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The importance of IALS, ALL and PIAAC results to U.S. policy

Author:
T. Scott Murray and Marilyn Binkley

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AIR-PIAAC Contact:

Jaleh Soroui (AIR-PIAAC Director)
Saida Mamedova (Senior Research Analyst)
PIAACgateway.com
piaac@air.org

Author Contact:

DataAngel Policy Research
T. Scott Murray at dataangel@me.com
Marilyn Binkley at mrbinkley@aol.com

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T. Scott Murray
Marilyn Binkley

DataAngel Policy Research

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Summary

The following report makes the case for a shift in emphasis in U.S. education and workforce development policy. Specifically, the report sets out a rationale for investing more in upgrading the foundational skill levels of the U.S. workforce. The report summarizes the results of studies that used data from the 1994 IALS, 2003 ALL and 2011 PIAAC studies that confirm the central importance of literacy and numeracy skill to economic performance.

The U.S. economy is in a period of rapid change that is characterized by a rapid decrease in the demand for workers who are only able to apply procedural knowledge routinely, and a concomitant increase in the demand for workers who can solve information-intense problems fluidly in large, socially heterogeneous teams. These shifts in skill demand are largely being driven by what has been called skill-biased technical change. The basic story is that routine procedural tasks are being automated are a rapid rate, so the creation of replacement jobs depends on workers having much higher levels of key foundation skills, such as literacy and numeracy. This basic trend is being amplified by improvements in global supply chains, communication, and transportation networks.

U.S. market actors have been slow to adjust to these changes in demand.

The skill levels of youth leaving the education system have actually been falling with time.

Employers have been investing more in training their workers, but virtually all of these investments are being made in workers who are already skilled.

Policy makers have also been slower than needed to adjust. They have been investing to increase participation in post-secondary education, but these investments have not, for a variety of reasons, precipitated material increases in the supply of key foundation skills.

The report authors suggest a need to increase the skill levels of youth leaving all levels of the education system. This alone will not yield enough new skill to satisfy the predicted demand, so the authors also recommend that policy makers find ways to induce employers into upgrading the foundation skill levels of their workers. A failure to take these measures will lead to material declines in income and employment levels and rising skill-based inequality in valued labour market and educational outcomes.

Chapter 1. Introduction

The demand for skill in the U.S. economy is growing in response to technical advances and to fundamental changes in the structure of the global economy. The general increase in the demand for technical skills is accompanied by a rapid increase in the demand for literacy and numeracy skill, skills that are critically important to the acquisition of other skills and to the efficient application of other skills to productive ends.[1] [2]

Literacy skill, as measured in IALS, ALL and PIAAC, involves more than the simple act of reading. Literacy involves applying what has been read as a means to solve a range of increasingly difficult problems.[3] As such, literacy demands the application of a set of cognitive strategies that are acquired and maintained through practice. Literacy is a relative concept in which the adequacy of an individual's skill level can only be judged against the demands they face in work and daily life or that they need to realize their personal goals. Although most adults become fluid and automatic readers as a product of their initial education, one can learn to be a proficient reader in other ways at any age. Once acquired, literacy skill is maintained through practice. Adults who face low levels of demand for literacy skill use are, however, at risk of losing their skill over the life course.[4]

Analysis of data from the IALS, ALL and PIAAC assessments suggests that roughly half of U.S. workers have literacy skills below the level needed to do their current job fully productively. In addition, there is good reason to believe that the traditional sources of new literacy skill supply will not be large enough to reduce these occupational skill shortages, or to satisfy the projected rapid growth in demand for literacy skills.[5]

U.S. policy makers have traditionally relied heavily on demand-pull measures i.e., measures that serve to increase the demand for skills, including the demand for literacy skills. Such investments include investments in Research and Development and infrastructure to foster economic growth while assuming the education and labour markets would adjust efficiently to any demand shocks created by shifts in the terms of trade.

Significant investments have also been made to increase the supply of skill available to the economy. For the most part, these investments have served to increase educational participation rates and average years of schooling in the initial cycle of education with little attention being

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[1] Autor, D.H., Levy, F., Murnane, R.J. (2003) ***The Skill Content of Recent Technological Change: An Empirical Exploration,*** The Quarterly Journal of Economics, Volume 118, Issue 4, November 2003, Pages 1279–1333, https://doi.org/10.1162/003355303322552801

[2] Sackett, P.R. and Walmsley, P.T. (2014) ***Which Personality Attributes Are Most Important in the Workplace?*** Perspectives on Psychological Science 2014, Vol. 9(5) 538–551

[3] For a detailed summary of the theory and methods used in the IALS, ALL and PIAAC study see NCES and Statistics Canada (2003) The Adult Literacy and Life Skills Survey: New Frameworks for Assessment, Murray, T.S., Clermont, Y. and Binkley, M. (eds), Ottawa and Washington

[4] Murray, T.S., Binkley, M. and Shillington, R. (2015) ***Reconstructing the Evolution of the American Supply of Cognitive Skills: A Synthetic Cohort Analysis,*** AIR, Washington

[5] This assertion is inferred from evidence for Canada that has the benefit of having Essential Skills Demand Profiles by Occupation, ones that provide estimates of occupational literacy skill demand that can be compared to skill supply of job incumbents. See Murray, T.S. and Shillington, R. (2007) ***Understanding Essential Skill Markets in Alberta: A Market Segmentation Analysis***, DataAngel, Ottawa

paid to the quality of the education being provided or the fit of new skill supply to the evolving needs of the economy.[6] These supply-push measures served the needs of the post-World War II industrial economy well but are not providing the higher skill base needed to compete in the emerging global knowledge economy. In our view, the U.S. economy is facing a shift in the terms of trade that are rapid enough to raise serious questions about the ability of the traditional policy approaches to maintain U.S. competitiveness on global markets and to maintain skill-based social and economic inequalities at manageable levels.

U.S. policy makers might respond to the on-going changes in the terms of trade in four ways. They might:

- Take measures to further increase the rate at which skill demand is rising, measures that can be called demand pull measures

- Take measures to increase the rates at which key sources of new skill supply are adding to the supply. Additional supply will allow employers to increase the rate at which they are able to adjust to rising skill demand and that attenuate the negative impacts of skill shortages on economic performance

- Take measures to improve the efficiency of the markets that match workers skills with employer demand for skill so that more of the available supply of skill gets put to productive use.

- Chose to do nothing, trusting that markets are sufficiently efficient to adjust rapidly enough to avoid any serious economic impacts

The key objective of this report is to highlight what analyses of IALS, ALL and PIAAC data suggest about the optimal mix of these policy alternatives. The interpretations presented are based upon the authors' involvement in the design and implementation of the IALS, ALL and PIAAC studies and their extensive experience in specifying and interpreting the results of analyses that use data from the three assessments. One of the authors – Murray – has also played a pivotal role in defining the Government of Canada's policy response to the broadly writ findings.

