory attendance legislation for the bulk of the younger age cohorts enrolled,[16] tertiary education enrolling far smaller numbers. Spending at elementary and secondary levels is also dominated by the high costs of instructional activities driven almost completely by teacher salaries, whereas tertiary-level spending funds a more varied range of activities, typically employing staff distributed across a wider range of salaries. Both characteristics reflect the fundamental nature and importance of elementary and secondary level education in generating knowledge capital.

Education at the elementary level provides an unavoidable, universal foundation for future learning, the scope and quality of which will enable or hinder the success and extent of further education. Secondary graduates feed tertiary level programs but also fuel and sustain development of a skilled workforce through opportunities for a wide range of further learning, increasing knowledge capital in an interactive process in which "skill begets skill through a multiplier process" (Cunha, Heckman, Lochner, and Masterov, 2006: 698). While increased investment in expanded tertiary education structures has been popular in Canada in recent decades, such further education necessarily builds on the fundamental knowledge and skills obtained through elementary and secondary education, the economic returns from which will be conditional on the quality of this earlier education (Cunha and Heckman, 2007; Hanushek and Woessmann, 2012: 275).

15 Both table C1.1 in *Education at a Glance 2021* and the updated data available through OECD.Stat show missing data for post-secondary, non-tertiary per-student spending for both countries.

16 The OECD average enrollment rate for the 6-to-14 year age cohort (the PISA cohort) is 99% (OECD 2021: table B1).

Comparative elementary and secondary spending among high-income nations.

Focusing on elementary and secondary education in figure 1.1: per-student spending for these 33 high-income countries spans a substantial range of US$15,417, extending from a markedly prominent high of US$21,968 in Luxembourg to a low of US$6,551 in Lithuania. Luxembourg's notably higher level of spending appears to be accounted for by substantially higher salaries for elementary and secondary teachers coupled with low teacher-to-student ratios (OECD, 2021: tables D3.1, D2.2). Canada occupies 14th place in the descending order of elementary and secondary spending at US$11,771 per student, 6.7% above the average for these 33 high-income countries. Canada also sits in the middle of the spending range across G7 countries, placing fourth between the third-ranked United Kingdom (US$12,171) and fifth-ranked France (US$11,190), well below first-ranked United States (US$14,009).

In addition to top-spending Luxembourg and fifth-ranked United States, six other countries fall into the upper quartile (top 25%) of the distribution, including second- and third-ranked Norway (US$15,994) and Austria (US$15,227), sixth-ranked Asian tiger Korea (US$13,969), as well as Belgium (US$13,298) and Denmark (US$13,145). Five other countries are ranked between Denmark and Canada, including Sweden (US$13,136), Germany (US$12,796) and Australia (US$14,073). Hence, while Canada is a prominent high-income country and a long-time G7 member, it is not among the countries spending the most on elementary and secondary education per student. Moreover, to narrow the spending gap between Canada and the high spenders would require a hefty increase in per-student spending. To match third-place Austria, for example, Canada would need to spend an additional US$3,456 for each FTE elementary or secondary student; to equal Germany, an additional US$1,025 per FTE student.

At the lower end of the distribution, the eight countries spending below the 25th percentile (bottom quarter) include Poland (US$8,337) and New Zealand (US$7,830). Chile (US$6,607) and Lithuania (US$6,551) have the lowest levels of per-student spending on elementary and secondary education among these high-income countries.

It should nonetheless be kept in mind that there is some inevitable imprecision in these numbers due to the many structural differences between national education systems and the methodologies used within those systems to collect the data that are converted to common metrics by the OECD. Yet, while these data lack the precision needed to justify drawing fine distinctions, the average difference between the 33 data-points spread across the full range of the distribution is a hefty US$467 per FTE elementary and secondary student, US$296 if Luxembourg is excluded as a distorting outlier.

Spending by Canadian provinces

Figure 1.2 slots provincial per-student spending[17] on elementary and secondary education into spending by all 34 high-income OECD countries, including Switzerland, with jurisdictions ranked in descending order. It also shows the 75th, 50th (median), and 25th percentiles for the full distribution, dividing spending amounts for all 46 jurisdictions into quartiles.

Saskatchewan (US$14,245) and Manitoba (US$12,819) both have 2018 elementary and secondary per-student spending levels within the top quarter of the distribution, Saskatchewan having the fifth-highest spending among the 46 jurisdictions, close to the 90th percentile (US$14,281) and a little higher than the United States (US$14,009). Manitoba spent US$1,426 less per student, ranking 11th, between Sweden and Germany, just above the 75th percentile.

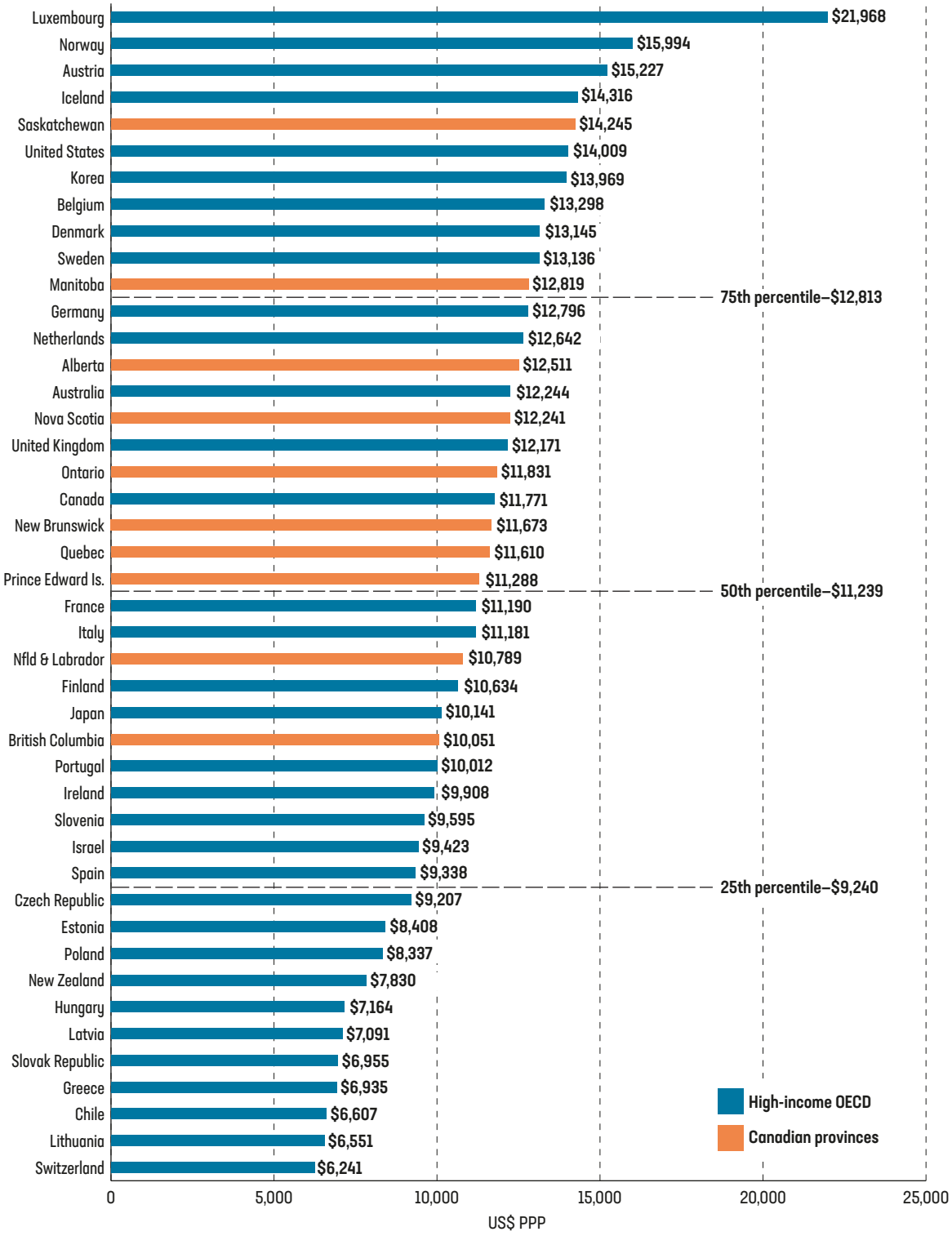
Newfoundland & Labrador (US$10,789) and British Columbia (US$10,051) were the two provinces that spent the least, their elementary and secondary per-student expenditures falling below the median value (US$11,239) for the full distribution. Spending by Newfoundland & Labrador ranks 27th, between Italy (US$11,181) and Finland (US$10,634); British Columbia's elementary and secondary spending ranks 30th, between Japan (US$10,141)—the lowest-spending G7 nation—and Portugal (US$10,012). These lower-spending provinces nonetheless spent more than 16 high-income countries, including Estonia (US$8,408) and New Zealand (US$7,830), and placed comfortably above the 25th percentile of the full national and provincial distribution.

The six remaining provinces all fall within the interquartile range (between the top and bottom quarters) of the expanded distribution. Ontario, the largest province, spent US$11,831 per elementary and secondary student in 2018, US$592 above the median. Per-student elementary and secondary spending in New Brunswick (US$11,673), Quebec (US$11,610) and Prince Edward Island (US$11,288) cluster between Ontario and the median value in that order, slightly above France (US$11,190) and Italy (US$11,181), both G7 members. Nova Scotia (US$12,241) and Alberta (US$12,511) spent at higher per-student levels than these other mid-range provinces, with spending levels closer to the 75th percentile than the median.

In sum, while national level K-12 spending in Canada falls just above the midpoint of per-student elementary and secondary spending among high-income OECD members, the range of provincial spending leans toward the higher end of this distribution, Saskatchewan spending US$3,006 above the median and British Columbia, US$1,188 below.

17 It should be kept in mind that the measure of per-student elementary and secondary school spending used here differs from that used in the Fraser Institute's annual reports on provincial spending on public schools in Canada, the most recent of which is Zwaagstra, Li, and Palacios (2023). Key differences are the inclusion of the independent schools sector, use of the OECD elementary and secondary post-secondary non-tertiary indicator, expression in US currency adjusted by purchasing power parity values for the calendar, rather than academic, year.

Figure 1.2: Total spending (US$ PPP) per-student on elementary and secondary schools for high-income OECD countries and Canadian provinces, 2018



Sources: High-income OECD: OECD, 2021: table C1.1, updated from OECD.Stat Educational finance indicators database, as of September 17, 2023.
Provinces: OECD.Stat Financial resources invested in education, subnational database, as of September 17, 2023.

Even so, the difference between the highest- and lowest-spending provinces (US$4,194) is only a quarter (27.6%) of the full range between the highest and lowest spending high-income OECD nations (US$15,727), and a little under half (43%) of the high-income range if Luxembourg is excluded as a distorting outlier. Further, the range of provincial spending is far smaller than it is for state spending in the United States, where there is a difference of US$16,066 between New York state's spending of US$24,825 per student and Idaho's expenditure of US$8,759, making the range of 2018 state-level spending in the United States 3.8 times greater than the range among Canadian provinces.

Alternative national measures

The 33 high-income OECD countries in the dataset spent an average of 3.4% of GDP on elementary and secondary education in 2018, ranging from a high of 4.8% in Israel to a low of 2.3% in Ireland. Canada ranked 14th in descending order on this measure, spending 3.5% of GDP, slightly above the high-income average, spending the same proportion of GDP as the United States and New Zealand, but less than fellow G7 members United Kingdom (4.1%) and France (3.7%), once more placing comfortably within the middle of the distribution.[18]

Data on the growth of elementary and secondary per-student spending in constant PPP US dollars show there has been little real growth between 2012 and 2018 for the 27 high-income OECD countries with available data (OECD, 2021: table C1.3). These data show an average of 1.7% annual growth in per-student spending, ranging from a high of 6.7% in Hungary to a low of 0.2% in Belgium, with five countries reporting negative annual growth rates, ranging from –0.1% in Luxembourg to –2.4% in Denmark. Canada ranks 17th in descending order on this variable with 0.6% annual growth in constant elementary and secondary per-student spending from 2012 to 2018, between the median value of 1.3% and the 25th percentile value of 0.4%. This compares to a higher 1.1% average annual growth rate for all G7 countries, ranging from 1.8% in Italy to 0.4% in Japan. Once again, Canada is in the middle ranges of these distributions, this time toward the lower end of the interquartile range. Change in student enrolment over this period was a weak and non-significant negative predictor of growth in per-pupil spending for the 27 high-income countries with available data.[19]

Governments in the 34 high-income countries allocated an average of 10.5% of total expenditures to all levels of education in 2018, spending on elementary and secondary education accounting for an average of 7.7% of total public spending. Chile devoted the greatest share of public spending to elementary and secondary education (12%), followed by Israel (10.8%)