This chapter, **Chapter 1** introduces the report by summarizing its objectives and organization. The goal is not to analyze data but to organize already available findings in a way that lets readers know if they are as predicted by theory and whether they tell a coherent story for policy. Most, but not all, of the evidence presented is based on analysis of data from the 1994 and 1996 International Adult Literacy Surveys (IALS), the 2003 and 2005 Adult Literacy and Life Skills Surveys (ALL) and the 2011 Program for the International Assessment of Adult Competencies (PIAAC). All three studies are household-based assessments of literacy and numeracy skill that allow one to profile the social distribution of skill, to identify the determinants of skill and to document the impact that skill differences have on individual, institutional and macro-outcomes. The studies were enabled by theoretical advances in our understanding of the factors that

[6] See The Condition of Education 2021 https://nces.ed.gov/programs/coe/

underlie the relative difficulty of reading tasks and practical advances in the methods used to summarize test results in a valid, reliable and interpretable way. Importantly for the current context, the manner in which literacy was tested, and the methods used to summarize literacy proficiency, allow for the direct comparison of skill distributions across the three studies.

Chapter 2 summarizes what is known about the knowledge intensification of the U.S. economy and the forces that are driving it.

Chapter 3 outlines three possible policy responses that U.S. policy makers might take in response to the projected knowledge and skill intensification and provides an economic rationale for each, either to realize the potential benefits that might accrue to more rapid adjustment or to attenuate the effects of lower than needed rates of adjustment.

Analyses of IALS, ALL and PIAAC data are used to:

- Characterize several skill-related problems and issues in the U.S. economy
- Reveal the links how these skill-related problems may affect economic performance.
- Describe some of the policy options that are available to policy makers and what impact each might have on economic performance at the individual, firm and macro-levels. The basic consideration in this analysis is that there would be merit in U.S. policy makers paying more attention to literacy when developing their policy responses.

Chapter 4 summarizes the report and recommends next steps.

It is hoped that the report will improve use of the PIAAC results by making explicit connections to the underlying economic theories that informed the studies and by presenting results in a way that is easily accessible to policy makers, politicians and the policy process.

More specifically, this report outlines four policy options that emerge from analysis of IALS, ALL and PIAAC data, each of which has the potential to push U.S. policy in new directions.

The report establishes that the first three policy options fit tightly with what prevailing economic theory would predict. Moreover, the analysis presented establishes that the underlying trends that have been driving change will continue to amplify the impact of skill differences on rates of economic growth and on the rates at which skill-based inequalities in individual social, labour market, educational and health outcomes grow. Prosaically, the findings are important, and are likely to become more so, under the assumption that education and skill markets are unlikely to adjust rapidly enough.

Each of the policy options presents an opportunity to either precipitate higher levels of economic growth or to attenuate social inequality in individual labour market, educational, social and health outcomes. In some cases, policy can accomplish both goals simultaneously.

At the same time, the analysis suggests that a failure to act has the potential to seriously impair the performance of the U.S. economy. It is also unlikely that other market actors - individuals, firms, training providers – will adjust rapidly enough to capitalize on the opportunities at hand. So, there is an opportunity for governments to intervene to increase the speed at which the education and labour markets adjusts to the economic forces driving change.

Chapter 2. The knowledge and skill intensification of the global economy

According to several researchers, the U.S. economy is experiencing a rapid and sustained increase in the demand for technical skills and the advanced levels of cognitive skills needed to apply technical skills to globally competitive levels. In this chapter we consider two questions:

- What is known about the skill intensification of the U.S. economy, and
- What forces are driving that trend.

2.1 The skill intensification of the U.S. economy

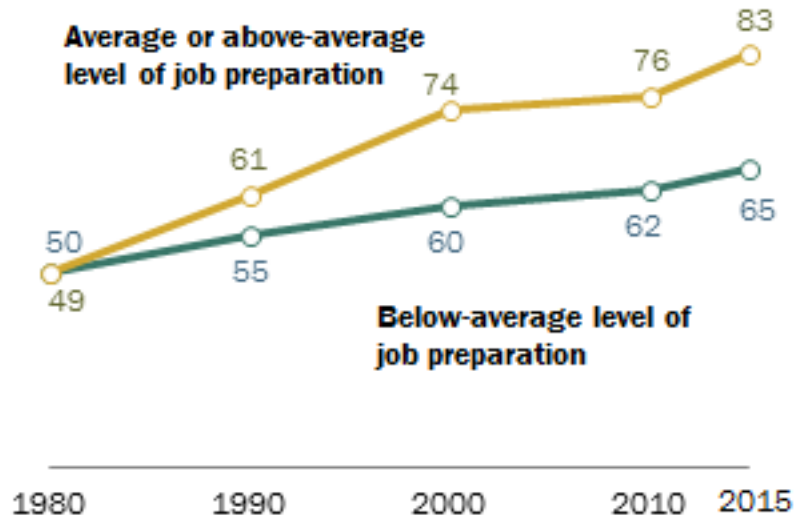
To establish whether the shift in skill intensification is actually happening, we consider research done by a number of authors:

A. Research by **the Pew Research Center** uses monthly Bureau of Labor Statistics Current Population Survey (CPS) employment data for the United States to document how rapidly the knowledge intensity of jobs has increased skill demand surely and steadily over recent decades.[7]

[7] Pew Research Center (2016) ***The State of American Jobs: Changes in the American workplace*** https://www.pewsocialtrends.org/2016/10/06/1-changes-in-the-american-workplace/

Employment is rising faster in occupations requiring higher levels of preparation

Number employed, in millions



Note: Based on employed civilians ages 16 and older. The job preparation level is based on a scale of one (little or no education/ experience/training) to five (extensive education /experience/ training).
Source: Pew Research Center analysis of O*NET and monthly Current Population Survey data (IPUMS).
"The State of American Jobs"

PEW RESEARCH CENTER

A key factor adding to the increase in skill demand since 1990 is the decline in manufacturing employment by about a third at the same time employment in knowledge-intensive and service-oriented sectors, such as education, health, and professional and business services, has about doubled. Pew attributes this trend to underlying factors such as globalization, outsourcing of jobs and technological change.

B. In 2005, **Mckinsey** published a ground-breaking research report that identified the fact that the most valued workers had to undertake business activities that economists call "interactions": in the broadest sense, the searching, coordinating, and monitoring required to exchange goods or services.[8] The **Mckinsey** report furthers the argument by pointing out that between 1999 and 2005, the number of U.S. jobs that include tacit interactions as an essential component grew two and a half times faster than the number of transactional jobs and three times faster than employment in the entire national economy. To put it another way, 70 percent of all U.S. jobs created between 1998 and 2005 —4.5 million, or roughly the combined U.S. workforce of the 56 largest public companies by market capitalization—require judgment and experience that demands literacy and numeracy skill to apply reliably. By 2005, these jobs made up 41 percent of the labor market in the United States. Indeed, most developed nations are experiencing this trend.

Recently published research undertaken by **Prudential** suggests that the trend towards more knowledge and skill intense jobs continues unabated.[9] The Prudential analysis concludes that there appears to be an acute mismatch between skill levels associated with job openings relative to the education and skills of people looking for work. According to business surveys, 44% of firms report that they have one or more job openings, the highest percentage on record.

Previous research by McKinsey had already shown that specialization, globalization, and technology were making interactions far more pervasive in developed economies.

This can be explained by understanding that:

- Specialization tends to atomize work and to increase the need to interact,
- Outsourcing, like the boom in global operations and marketing, dramatically increases the need to interact with vendors and partners, and,
- Communications technologies such as e-mail and instant messaging make interaction easier and far less expensive.

Within the realm of interactions, McKinsey identified another shift, one that they predicted would have dramatic implications for the way companies organize and compete. Their work on job trends in a number of sectors found that companies were hiring more workers for more complex, than for less complex, interactions.