18 Calculated from OECD, 2021: table C2.1.

19 (β (1) = –0.631, t (25) = –1.70, p. = 0.102, R^2 = .10.

and then Korea (10.3%), with Hungary (5.6%) and Greece (5.5%) allocating the smallest proportions of public expenditure to K-12 education. Public spending on elementary and secondary education in Canada accounted for 7.5% of public spending, again close to the median of 7.4%. The United Kingdom and United States both assigned 8.3% of their public expenditures to elementary and secondary education, the highest share among the G7, each of the remaining four G7 members spending close to only 6.3% of total government budgets on K-12 education.[20]

While the average proportion of government spending on elementary and secondary education in all OECD countries with available data declined slightly between 2012 and 2018 (–1%) as a result of education budgets increasing at a slower rate than overall government spending, the average proportion of spending on elementary and secondary education in the 28 high-income countries showed a small average increase (1.6%),[21] although total government spending in the high-income countries increased at a slower rate (9.7%) than all OECD members with data (12.1%). The G7 average followed the more general trend, with the share of public spending on elementary and secondary declining from 2012 to 2018, but by just 0.2%. In Canada, K-12 spending as a proportion of total government spending declined by a relatively substantial 4.1% between 2012 and 2018, second only to fellow G7 member Japan (–5.4%). The Canadian decline was a result of the 8% increase in K-12 spending falling behind the 12.8% increase in total government spending. In the United States, the proportion of government spending allocated to K-12 education over this period increased by 2.7%, fueled by a substantial 11.2% increase in K-12 spending compared to a more modest 8.4% increase in total government spending.[22]

Preliminary data show sharp and substantial increases in government spending during the COVID-19 pandemic that considerably reduced the relative proportions of government spending allocated to education. While total government expenditures from the 30 countries contributing data increased an average of 10.9% between 2019 and 2020 after accounting for inflation, education spending increased by just 1.4% (OECD, 2022: 284–285; figure C4.4).

All the various spending amounts reviewed above are for a single financial year. As such they represent but a portion of the total cost of educating a single student through the full course of elementary and secondary schooling. Such single-year "snapshots" or "slices" of the total per-student costs of education programs are nonetheless commonly used to compare spending levels and, indeed, this is the standard approach in the OECD data and in Fraser Institute studies, such as the annual analyses on public school spending in Canada. The

20 Calculated from OECD, 2021: table C4.1.

21 Seven of these high-income countries increased public spending on elementary and secondary education by 10% or more during this period, the Czech Republic boosting spending by 17.4% and Greece by 15.4%.

22 Calculated from OECD 2021: tables C4.1 and C4.3.

Education at a Glance database does, however, include an estimate of the cumulative expenditures incurred to educate a full-time equivalent student from age 6 to 15 (OECD, 2021: table C1.7 [web only]), and this could appear as a preferable measure when investigating relationships between PISA scores and education spending. The cumulative amount is nonetheless highly correlated with the single-year "snapshot" amounts for the high-income countries in the dataset.[23] Even so, the final data display in the following section, focusing on the relative performance of all four Asian tigers, uses the cumulative expenditure variable, offering an alternative perspective on relationships between spending and performance.

Summary

Per-student spending on elementary and secondary schools in high-income OECD countries dominates overall education spending as a result of almost universal enrollment in those countries together with the underlying basal importance of this fundamental form of education. There is nevertheless considerable variation in the per-student amounts spent on this basic level of education by these high-income countries. Canadian spending falls in the middle of this range as do the other measures of elementary and secondary spending considered. Spending per student by each of the provinces falls largely within the upper mid-range of spending by high-income OECD nations, although the high levels of spending by Saskatchewan and Manitoba place them in the upper quartile of the combined national-provincial distribution. Yet, while there is a difference of US$4,194 between K-12 per student spending by highest spending Saskatchewan and lowest spending British Columbia, the difference between per-student spending by the highest and lowest states in the United States is more than triple that amount.

23 $r(31) = .972$, $p. < .000$.

Spending and Performance

High-income OECD countries

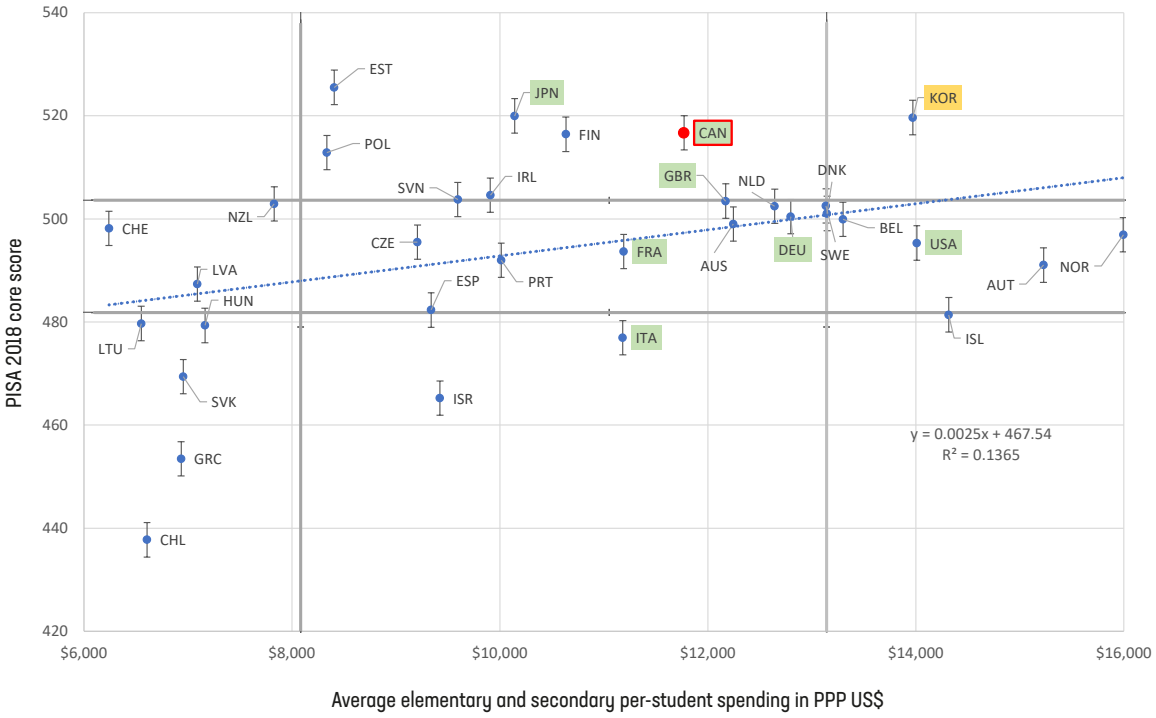
Figure 2.1 plots 2018 elementary and secondary spending per student for all high-income OECD nations except Luxembourg against 2018 PISA core scores, calculated as the average for the reading, math, and science scores. The 'T' bars extending above and below the plotted points show the ranges of the 95% confidence intervals. Identifying codes for the data points are given in the Appendix. Codes for the G7 countries are coloured green, with a red border and marker for Canada. Korea, the only Asian tiger in the display, is coloured yellow. The grey vertical and horizontal lines mark the 25th and 75th percentiles along each axis. The dotted line shows the best fit linear regression line of per-student spending on PISA core scores.