Most jobs mix both kinds of activities—when managers fill out their expense reports, that's a transaction; leading workshops on corporate strategy with their direct reports is

[8] Johnson, B., Manyika, J. and Yee, L. (2005), ***The next revolution in interactions,*** Mckinsey Quarterly
[9] Prudential (2021) ***U.S. Labor Market Trends,*** https://assets-global.website-files.com/5fff16b6c0c7de22bc680b0f/60d09a23b34482cfd6d3345e_EP%20Final_2021_06_21.pdf

tacit work. But what counts in a job are its predominant and necessary activities, which determine its value added and compensation.

Complex interactions typically require people to deal with ambiguity—there are no rule books to follow—and to exercise high levels of judgment. Literacy as currently conceived involves drawing inferences from what has been read. Similarly, numeracy involves understanding the problem that needs to be solved and then selecting and performing the required steps to derive a result. Men and women in jobs requiring complex interactions (such as managers, salespeople, nurses, lawyers, judges, and mediators) must often draw on deep experience, which economists call "tacit knowledge." McKinsey referred this more complex level of interaction as *tacit* and to the more routine ones as transactional.

The basic issue addressed in this paper is that it is highly unlikely that the markets that generate new skill supply will adjust rapidly enough to these fundamental changes in the nature of work, specifically in the exploding demand for workers to use advanced levels of cognitive and non-cognitive soft skills to solve complex problems in a fluid and automatic way.

C. Handel:

More recent analysis by **Handel** examined skill trends in 24 OECD countries over the past several decades. [10] The skill measures used included broad occupation groups, country-specific direct measures of skill requirements from international surveys, and direct skill measures from the Occupational Information Network (O*NET) database applied to data from both United States and European labour force surveys. According to the author, each kind of data has its own strengths and limitations, but they tell a consistent story.

Handel's analysis revealed that economically advanced countries experienced a generally steady, continuous process of skill upgrading over the time periods for which data are available. Blue collar occupations saw the most pronounced relative declines, while less skilled white-collar occupations increased their shares of the workforce initially before stabilising or declining slightly. Using the more specific skill measures in the O*NET database, Handel's analysis suggests higher educational, cognitive and interpersonal skill requirements, while craft skills, physical demands and the frequency of repetitive physical tasks, declined. Changes in European countries happened at a more rapid rate, something that closed the measured gap with the United States. This more fine-grained method of measuring skills also suggests that trends are gradual, a finding that fits with episodic nature of employer adjustment to technological shocks.
Handel's analysis found no strong evidence of a general acceleration of skill upgrading in recent decades despite widespread talk of it as a consequence of the diffusion of

[10] Michael J. Handel, M.J. (2012) ***OECD SOCIAL, EMPLOYMENT AND MIGRATION WORKING PAPERS, No. 143 TRENDS IN JOB SKILL DEMANDS IN OECD COUNTRIES,*** **OECD, Paris** https://www.oecd-ilibrary.org/social-issues-migration-health/trends-in-job-skill-demands-in-oecd-countries_5k8zk8pcq6td-en

Information and Communication Technologies. Official forecasts in the EU, Australia, Canada, New Zealand and the United States do not suggest acceleration in the next ten years, a finding that my own research on skill demand, skill gain and skill loss traces to a market failure in which employers are reducing the skill levels demanded by their jobs as a means to avoid having to pay shortage-induced, rapidly rising, wage premia to literacy and numeracy.[11]

Sackett and Walmsley: Recent analysis by Sackett and Walmsley generally corroborate the Mckinsey and Handel conclusions, but provide more focus on changes in the demand for, and the impact on job performance, of "soft" non-cognitive skills.[12]

D. Additionally, **Fernandez and Umbricht** use IALS, ALL and PIAAC data to explore whether the demand for skills has been rising in the U.S. and how their impact on key labour market outcomes has evolved.[13] Although the analysis is silent on the causes, the authors conclude that skill demand is rising and that skill differences are associated with growing differences in labour market outcomes.

As a result of these analyses, researchers have become much more interested in what levels of both cognitive and non-cognitive skills are needed to support complex interactions and their impact on individual, institutional and macro-outcomes. This interest has been driven by the impact of technical advances and globalization on the relative demands for different kinds of skill, most specifically the need for workers who possess both advanced levels of cognitive and non-cognitive skills.

The following section of the report provides a high-level summary of the forces that are driving the increased demand for complex interactions and, with it, higher levels of literacy and numeracy skills.

2.2 The forces that are driving the increased demand for complex interactions and higher levels of literacy and numeracy skills

In keeping with Pew's conclusion, analysis by Murray identifies four forces that are driving the increased demand for complex interactions and with it the demand for higher levels of literacy and numeracy skill:

A. Skill-biased technical change,
B. The globalization of markets for key production inputs,
C. The increase in the global supply of economically important skills, and
D. Falling trade barriers.

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[11] Murray, T.S., Binkley, M. and Shillington, R. (2015) ***Reconstructing the Evolution of the American Supply of Cognitive Skills: A Synthetic Cohort Analysis,*** AIR, Washington

[12] Sackett, P.R. and Walmsley, P.T. (2014) ***Which Personality Attributes Are Most Important in the Workplace?*** Perspectives on Psychological Science 2014, Vol. 9(5) 538–551

[13] Fernandez, F. and Umbricht, M. (2015) ***Education and Work in the 21st Century: Credential Inflation or Transformation?*** AIR, Washington.

We consider each of these in turn.

A. **Skill based technical change**

Skill-biased technical change is "a shift in the production **technology** that favors **skilled** (e.g., more educated, more able, more experienced, more literate and numerate) labor over unskilled labor by increasing its relative productivity and, therefore, its relative demand". Recent analysis of PIAAC data confirms the hypothesized relationships and their impacts on skill demand.[14]

Numerous researchers have made the general connection between education, technology and skills, including key cognitive skills. For example, Goldin and Katz, in their seminal 2008 book "The race between education and technology", document how technical advances have precipitated a secular increase in the demand for education, a demand that precipitated the growth of universal secondary education and, more recently, the rapid expansion of the post-secondary education system.[15] These authors focussed almost exclusively, however, on the impact of technology on the demand for the **quantity** of education and have very little to say about the quality of education nor how the required skill mix is changing with time. Implicitly, they assume that the education system will deliver sufficient skill of the requisite quality.

Card and DiNardo also explored the rise in U.S. wage inequality that is usually attributed to skill-biased technical change (SBTC), associated with new computer technologies. They identified that a key problem for the SBTC hypothesis is that wage inequality stabilized in the 1990s despite continuing advances in computer technology. They also found that SBTC also failed to explain the evolution of other dimensions of wage inequality, including the gender and racial wage gaps and the age gradient in the return to education in the U.S.[16] Further, by using averages of either technology availability or undifferentiated use, the Card and DiNardo analysis failed to account for the huge variability in what workers are doing with the technology. More specifically, their analysis did not capture any of the inter-worker variation in the relative difficulty of the tasks being undertaken by workers, whether judged in Bloom's taxonomy terms – knowledge, comprehension, application, analysis, synthesis, evaluation – or by the determinants that predict the relative difficulty of the technology-assisted literacy, numeracy and problem-solving tasks.

Collectively what these studies demonstrated was the need for a more nuanced measure of both the cognitive and non-cognitive skills inherent in the increased demand of the evolving technological workplace.

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[14] Pouliakas, Konstantinos; Russo, Giovanni (2015): ***Heterogeneity of Skill Needs and Job Complexity: Evidence from the OECD PIAAC Survey***, IZA Discussion Papers, No. 9392, Institute for the Study of Labor (IZA), Bonn

[15] Goldin, C. and Katz, L. (2008) ***The race between education and technology***, Cambridge and London

[16] Card, D. and DiNardo, J.E. (2002) ***Skill-Biased Technological Change and Rising Wage Inequality: Some Problems and Puzzles*** Journal of Labor Economics, 2002, vol. 20, no. 4, Chicago.

Fortuitously, theoretical advances related to predicting the relative difficulty of literacy and numeracy tasks, as well as advances in the statistical methods used to derive reliable proficiency scores, provided a means to measure the level and distribution of literacy and numeracy. Initially applied in student populations, the first assessments of adult cognitive skills conducted in the 1980's revealed much more variance in education quality at each level of attainment than expected a finding that led policy makers to want to find out if the observed level of variation persisted in adult populations. This interest was further fueled by complaints from employers about the skill deficiencies of their new hires. This interest initially led to the conduct of the 1987 Literacy Skills Used in Daily Activities (LSUDA) assessment in Canada, a clone of the 1985 U.S. Young Adult Literacy Survey (YALS) applied to a representative sample of the Canadian adult population that was largely motivated by concerns voiced by employer's organizations, including the Conference Board of Canada.[17] Analysis of data from the YALS, LSUDA and 1990 U.S. National Adult Literacy Survey (NALS) eventually led to the conduct of the 1994 IALS, ALL and PIAAC comparative assessments that yield reliable indicators of individual education and skill differences linked to outcomes.

Subsequently, PIAAC has been found to provide a good measure of key cognitive skills in a valid, reliable and comparable way. The PIAAC measures capture inter-worker differences in worker proficiency levels and in the incidence and frequency of key skill uses that are absent from the SBTC econometric literature and that, if included, should improve the predictive power of the theory.[18]

[17] This assertion is based upon work I did as the LSUDA National Study Manager at Statistics Canada and my role as the IALS International Study Manager. LSUDA responded directly to pressure on the federal Secretary of State to improve the quality of the labour supply.

[18] It is worth noting, however, that PIAAC does not provide all of the measures that one would need to test SBTC theory. First, it measures supply of skill that workers bring to the job rather than the skills that are demanded by a specific job. Thus, PIAAC itself cannot identify instances of skill shortages, nor variation in how efficiently and effectively different employers apply skill to productive ends. Second, the PIAAC skill supply estimates assume that the mastery level of RP 67% assumed in deriving the PIAAC skill supply estimates accurately captures inter-employer variation in the actual demands of employers that itself reflects variation in their tolerance for error and how they organize and manage work. Analysis, commissioned by one of the authors (Murray), re-analyzed the IALS item data to determine what RP levels yielded the most reliable classification of workers proficiency level in jobs that varied in their knowledge and skill intensity.

This analysis suggested that an RP of 5% yielded the most reliable classification of jobs that impose low knowledge and skill demands. In sharp contrast, an RP of 95% yielded the most reliable classification of jobs that impose the highest knowledge and skill intensity demands.[18] Thus, PIAAC significantly over-estimates the skill demands of low skill jobs and somewhat underestimates the demands of high skill jobs by adopting a single RP of 67% that cannot be empirically justified for the overwhelming majority of jobs.

Third, PIAAC does not provide reliable estimates of total hours worked in the year that are needed to derive reliable estimates of labour productivity i.e., effective hourly wage rates.[18] Card and DiNardo found that CPS-based productivity time series were subject to significant non-response bias and imputation error of a sort that also impact the reliability of PIAAC estimates.

As noted above, IALS, ALL and PIAAC offer only indirect evidence on how the demand for key skills is evolving. Specifically, shifts in the occupational distribution over time towards occupations that demand higher levels of literacy and numeracy skill implies a very rapid increase in the demand for these skills in the U.S.

The theory of skill-biased technical change predicts that technical advances have the effect of increasing the net demand for skill, including the cognitive skills assessed in IALS, ALL and PIAAC, as well as key non-cognitive soft skills. [19] [20] The OECD published a useful background paper, authored by Levy, on how technology changes the demand for skills, including the skills assessed by IALS, ALL and PIAAC.[21]

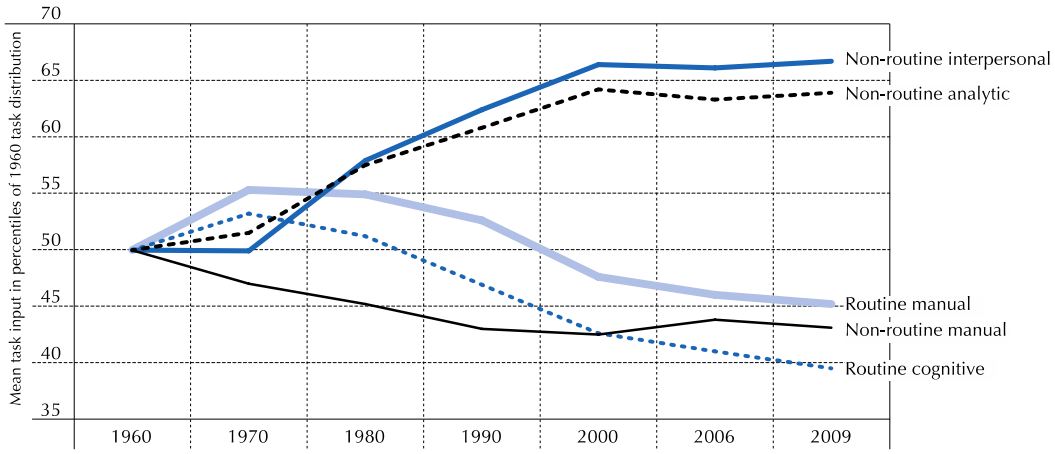
McKinsey's findings cited above were primarily intended for employers who adopt quite loose skill definitions. Autor, Levy and Murnane undertook a more rigorous economic analysis that argues that computer technology will displace large numbers of jobs that require the application of routine, procedural knowledge and that the remaining technology-rich workplaces will require advanced foundational skills, including numeracy and literacy as measured by IALS, ALL and PIAAC. [22] These technology-rich workplaces will also require workers to have advanced problem-solving skills and advanced written and oral communication skills, the application of both of which depend upon having advanced literacy and numeracy skills.

More generally, Autor, Levy and Murnane infer that technical advance, including the diffusion of digital technologies throughout the economy, reduces the demand for workers who are only able to apply routine procedural knowledge and concomitantly increases the demand for workers who are fluid problem solvers and good team-workers.[23] Efficient and effective problem solving, and collaboration, depend critically on having Level 3 or better literacy and numeracy skills as defined by the PIAAC scales. The following chart highlights the dramatic shift in skill demand in the U.S. economy that occurred between 1960 and 2009.[24]

[19] Acemoglu, D. (2002) ***Technical change, inequality and the labor* market**, Journal of Economic Literature Vol.XL, pp. 7-72, Cambridge.
[20] Goldin, C. and Katz, L. (1998) ***The Origins of Technology-Skill Complementarity***, Quarterly. Journal of Economics. 113:3, pp.
[21] Levy, F. (2010) ***How technology changes demands for human skills***, OECD Education Working Paper No. 45, Paris.
[22] Autor, D.H., Levy, F., Murnane, R.J. (2003) ***The Skill Content of Recent Technological Change: An Empirical Exploration,*** The Quarterly Journal of Economics, Volume 118, Issue 4, November 2003, Pages 1279–1333, https://doi.org/10.1162/003355303322552801
[23] Autor, D. H. and Price, B.M (2013) ***The Changing Task Composition of the US Labor Market***:
[24] OECD (2013) **OECD Skills Outlook 2013: First Results from the Survey OF Adult Skills**, Paris

Change in the demand for skills

Trends in routine and non-routine tasks in occupations, United States, 1960 to 2009



Source: Autor, D.H. and B.M. Price (2013), see Table A1.5 in Annex A.