Luxembourg was excluded after being identified as an influential outlier.[24] Although the regression model predicting PISA18 core scores from elementary and secondary per-student spending is significant, (F (1, 32) = 4.9024, p. = .034), spending only accounts for 14% of the variation in PISA core scores.

The percentile lines in figure 2.1 tell the story more graphically. While six countries, including the United States, fall squarely within the upper quartile of the spending distribution, only one, Korea, is unambiguously in the upper quartile of the core PISA scores. Sweden and Denmark are marginal candidates for inclusion in the higher spending quartile and the upper bounds of the 95% confidence intervals for both also fall into the upper spending quartile. Korea is nevertheless the only high-income OECD country that qualifies unambiguously as both a statistically significant high spender and also a high performer. Still, Korea's core PISA score is not significantly different from Canada's or from four other countries in the middle range of the spending distribution, two of which, Estonia and Poland, spent a third less per student than did Korea. Canada, together with fellow G7 member Japan and three other countries in the mid-spending range (Estonia, Finland and Poland) have PISA18 core scores significantly above the 75th percentile.

24 RStudent = –2.06, CooksD = 1.064. RStudent values > 2 identify outliers in the distribution, CooksD values > 0.5 show moderate influence, > 1.0 strong influence on regression results. A subsequent application of Grubbs' Outlier Test using Rosner's multiple outlier procedure yielded an ESD = 3.28 (p. = .011). For description, see <https://www.ncss.com/wp-content/themes/ncss/pdf/Procedures/NCSS/Grubbs_Outlier_Test.pdf>.

Figure 2.1: Total elementary and secondary spending per-student by high-income OECD countries (except Luxembourg) plotted against 2018 PISA core scores



Sources: PISA 2018 core scores calculated from OECD, 2019: tables I.B1.4, I.B1.5, and I.B1.6. Elementary and secondary spending from OECD, 2021: table C1.1, updated from OECD.Stat Educational finance indicators database, as of September 17, 2023.

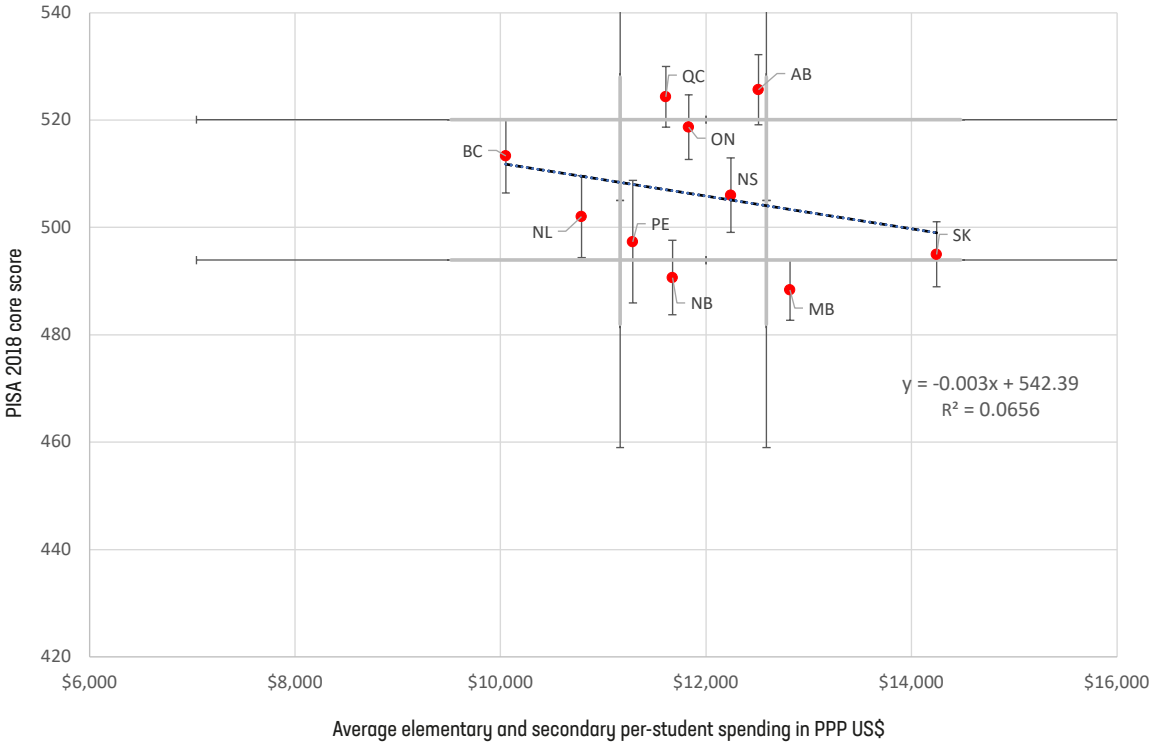
To directly answer the question with which we began, a third (31.3%) of high-income OECD countries spent more per student on elementary and secondary education than did Canada without achieving a significantly higher PISA core score.

Canadian provinces

Figure 2.2 charts the relationship between 2018 PISA core scores and per-student spending for the provinces. The axes are scaled as in figure 2.1 to aid comparison and show how the plotted values for the provinces fit quite tightly toward the higher mid-ranges of the national distributions. While the slope of the regression line shows an inverse relationship between spending and performance, it is not significantly different from zero[25] and the variation in the PISA18 core scores accounted for by variation in spending is a meagre 6.5%. In short, there was a negligible and non-significant statistical relationship between per-student K-12 spending and the production of knowledge capital by Canadian provinces in 2018.

25 $t.(8) = -0.749$, $p. = 0.475$.

Figure 2.2: Total elementary and secondary spending per-student by Canadian provinces plotted against 2018 PISA core scores



Sources: PISA 2018 core scores calculated from OECD, 2019: tables I.B1.4, I.B1.5, and I.B1.6. Elementary and secondary spending from OECD, 2021: table C1.1, updated from OECD.Stat Educational finance indicators database, as of September 17, 2023.

As shown by the many overlapping 'T' bars extending from the plotted values, the margins of measurement error around the core PISA scores make many of them statistically similar. Still, while the four provinces with the highest average PISA core scores have statistically overlapping scores, two (Alberta and Quebec) have scores significantly higher than the other six provinces. Spending by both Alberta and Quebec falls within the middle range, while that of both Manitoba and Saskatchewan is in the top quarter. British Columbia, the province that spent the least, also has a significantly higher test score than highest-spending Saskatchewan and second-place Manitoba. Also, New Brunswick, with mid-level funding, has a significantly lower test score than lowest-spending British Columbia. Alberta, with the highest PISA18 core score, is nonetheless the third-highest spender. Yet, of the six provinces in the mid-range of spending, Alberta has significantly higher test scores than Nova Scotia, Prince Edward Island, and New Brunswick. Overall, there is no clear relationship between 2018 spending and test scores among the Canadian provinces.

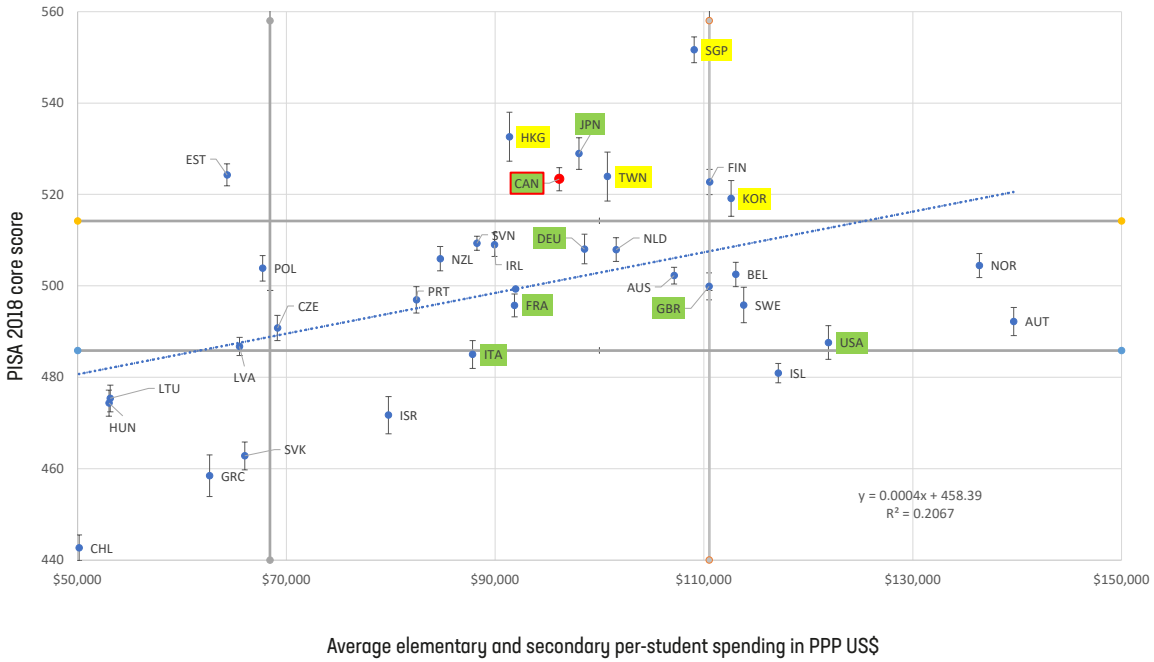
Compared with highest-scoring, low-spending Estonia in figure 2.1, Alberta, Quebec, and Ontario all have statistically similar PISA18 core scores, but spent an average of US$3,576 more per student. British Columbia, the lowest spending province, with a significantly lower PISA

core score than Estonia, spent US$1,643 more per student. Still, to maintain international perspective, British Columbia has significantly higher test scores than 13 higher-spending nations, including five G7 members. Indeed, British Columbia, the lowest-spending Canadian province, has a significantly higher PISA18 core score than the United States, which spent US$3,958 more per student.

Asian tigers

Figure 3 adds the three missing Asian tigers to the high-income OECD countries plotted in figure 2.1 to show how school spending and the production of knowledge capital in this small set of notable economic performers compares with other high-income countries. To integrate compatible data for the three Asian tigers, this plot draws on an alternate dataset that uses the OECD estimate of 2015 cumulative per-student spending over the theoretical duration of basic education from ages 6 to 15 in the countries considered (OECD, 2020: figure 4.1). As published, this dataset used 2015 PISA reading scores as the performance measure. For compatibility,

Figure 3: Total cumulative elementary and secondary spending per-student by high-income OECD countries plus Hong Kong (China), Singapore, and Taiwan plotted against 2018 PISA core scores



Sources: PISA 2018 core scores calculated from OECD, 2019: tables I.B1.4, I.B1.5, and I.B1.6. Elementary and secondary spending from OECD, 2021: table C1.1, updated from OECD.Stat Educational finance indicators database, as of September 17, 2023.

figure 3 plots 2015 PISA core scores calculated by averaging reading, math, and science scores as was done for the 2018 scores in figure 2.1. Luxembourg is again excluded as a distorting outlier in the spending distribution. Denmark, Switzerland, and Spain are also not included as cumulative spending data for these countries not available. Consequently, figure 3 plots values for 30 of the 33 high-income OECD countries included in figure 2.1, including Korea, together with the three additional Asian tigers, Hong Kong (China), Singapore, and Taiwan, for a total of 33 high-income countries.

There is a high rank-order correlation between the cumulative 2015 and 2018 annual per-student spending amounts, showing little overall variation in the ranked values of the two measures.[26] The main visual effect of substituting cumulative spending values for the single-year spending values as used in figure 2.1 is the expanded range of values along the horizontal axis together with a wider spread of the positions plotted along this axis, although the relative positions remain substantially similar.