StatLink http://dx.doi.org/10.1787/888932900308

A recent report from McKinsey confirms that global value chains have continued to become more knowledge intense at a rapid rate.[25]

Machines are simply more productive than workers, generating more output per hour at lower costs and with fewer mistakes, in repetitive, procedural jobs. In order to generate enough value to justify being hired, workers must be able to perform more cognitively and non-cognitively demanding, non-routine tasks.

More recently Pouliakas and Russo used information from the new OECD Survey of Adult Skills (PIAAC) to investigate the link between job tasks and cognitive skill demand in 22 advanced economies. [26] Skill demand was operationalized by the assessed literacy and numeracy skills of workers with well-matched skills to their job duties. Jobs were then categorised according to the nature of tasks, including the intensity of abstract reasoning, employee latitude, interactivity or manual work. Their analysis confirmed the significant relation between task complexity and higher skill needs. The significant relation held independently of the endogenous supply of formal human capital, occupational or industrial structure and other job or individual characteristics. The results confirm the (indirect) mapping between tasks and skills as predicted by the task approach to labour economics. Given the marked heterogeneity in workplace practices adopted by employers, it is clear that enterprise-level workplace development policies are warranted as enablers of skills matching and higher labour productivity.

[25] McKinsey (2019) ***Globalization in transition: The Future of Trade and Value Chains,*** San Francisco

[26] Pouliakas, K. Russo, (2015): ***Heterogeneity of Skill Needs and Job Complexity: Evidence from the OECD PIAAC Survey,*** IZA Discussion Papers, No. 9392, Institute for the Study of Labor (IZA), Bonn

The only evidence related to the efficacy of skill demand measures comes from macro-economic modelling that used IALS, ALL and PIAAC data to predict inter-country differences in the long-term growth rates of GDP and productivity. Successive analyses confirm that increases in literacy skill lead rather than lag increases in growth, a finding that suggests that skill supply is the limiting factor in the rate at which technical innovations can be adopted.[27] The fact that literacy skill increases lead rather than lag increases in key indicators of economic growth fits with the general predictions of skill biased technical change – that additional skill is required to capture the benefits of technical progress and, more specifically, with the extensive literature on the role that shortages of cognitive skills have played in the failure of computer technology to precipitate the expected increases in either labour productivity or overall productivity.[28]

More pointedly, synthetic cohort analysis of IALS, ALL and PIAAC data suggests that rising literacy skill shortages are driving equally rapid increases in the wage premia to workers with higher levels of literacy skill.[29]

Analysis of Canadian data that documents rates of wage rate growth by the level of literacy skill demanded by the job and analyses of the determinants of skill gain and loss provide evidence that Canadian employers are reducing the cognitive demands of their jobs. It is highly likely that similar wage premia are inducing a large proportion of U.S. employers to reduce the cognitive demands of their jobs as a way to reduce the rate at which their labour costs are rising.[30]
Two lines of evidence suggest that there is a causal link between literacy skill and productivity. First, skill upgrading randomized controlled trials in both Canada and the U.S. establish the positive impact that higher literacy skills have on labour productivity.[31] Second, macro-economic modelling that includes literacy estimates from IALS, ALL and PIAAC establish that differences in average literacy skill among countries are associated with large differences in long-term GDP and productivity growth rates and, coincidentally, that increases in literacy scores lead, rather than lag, increases in growth. [32] Because of the causal link between literacy skill and productivity, the fact that some employers are reducing the cognitive demands of their jobs as a means to avoid paying for the rising premia to advanced literacy and numeracy skills sacrifices a significant amount of output per hour worked. Ironically, this behaviour also precipitates significant

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[27] Coulombe, S.,Tremblay, J.F and Marchand, M.J. (1997) ***Literacy scores, human capital and growth,*** Statistics Canada, Ottawa and Weiderhold, S. and Schwerdt, G. and Murray, T.S. (2020) ***Literacy and Growth: New Evidence from PIAAC***, AIR, Washington.

[28] Aceogleu D. (2002) ***Technical change, inequality and the labor* market**, Journal of Economic Literature Vol.XL, pp. 7-72, Cambridge.

[29] Murray, T.S. and Shillington, R. (2014) ***The Efficiency of Essential Skills Markets in Alberta: Initial Results from PIAAC,*** DataAngel Policy Research, www.dataangel.com

[30] Murray, T.S., Binkley, M. and Shillington, R. (2015) ***Reconstructing the Evolution of the American Supply of Cognitive Skills: A Synthetic Cohort Analysis,*** AIR, Washington

[31] For the US see Reder, S. (2010, August). ***Adult Literacy Development and Economic Growth***. Washington, DC: National Institute for Literacy. For Canada see SRDC (2014) ***Upskill: A Credible Test of Workplace Literacy and Essential Skills Training***, Ottawa

[32] See, for example, Schwerdt, G., Weiderhold, S. and Murray, T.S. (2020) ***Literacy and Growth: New Evidence from PIAAC***, AIR, Washington

literacy skill loss through a lack of use by workers who initially had higher levels of literacy and numeracy skill.

The observed skill loss is large enough to more than offset all of the gains in average literacy skill supply from higher average years of schooling and higher levels of participation in adult education and training by U.S. workers. [33] To make matters worse, the shortage-induced increases in the wage premia accruing to higher levels of literacy skill are driving an equally rapid increase in U.S. income inequality.

A reasonable conclusion is that public investments that serve to increase the rate of technical change may be a good thing but only as long as the workforce has the skill levels needed to take fuller advantage of the productivity enhancing features of the technology than competitor's workforces. As noted earlier, rates of private investment in all forms of adult skill upgrading, including literacy and numeracy skill upgrading, are rising but not at a rate to satisfy rapidly growing demand, so public investment in skill upgrading may be needed to supply the requisite skills.

B. Globalization is driving up the demand for workers with advanced literacy and numeracy skills

The process of globalization has also served to increase the demand for skill, including the cognitive skills assessed by PIAAC. Recent publications by McKinsey and the World Economic Forum highlight these trends[34] [35] Globalization reduces the ability of firms to gain comparative advantage from lower prices for capital, raw materials, advanced production technology and even Research and Development services and increased the relative importance of the efficiency with which skills are utilized.