Even so, there is an improvement in the predictive power of the regression of cumulative spending on PISA core scores over the data used in figure 2.1, explaining a larger but still modest statistically significant proportion of the variance (R^2 = .21, F (1, 32) = 8.08, p. = .008). The increase from 14% to 21% of the variance explained is retained when the Asian tigers are removed from the values plotted in figure 3 (R^2 = .22, F (1, 29) = 7.61, p. = .01). This implies that the estimates of cumulative per-student elementary and secondary spending derived from total instructional time may provide more useful measures of financial investment. Still, the improvement in the variation explained by the two regression models remains small, with almost 80% of the variance in student scores remaining unexplained by spending levels in figure 3.

The most notable visual difference between figure 2.1 and figure 3 is the effect of the additional three Asian tigers, particularly Singapore, which forces an extension of the vertical axis to accommodate a markedly higher PISA15 core score, a remarkable 27.3 score points greater than the country with the highest score among OECD countries plotted in figure 2.1. A second Asian tiger, Hong Kong, also has the second highest PISA15 core score in figure 3, supplanting the second-place position held by Japan in the 2018 result plotted in figure 2.1. In this instance, Japan lost 8.9 core score points between the 2015 and 2018 assessments, while Hong Kong lost 1.9 points. Taiwan, the third Asian tiger added in figure 3, occupies the fifth-ranked position on the descending order of PISA15 scores, with a core score just slightly greater than Canada and Finland, who have virtually identical 2015 core scores. In this case, core scores for all three countries declined by some six or seven points between the two assessments.

Hong Kong, another of the added Asian tigers, has the second highest average PISA15 core score in figure 3, but with a margin of measurement error that overlaps Japan, making the

26 Spearman ρ (28) = .95, p. = < .001.

scores statistically similar. Taiwan, the third added Asian tiger, has a lower average score that is also statistically similar to those of Hong Kong and Japan, as well as to the scores of four lower scoring countries also with overlapping margins of measurement error, namely, in descending average score, Estonia, Canada, Finland, and Korea (the last the sole Asian tiger that is an OECD member and thus included in figure 2.1). All eight of these highest-scoring school systems have average PISA15 scores above the 75th percentile, but only Korea and, marginally, Finland, is also in the top quarter of cumulative spending. Furthermore, of the additional six countries in the top quarter of cumulative spending, five are in the mid-range of the PISA15 core scores and one, Iceland, is in the lower quarter.

Summary

Each of the three scatterplots of per-student spending and PISA test scores in high-income countries show school spending and student achievement to be largely independent of each other. This is particularly marked in the cases of the two highest-performing Asian tigers in figure 3, with Singapore and Hong Kong's significantly higher PISA core scores plotted in the mid-range of cumulative spending. Low-spending Estonia's comparative position is also striking, with the fourth highest 2015 PISA score in figure 3, and the top 2018 score in figure 2.1, which excludes the high scoring Asian tigers. Canada, too, is solidly located in the top quarter of PISA scores and the mid-range of both single-year and cumulative spending. The disconnect between school spending and the achievement of 15-year-olds was also evident in the Canadian provinces where, as shown in figure 2.2, Saskatchewan and Manitoba, the two highest-spending provinces, had the lowest test scores, while British Columbia, the lowest-spending province, achieved the fourth-highest test score.

Discussion

The main assumption underlying this study has been that test results from large-scale international assessments such as PISA matter. They matter not just because they offer a way of comparing how national (and sub-national) education systems are performing—a way of keeping score, as it were—but because performance on these international tests is a measure of the production of knowledge capital, which research has shown to be a driver of future economic growth and prosperity.

On this view, improving PISA and similar international scores of student achievement becomes an important strategic goal for both education and economic policy. In developing economies, the challenges of building and staffing more schools and getting more children and youth into them for longer periods of time are comparatively straightforward and achievable if the necessary financial resources can be found. But once high-capacity, well-resourced, and mature systems of elementary and secondary education are in place, it is not at all clear how additional investment can improve the production of knowledge capital. Nor is it necessarily the case that such legacy systems will be able to maintain established levels of knowledge production as social and economic environments change and system components age, as appears to be happening in Canada given the steady, albeit slow, decline in PISA scores (Allison, 2022: 22–26, figure 8, App. B).

If ways to improve the production of knowledge capital can be found, the returns could be substantial. As mentioned earlier, Hanushek and Woessmann (2015: 161–163) discuss how policy changes in an education system that produce a 25-point increase in PISA scores could plausibly produce a 3% gain in GDP over a 20-year period. They point out 25-point gains in PISA scores are quite feasible, similar gains having been achieved on equivalent assessments in their historical data for the 1975-to-2000 period by Finland and Canada (Hanushek and Woessmann, 2015: 88–94, 161). For Canada, these gains followed extensive changes in the organization and operation of elementary and secondary schools instituted at different times by each province over the post-war decades. These expensive investments transformed not just Canada's schools but contributed to the transformation of Canada's economy and society. In modern times, Estonia and Singapore increased their core PISA scores by 11.5 and 13 points, respectively, over the nine years from 2009 to 2018, putting them on track for Hanushek and Woessmann's 25-point gain in 25 years. In contrast, Canada's core PISA score

has declined by 10 points from 2009 to 2018, perhaps on-track for a 25% decline over the same 25 years. Should these patterns continue, Canada's economic competitiveness can also be expected to decline.

The knotty education policy puzzle for Canada and other high-income societies that have been reaping the rewards from earlier investments in expanded and better resourced K-12 schooling, is what to do next to fuel, or even sustain, the accumulation of knowledge capital. Maintaining the *status quo* will likely bring about primarily inflation-driven increases in spending with little improved knowledge production and a risk of decay, while emergent economies increase their knowledge capital and forge ahead.

Expanding tertiary education may appear as an attractive option, but any economic returns will remain dependent on strong knowledge production at lower levels and may yield little extra advantage, especially if tertiary curricula continue to be overly influenced by fashionable trends. One intermediate strategy available in Canada could be to encourage growth and choice in post-secondary, non-tertiary learning opportunities, which could provide a responsive market for investment in revitalized vocational education. Many European nations have long had more extensive options of this kind than Canada, providing scope for innovation by provinces. Even so, such intermediate investment must still build on the products of elementary and lower-secondary schools.

The pivotal policy challenge is to find and implement effective ways of improving the production of knowledge capital in K-12 schools or, more accurately, the age cohorts they enroll. Established options have a poor track record as illustrated by a half-century of largely unsuccessful attempts at education improvement across OECD countries. Popular but expensive policies, such as smaller class sizes, extended compulsory enrollment, extended teacher education, and consolidated administrative structures, have proved disappointing, while alternative ways of boosting achievement, such as more extensive accountability systems, teacher salary reforms, and more selective specialist curricula such as International Baccalaureate programs and Advance Placement courses have been politically unpopular.

Even so, the research consensus is that how new money is spent will be more important than how much is spent. One important lesson from attempted reforms in recent decades appears to be that uniform, system-wide and typically expensive reforms to established, well-resourced school systems have proven largely ineffective. One interesting implication is that effective school reform may not need to be expensive. Another is that effective reforms may be best achieved through distributed strategies that encourage individual schools, associations of collaborating schools, or other local agents to innovate. A key implication for legislators is that a regulatory environment that allows and even promotes and encourages such an approach may well be more likely to improve knowledge capital production than uniform, system-wide, one-size-fits-all legislated changes. In this respect, providing flexibility

and accountability for budgetary decisions by provincial finance officers appears crucial, as discussed in recent supportive Canadian research by Mou, Atkinson and Marshall (2019).

Given that reform means doing things differently as well as doing different things, then the higher performance and lower cost of some education systems in this study is encouraging. It does not necessarily follow that elements of a better performing system could be successfully transplanted into another system. Social, cultural, and economic environments will be key considerations in this respect. Adopting features of the more extensive testing regimes in place in Singapore or Hong Kong, for example, would likely not succeed without also implementing other features of those systems, such as more selective schools, test-dependent program access, or extensive out-of-school tutoring services, as well as promoting a more muscular meritocratic culture. It would seem both practically and politically challenging if not impossible to legislate such reforms within a provincial school system at the current time. Yet it may be possible to move toward such changes in, for example, one or an association of independent schools with supportive staff, parents, and students where there is already a commitment to more meritocratic norms. A wide range of other promising innovations might sensibly be borrowed from other systems if not prohibited or constrained by regulations or cultural norms. Indeed, this has been the essence of the charter school revolution in the United States. Not that the charter model would necessarily be as successful in all provinces, although the underlying engine of choice could well be profitably learned by other provinces from top-performing Alberta.

Even without a more innovation-friendly environment, the ongoing electronic revolution is already creating new, seemingly more efficient and effective ways of teaching and learning, both within schools and without. Despite the views of some, schools, especially inflexible government schools, do not have a monopoly on teaching: individuals and groups of learners can and do find and use alternative ways of acquiring economically valuable knowledge and skills, as do agents and agencies interested in disseminating knowledge they wish to propagate. This has always been the case, but opportunities for non-school teaching and learning have exploded in recent times through innovations such as on-line credit courses, web-based learning programs, internet search engines, and searchable knowledge repositories like Wikipedia, and YouTube. Whereas my generation had to rely on book-filled libraries accessed via the bus for out-of-school learning, my grandchildren tell me they routinely learn much of value quickly and efficiently through their mobile phones.

In this new world, the emergent promise of generative language-based artificial intelligence technology, for which ChatGPT is the current poster-child, promises to supercharge both school and non-school learning. Students' use of this technology to submit AI-created essays is already notorious, but some teachers are also using the technology to improve their lesson planning and pedagogy. Although AI has been branded a threat to established

education practices and educators by some, its potential to cheaply transform how young minds learn both inside and outside schools appears huge, if it can be sensibly harnessed.

A key problem—probably the key problem—posed by new learning technologies that challenge established schooling is assessment and certification. As already shown by concerns over bias and selectivity in on-line learning sources such as Wikipedia, learners can acquire inaccurate or misleading knowledge and risk being indoctrinated into suspect understandings and beliefs. Generative artificial intelligence raises these stakes while also offering increased opportunities to cheat. Even so, indoctrination and cheating have been ever present threats in schools and, as highlighted by current concerns over curriculum content and instructional standards in an increasingly "woke" world, legacy schools appear vulnerable to easy capture by activists seeking to challenge established standards and promote alternate epistemologies.

Who then will guard the guardians? How can basic learning of the kind traditionally provided by elementary and secondary schools be monitored, managed, and validated in ways that will encourage the growth of appropriate knowledge capital in more varied, flexible, and distributed learning systems? The long-established answer is through reliable and comparable tests of acquired knowledge and skills that are accepted by society, employers, and higher education institutions as valid and reliable indicators of competence. Legacy models of such instruments are formal examinations and standardized tests. In a world where knowledge capital is recognized as a key economic resource, there are strong arguments for rehabilitating formal examinations and expanding access to standardized testing, as well as for moving it closer to the general competence model used by PISA and away from the curriculum-based approach that currently dominates legacy systems. More broadly based measures of what young people can do rather than what they know about fragments of a specific curriculum are more broadly comparable and practical. Interactive generative artificial intelligence could well play an increasing role in evolving these forms of learner attainment and validation.

PISA and other large-scale international assessments, including our domestic Pan-Canadian Assessment Program (PCAP), test small samples of the assessed populations at multi-year intervals. Current provincial testing models annually assess students enrolled in selected grades against standards linked to provincial curricula. Regardless of the reliability and validity of results, they can only show whether knowledge production is improving or declining within the provincial population concerned and with reference to the curriculum content tested, which falls short of the meaningful international comparisons needed. This points to a pressing need for more frequent and, where feasible, more universal PISA-like competence testing as a way of both paying closer attention to the production of economically valuable knowledge capital and assessing the merits of any instructional innovations. How this might be achieved, or if it is even feasible, is not readily evident. It is nonetheless worthy of serious and sustained effort given its potential to foster and measure production of knowledge capital in Canada.

Conclusions

Canada's strong performance on the PISA assessments cannot be attributed to spending more than other countries on elementary and secondary education. Nor is it the case that higher levels of spending on such basic education are reliably associated with higher test scores in other high-income countries. In 2018, a third of the high-income OECD countries considered in this study spent more per elementary and secondary student than did Canada, but all achieved significantly lower PISA scores.

A similar pattern obtains within Canada. Manitoba and Saskatchewan, the two highest spending provinces in 2018, had the lowest 2018 core PISA scores, while Alberta, Quebec, and Ontario had statistically higher scores but were in the middle of the provincial spending range. British Columbia, which spent the least, had a statistically higher score than the highest spenders.