C. Rising global supply of key cognitive skills

At the same time, a rapid increase in average years of schooling is driving an equally rapid increase the global supply of key cognitive skills, much of it in low wage economies, but not enough to satisfy the predicted growth in skill demand. The World Bank has published data on the extraordinary increase in average years of schooling occurring over the past few decades. [36] A decline in trade in physical goods has been offset by an increase in trade in services and technology, trends that have kept downward pressure on wages in the advanced economies of the OECD. An increasing number of

[33] Murray, T.S., Binkley, M. and Shillington, R. (2015) ***Reconstructing the Evolution of the American Supply of Cognitive Skills: A Synthetic Cohort Analysis,*** AIR, Washington, D.C.
[34] Lund, S, Manyika, J., Woetzel, J Bughin, J., Krishnan, M., Seong, J. and Muir, M (2019) ***Globalization in***
[35] World Economic Forum (2020) **The Future of Jobs Report 2020**
[36] See https://tcdata360.worldbank.org/indicators/h22a4bb2b

foreign competitors are able match U.S. producers on product quality and to beat them on price in a range of markets.[37] [38]

Faced with a level playing field for other inputs, U.S. firms can only gain market share by wringing more output per hour worked out of the same inputs i.e., by being more productive than their foreign competitors. As noted above, differences in literacy and numeracy are the single most important determinant of inter-country differences in productivity growth over the long term.

Rapid increases in education levels in low wage foreign economies have also allowed American firms to outsource jobs without sacrificing quality. The inevitable conclusion drawn from skill-biased technical change theory is that higher levels of the cognitive skills that are measured by PIAAC are essential to applying technical skills productively enough to maintain competitiveness on global markets. The related policy question remains, will the education system generate the needed additional human capital? So far, the answer in the U.S. and Canada would seem to be not, as average literacy and numeracy scores of recent cohorts of graduates have actually been falling over time.[39]

The trends enumerated above have had a dramatic impact on the rate at which skill demand has been growing in the U.S. economy. There is every reason to believe that these trends will continue to drive up the demand for skill being generated by the U.S. economy, including, but not limited to, the demand for literacy and numeracy.

D. Falling trade barriers

A series of trade agreements has served to reduce tariff and non-tariff barriers to trade with several key trading partners. This freeing of trade opens the potential of significant economies of scale to U.S. producers, but also opens U.S. markets to foreign competitors who now have access to all of the requisite inputs – raw materials, capital, advanced production technology and a skilled workforce – to allow them to compete on both price and quality.

Because policy makers and training providers did not predict the speed with which the U.S. economy is knowledge and skill intensifying, shortages of key skills, including literacy and numeracy, were inevitable.

Despite the fact that the education system provided the skill mix necessary for the industrial economy for most of the post-war period, it has been slow to respond the increased demand for literacy and numeracy skills needed by the emerging knowledge and information economy associated with the so called "Fourth Industrial Revolution". It was only in the 1980's where technical advance, globalization and global investments in education started to have enough of

[37] World Economic Forum (2020) **The Future of Jobs Report 2020**
[38] Grundke, R, Jamet, S. Kalamova, M., Squicciarini, M. (2017) ***HAVING THE RIGHT MIX: THE ROLE OF SKILL BUNDLES FOR COMPARATIVE ADVANTAGE IN GVCS***, OECD, Paris
[39] Murray, T.S., Binkley, M. and Shillington, R. (2015) ***Reconstructing the Evolution of the American Supply of Cognitive Skills: A Synthetic Cohort Analysis,*** AIR, Washington, D.C.

an impact on the demand for the skills measured by PISA, NALS, IALS, ALL and PIAAC to get the attention of educators and economists.

The United States Departments of Education and of Labor have played a central role in the development and application of comparative assessments of economically and socially important cognitive skills, including literacy, numeracy and problem solving.

Beginning with the 1985 Young Adult Literacy Survey (YALS) and the 1990 National Adult Literacy Survey (NALS), the U.S. has participated in a series of international comparative adult skill assessments, including the 1994 International Adult Literacy Survey (IALS), the 2003 Adult Literacy and Life Skills Survey (ALL), the 2005 International Survey of Reading Skills (ISRS) and most recently the Organization for Economic Cooperation and Development's 2012 Program for the International Assessment of Adult Competencies (PIAAC) assessment. A forthcoming round of PIAAC data collection is now scheduled for 2022.

Analysis of these datasets has added greatly to the collective understanding of how skill supply is generated, how skill demand is evolving, how efficiently markets for skill work and what impact skill has on a broad range of individual, institutional and macro labour market, social, health and educational outcomes.

At a general level analyses of these datasets fit with the predictions of skill-biased technical change's impact on the demand for higher skills. They confirm that the demand for key cognitive skills is increasing, including literacy, that literacy skill supply shortages and misfit are impairing economic performance and amplifying wage inequality. Additionally, the impact of literacy skill shortages on economic performance is likely to continue to grow. What seems to have caught both policy makers and politicians off guard is the speed with which they have had to adjust to the rising importance of literacy to maintaining competitiveness on global markets.

These findings raise several important questions for U.S. policy makers.

> First, Is the rate of knowledge and skill intensification rising as rapidly in the U.S. economy as it is in key trading partners? If not, why not and what might be done to raise rates?
>
> Second, even if the U.S. rates of knowledge intensification are in line with those being realized by their key competitors, are there additional economic benefits that would accrue to measures that are designed to drive up rates of knowledge intensification even more rapidly? What, if anything, might stand in the way of achieving higher rates of knowledge and skill intensification?
>
> Third, what is the relative impact of different types of skill sets on economic outcomes for individuals, firms and for overall economic performance? The analysis by Grundke cited above identifies cognitive skill bundles that have been highly predictive of inter-country differences in the growth rates of value-added trade. How important to outcomes are the cognitive skills assessed in the IALS, ALL and PIAAC assessments? Will

continued knowledge and skill intensification increase the demand for key "soft" skills such as collaboration and communication?

Fourth, will the sources of new skill supply – youth leaving the secondary system and entering work, post-secondary graduates entering the workforce and older adults, including immigrants, entering the labour force – be sufficiently skilled to satisfy rising demand?

Fifth, is the available skill supply being fully utilized? Are there gains to be had from improving the fit between skill demand and supply at the job level i.e., improved market? efficiency)

Sixth, how might skill shortages impair the relative economic performance of the U.S. economy over the medium term?

A comparison of NALS, LSUDA, IALS, ALL and PIAAC data suggests that skill-biased technical change is having the expected effects on the demand for key cognitive skills, including literacy and numeracy. These data also support general labour market theory that predicts rising skill demand as a result of technical advance and creates the conditions for rising wage premia to skills that are in short supply.[40]

The next chapter uses evidence from IALS, ALL and PIAAC to suggest how policy makers might respond to the expected skill shortages and to rising inequality in labour market outcomes, including in incomes and wages.

[40] General labour market theory refers to the market that mediates transactions that match the supply of and demand for labor. Employees provide the supply and employers provide the demand. It is a major component of any economy and is intricately linked to markets for capital, goods, and services. The equilibrium of the classical labour market is one where everyone willing to work at the real wage $(W/P)_F$ is able to find work. Since the classical model is a supply-determined one, it says that equiproportionate increases (or decreases) in both money wage and the price level will not change labour supply. Analysis of IALS, ALL and PIAAC data show that literacy technology-induced supply demand disequilibria can increase wage premia for skilled workers, can reduce the relative wages of low skilled workers, both that reduce the willingness of low skilled workers to supply labour.

Chapter 3. A review of policy options

Depending on the responses to the six questions enumerated above, evidence from IALS, ALL and PIAAC suggests that government policy might choose among three types of measures to realize higher and more equitably distributed rates of economic growth. They might pursue:

- Demand-side measures that serve to induce higher rates of knowledge and skill intensification, taking care to avoid supply/demand imbalances

- Supply-side measures that ensure that the supply of required skills is adequate to satisfy current and projected levels of demand and, thereby, to avoid the negative economic consequences associated with skill shortages.