Embedded in these results is Canada's perhaps surprising position in the midrange of elementary- and secondary-level per-student spending among high-income nations. Canada had only the fourth-highest level of elementary and secondary spending per student among its G7 partners in 2018, slightly above the average for all 34 high-income OECD countries considered.

Given that credible research shows performance on tests such as PISA is related to future economic growth and prosperity, finding ways to improve such test results is an important concern for economic as well as education policy. This and related studies show that these test results are unlikely to be improved by simply spending more money on established legacy K-12 systems. Yet finding ways of improving PISA and PISA-like test scores among young Canadians so as to boost the production of knowledge capital is becoming an increasingly pressing problem as Canadian PISA scores decline and those of emergent economies rise.

Given Canada's position in the mid-range of K-12 spending by high-income countries, there is room for some modest, sensibly designed, spending increases. The challenge will not be how much more to spend, but what to spend it on. In making and monitoring these choices, policy makers and brokers will need to pay as much attention to test results as is currently given to spending. But to do this effectively, there is a pressing need to build better, more performance-based, PISA-like systems of provincial and national testing keyed more to international standards than provincial curricula.

Appendix

Table 1: Analytical and contextual data

Jurisdiction		Population (000s)	GDP		2018 Elementary and secondary per-student spending (US$ PPP)			PISA 2018
High-income OECD members	Label		US$ millions 2015	Per capita	OECD 2021: table C1.1	OECD.Stat	% pub. exp.	Core score
Australia	AUS	24,993	1,209,289	51,647	12,227	12,244	9.2	498.99
Austria	AUT	8,838	460,379	57,069	15,254	15,227	6.0	491.04
Belgium	BEL	11,427	545,629	52,668	13,322	13,298	7.9	499.90
Canada	CAN	37,058	1,705,882	48,721	11,854	11,771	7.5	516.70
Chile	CHL	18,770	434,897	24,743	6,356	6,607	12.0	437.75
Czech Republic	CZE	10,626	397,936	41,148	9,206	9,207	6.8	495.49
Denmark	DNK	5,794	301,805	57,459	11,551	13,145	7.1	501.06
Estonia	EST	1,319	43,467	36,406	8,466	8,408	7.6	525.51
Finland	FIN	5,516	249,873	49,727	10,661	10,634	6.9	516.42
France	FRA	67,265	2,863,681	46,456	11,201	11,190	6.3	493.66
Germany	DEU	82,906	4,122,427	54,955	12,774	12,796	6.3	500.44
Greece	GRC	10,733	296,167	29,681	6,943	6,935	5.5	453.47
Hungary	HUN	9,776	296,178	31,830	7,153	7,164	5.6	479.33
Iceland	ISL	353	18,910	58,140	14,593	14,316	10.1	481.40
Ireland	IRL	4,861	392,692	85,027	9,921	9,908	9.0	504.61
Israel	ISR	8,881	340,903	40,351	9,572	9,423	10.8	465.22
Italy	ITA	60,459	2,329,132	43,085	11,202	11,181	6.2	476.96
Japan	JPN	126,443	5,361,159	41,654	10,185	10,141	6.1	519.99
Korea	KOR	51,607	2,113,167	42,487	13,794	13,969	10.3	519.66
Latvia	LVA	1,926	54,314	30,814	7,076	7,091	7.0	487.36
Lithuania	LTU	2,802	93,125	36,346	6,550	6,551	6.6	479.71
Luxembourg	LUX	609	66,142	116,481	23,376	21,968	6.6	476.73
Netherlands	NLD	17,232	917,048	57,900	12,658	12,642	7.8	502.47
New Zealand	NZL	4,863	194,589	42,143	9,934	7,830	9.6	502.90

Table 1, cont'd: Analytical and contextual data

Jurisdiction		Population (000s)	GDP		2018 Elementary and secondary per-student spending (US$ PPP)			PISA 2018
High-income OECD members	Label		US$ millions 2015	Per capita	OECD 2021: table C1.1	OECD.Stat	% pub. exp.	Core score
Norway	NOR	5,312	329,378	57,577	15,972	15,994	8.3	496.94
Poland	POL	38,413	1,168,478	31,614	8,344	8,337	6.9	512.85
Portugal	PRT	10,284	333,668	34,932	10,013	10,012	8.0	491.99
Slovak Republic	SVK	5,446	177,953	31,562	7,025	6,955	6.4	469.40
Slovenia	SVN	2,072	73,737	38,952	9,584	9,595	7.2	503.75
Spain	ESP	46,729	1,760,132	40,780	9,336	9,338	6.4	482.32
Sweden	SWE	10,175	513,569	53,553	13,144	13,136	8.4	502.54
Switzerland	CHE	8,514	575,249			6,241		498.17
United Kingdom	GBR	66,436	2,952,604	45,957	12,245	12,171	8.3	503.46
United States	USA	326,949	19,481,976	61,408	14,009	14,009	8.3	495.33
Canadian provinces								
Alberta	AB	4,298	263,768	61,366		12,511		525.67
British Columbia	BC	5,010	226,608	45,227		10,051		513.33
Manitoba	MB	1,353	55,908	41,327		12,819		488.33
New Brunswick	NB	770	28,314	36,757		11,673		490.67
Nfld & Labrador	NL	526	26,356	50,148		10,789		502.00
Nova Scotia	NS	958	34,194	35,678		12,241		506.00
Ontario	ON	14,309	655,384	45,803		11,831		518.67
Prince Edward Is.	PE	153	5,321	34,688		11,288		497.33
Quebec	QC	8,402	335,032	39,877		11,610		524.33
Saskatchewan	SK	1,162	63,757	54,879		14,245		495.00

Sources: Population for OECD members: OECD, 2021: table X2.2. • Population for Canadian provinces and territories: OECD.STAT Regional economy database • GDP for OECD members: OECD.STAT Annual National Accounts, Gross domestic product (expenditure approach) Constant prices, constant PPPs • GDP for Canadian provinces and territories: OECD.STAT, Regional economy database, Regional GDP • GDP per capita for OECD members: OECD, 2021: figure C1.4 (web). • GDP per capita for Canadian provinces and territories calculated from population and GDP values. • Elementary and secondary spending per student for OECD members: OECD, 2021: table C1.1. • Elementary and secondary spending per student for Canadian provinces and territories: OECD.STAT / Education and Training / Education at a Glance / Subnational data / Financial resources invested in education. • PISA18 average scores: calculated from OECD, 2019: tables I.B1.4, I.B1.5, and I.B1.6.

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