- Market efficiency measures that improve the efficiency of the markets that mediate education and labour markets transactions e.g. field of study/career choices, hiring, promotion, skill upgrading

This chapter summarizes the economic case for each of these measures and their likely impact on rates of growth. Wherever possible the chapter uses analysis of IALS, ALL and PIAAC data that isolate the impact of literacy and numeracy skill differences on key indicators of macroeconomic and microeconomic performance. As many readers will be unfamiliar with the evolution of macro growth models, a summary of key developments in the field has been included as Annex A.

The chapter also profiles the quality and quantity of the flows of literacy and numeracy skill and the impact that each is likely to have on the aggregate supply of these skills.

Finally, the chapter presents ALL and PIAAC-based analysis that highlights the level of skill supply and demand misfit in the U.S. economy and the magnitude of benefits that would accrue to measures that tighten the fit.

3.1 Skill demand-pull measures

According to the Clinton White House, increasing the productivity of the American workforce is the key to higher living standards and stronger economic growth in the future.[41] Their report described U.S. expenditures on R&D, how they have been changing over time, and how they compare with other countries. It then examines the rationale and describes a role for government involvement in R&D and documents the high returns to R&D investments, specifically ones that generate additional economic growth through investments that both fosters technical advances directly, or that supports the rapid adoption of technical advances.

Direct investments that might drive higher rates of skill intensification include, for example, public investments in the development of digital technologies, such as the internet and, more

[41] https://clintonwhitehouse2.archives.gov/WH/EOP/CEA/econ/html/econ-rpt.html

recently, Artificial Intelligence (AI), that hold, according to the World Economic Forum, the promise of precipitating significant productivity growth. [42]

Indirect investments that might drive higher rates of skill intensification include, for example, public investments in infrastructure that support rapid adoption of new technologies. A current example includes the roll out of the 5G internet infrastructure.

While a general case can be made for government investment in R&D, the optimal level of investment will be dictated by the degree to which private investment is judged to be inadequate and whether markets are efficient enough to adopt the new technologies rapidly. Data from IALS, ALL and PIAAC provide little if any insight into these questions.

The IALS, ALL and PIAAC findings cited above can, however, understand whether the skills needed to apply new technologies are readily available and that current labour market matching mechanisms are efficient enough to get workers with the requisite skills in the right job.

The available evidence suggests that neither of these latter assumptions hold.

Recent analysis published in the Harvard Business Review suggests that, while the use and application of technology has become near ubiquitous around the world, the actual adoption of new and emerging technologies across most organizations continues to be less than optimal. [43] Costs, complexity and shortages of key skills mean that tech adoption at an organizational level is often slow or even nonexistent. This keeps old legacy systems alive and hinders an organization from achieving its full potential efficiently. This lag in adoption has long been a concern for companies but now, amid a pandemic, it's a crisis.

As noted earlier in this report, levels of occupational literacy and numeracy skills misfit in the U.S. economy remain high, something that further reduces the incentives for firms to adopt leading edge technologies. It is reasonable, therefore, to assume that additional demand-pull measures would fail to precipitate additional growth and would likely increase the rate at which social and economic inequalities are growing in the U.S. By extension, this insight suggests a need for U.S. policy makers to shift their attention to supply-push measures that ensure that the economy has access to a sufficient aggregate supply of key cognitive and non-cognitive skills and more market efficiency measures that make sure that a higher proportion of the available literacy supply gets fully utilized.

3.2 Skill supply-push measures

The second more conventional option available to U.S. policy makers would see them invest in adult skill upgrading of working age adults, both those currently employed and those not currently working. Supply push measures might involve encouraging education and training providers to improve the literacy and numeracy skill levels of their graduates. As attractive as this option is, the relatively small size of incoming cohorts of labour market entrants precludes them having a significant impact on the aggregate supply of key skills, including literacy over

[42] World Economic Forum (2020) **The Future of Jobs Report 2020**
[43] https://hbr.org/2020/08/why-do-your-employees-resist-new-tech?ab=at_art_art_1x1

the short and medium term. The inescapable conclusion is that the policy response needs to include additional supply push measures that serve to increase the skill levels of adults who are already in the workforce – either by encouraging employers to upgrade the skills of their workers, by funding literacy skill upgrading directly, or by increasing the skill levels of immigrants through more demanding selection or post-arrival upgrading. The policy response also needs to include additional market efficiency measures that serve to improve the efficiency with which the available skill supply is utilized, including tightening the fit between the skill demands of specific employers and the skills of successful job applications and, more generally, finding ways to induce employers to increase the knowledge and skill intensity of their production processes and work organizations organically.

In this case, analysis of IALS, ALL and PIAAC data provides a wealth of evidence in support of all of these measures.

The first body of evidence comes from macro-economic modelling that used the IALS, ALL and PIAAC data to establish that differences in average literacy scores, and in the distribution of literacy and numeracy by proficiency levels, are the single most important determinants of differences in the growth rates of GDP per capita and productivity over the long term.

This research suggests that Investments designed to raise average scores would precipitate significant increases in economic growth at a reasonable cost. The model suggests that a 1% increase in average literacy scores – 5 points on the 500-point PIAAC literacy proficiency scale – would result in a 3% increase in the rate of GDP growth and a 5% increase in the rate of productivity growth over the long term.[44] These impacts are observed both between and within countries.

Even larger increases in growth rates would be generated if average literacy skill levels were raised by literacy skill upgrading that raises the literacy skills of the least skilled. Specifically, higher levels of adults below Level 3 literacy were shown to have a marked negative impact on observed growth rates of GDP and productivity [45] This finding fits with theories that suggest that "the weakest links" in the production process reduce output per hour more than theory that suggests that "the best and the brightest" are responsible for most growth. The available evidence suggests that the presence of workers with low levels of literacy skill induce employers to adopt less efficient work organizations and production technologies, choices that reduce output per hour worked. Reduced numbers of workers with low levels of literacy skill allow firms to move closer to the production frontier for their industry. More subtly, the available evidence suggests that no country has been able to obtain a comparative advantage from the highly literate end of the skill distribution with the result that observed inter-country differences in economic performance are the product of differences in the skill levels of the least skilled.

[44] Schwerdt, G., Weiderhold, S. and Murray, T.S. (2020) ***Literacy and Growth: New Evidence from PIAAC***, AIR, Washington

[45] Schwerdt, G., Weiderhold, S. and Murray, T.S. (2020) ***Literacy and Growth: New Evidence from PIAAC***, AIR, Washington

Importantly, increases in skill levels lead, rather than lag, increase**s** in growth, a finding that supports a causal relationship between skills and growth.

The associated increases in growth would be significant. The macro modelling undertaken by Weiderhold, Schwert and Murray cited above suggests that the elimination of occupational literacy skill shortages alone would double average income per capita in a 10-year period, something that would take 22.5 years at current rates.

Although not self-evident, the idea that differences in adult literacy skill are associated with economic growth is predicted by both macro-economic and micro-economic theory and evidence.

A large body of educational research establishes that literacy is an important dimension of human capital, one that supports the efficient acquisition of other skills and knowledge and their productive application in work.[46]

A similarly large body of individual econometric analyses has used Mincer-style wage equations to estimate the impact of education on wage rates.

Analysis of data from the earliest direct literacy skill assessment data allowed researchers to partial out the marginal impact of literacy and numeracy skill on wage rates and other labour market outcomes, including annual hours worked.[47] [48] The most recent analyses suggests that the additional wages paid to workers with higher literacy skill in the U.S. are among the highest in the advanced economies of the OECD even after controlling for a large number of other factors that are known to influence wages such as age, gender and race. Education and literacy measures explain sightly over 60% of wage differences in the U.S.[49] [50] [51] [52]

Macro-economists were slower to document the impact of literacy skill on macro-economic performance. As outlined in Annex A, the initial macro-economic models included no human capital measures whatsoever, so all the observed variation in the per capita economic performance of countries was attributed to differences in technical advances and financial capital. Consequently, the impacts of education and skills, including literacy and numeracy skill, on indicators of macro-economic growth, were invisible to policy makers.

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[46] Lane and Murray (2018) ***Literacy Lost: Canada's basic skills shortfall***, Canada West Foundation, Calgary
[47] OECD and Statistics Canada (1997) ***Literacy skills for the Knowledge Society: Further results from the International Adult Literacy Survey***, OECD and HRSDC, Ottawa and Paris
[48] Raudenbush, S. and Kasim, R. (1996) ***Adult Literacy, Social Inequality, and the Information Economy: Findings from the National Adult Literacy Survey,*** Statistics Canada, Ottawa
[49] Hanushek, E. A., Schwerdt, G., Wiederhold, S., Woessman, L. "Coping with change: International differences in the returns to skills" *Economic Letters* 153 (2017): 15–19.
[50] Hampf, F., Wiederhold, S., Woessman, L. "Skills, earnings and employment: Exploring causality in the estimation of returns to skills" *Large-scale Assessments in Education* 5:12 (2017).
[51] Murnane, R. J., Willett, J. B., Duhaldeborde, Y., Tyler, J. H. "How important are the cognitive skills of teenagers in predicting subsequent earnings?" *Journal of Policy Analysis and Management* 19:4 (2000): 547–568.
[52] Denny, K., Harmon, C., O'Sullivan, V. (2003) ***Education. Earnings and Skills: A Multi-country Comparison*** **Institute for Fiscal Studies Working Papers No.04/08, 2003.**

Theoretical advances eventually came to include crude measures of human capital in macro-economic models, i.e., the proportion of college educated in the workforce. The estimated impact of human capital on growth rose in these models, but not to the higher levels indicated in Mincer-style wage regressions run to explain differences in individual wage rates among groups. In fact, the estimated impacts of literacy on income at the macro level were roughly half those observed at the individual level.

In the absence of evidence to the contrary, many macro-economic policy makers believed that the observed growth differences among countries were the product of technical change and/or the supply of very highly qualified Science, Technology, Engineering and Mathematics (STEM) workers, PhD's and workers with the so called 21st Century communication, collaboration and innovation skills. At that time, policy makers held a very dated view of literacy in which adults were either literate or illiterate. The idea that roughly half of the American workforce lacked the levels of literacy and numeracy skill associated with reliable and fluid problem solving had not yet entered their consciousness.

Another related misapprehension of economic policymakers is that literacy was simply an allocative mechanism, one that is arbitrarily allocating better labour market outcomes – e.g., higher wage rates, higher incomes, less unemployment – to workers with higher literacy scores. Economic policy makers were not yet aware that literacy was a fundamental determinant of economic growth.

Macro-modelling using data from the 1994 IALS and the 2003 ALL assessments documented the central importance of literacy skill levels and distributions to key indicators of macro-economic performance.

Not only was literacy a fundamentally important determinant of economic growth, differences in average literacy score among countries were by far the single most important determinant differences in the growth in the size of the economic pie to be divided.

Notably, more recent analysis using data from the 2011 PIAAC assessment, revealed that the effect of literacy on U.S. macro-economic performance doubled between 2003 and 2011 in response to skill-biased technical change, the globalization of markets for key inputs, the globalization of consumer markets, and a dramatic increase in the global supply of literacy skill driven by UNESCO's Education for All initiative.[53]

As noted above, by 2011, differences in average literacy skill were double those observed in 2003 i.e., what was a 1.5% increase in long-term rate of GDP and a 2.5% increase in long-term rates productivity growth in 2003 had become a 3% increase in long-term rate of GDP and a 5% increase in long-term rates productivity growth. Notably, this effect is more than any other variable included in the model, including differences in rates of improvement in educational attainment.[54]

[53] Schwerdt, G., Weiderhold, S. and Murray, T.S. (2020) ***Literacy and Growth: New Evidence from PIAAC***, AIR, Washington

[54] Schwerdt, G., Weiderhold, S. and Murray, T.S. (2020) ***Literacy and Growth: New Evidence from PIAAC***, AIR, Washington

Additionally, higher proportions of adults with literacy and numeracy skills below Level 3 on the IALS proficiency scale continued to reduce GDP and productivity growth rates significantly over the long term in the 2011 PIAAC-based analysis.[55]

Finally, increases in literacy and numeracy skill led increases in growth rather than following them, a finding that suggested a causal relationship is at work.[56]

Thus, it is reasonable to assume that policies and programs designed to raise average scores have the potential to at least double current rates of economic growth, particularly if investments were focussed on the adults at the lower end of the literacy scale.

Put differently, done efficiently and effectively, targeted investments in literacy skill upgrading of the adult population have the potential to double U.S. adult's real incomes in 12.5 years rather than the 22.5 years the U.S. economy would normally take to reach its steady state. [57]

Annex A summarizes the evolution of macro-economic theory over the past 70 years for the benefit of readers who are unfamiliar with this literature.

So, a premia facie case can be made that suggests that material increases in economic performance could be realized by investment in raising the aggregate supply of adult literacy and numeracy through skill upgrading.

The case for a causal relationship between literacy and numeracy skill and economic growth is buttressed by the results of a large-scale workplace literacy and numeracy skill upgrading experiment conducted in Canada.[58] Known as Upskill, the study used a two-level random assignment design to document skill gain and its impact on worker and firm performance in the food and accommodation industry across Canada. Among other things, the study revealed that the instructional technology existed to raise skills by an average of 15 points with a 15-hour focussed intervention. A subsequent study, known as Skilling Up, refined the instructional model applied in the Upskill experiment and managed to generate 24 points of average skill gain per learner at a reasonable cost.[59] [60]

A reasonable question is whether individuals and/or employers might adjust their investment behaviour to capture these benefits.

Discussions by one of the authors (Murray) with a range of senior U.S. and Canadian economic policy makers over a 20-year period suggests that policy makers in both countries believe that education and training providers, individuals and firms will adjust their investment behaviour to

[55] Schwerdt, G., Weiderhold, S. and Murray, T.S. (2020) ***Literacy and Growth: New Evidence from PIAAC***, AIR, Washington
[56] Ibid
[57] Schwerdt, G., Weiderhold, S. and Murray, T.S. (2020) ***Literacy and Growth: New Evidence from PIAAC***, AIR, Washington
[58] SRDC (2007) ***Upskill: A credible test of workplace literacy and Essential Skills Upgrading***, Ottawa
[59] SRDC (2019) ***Social Finance Pilots on Essential Skills Pilots: Final Report,*** Ottawa
[60] Murray, T.S. (2009) ***Addressing Canada's Literacy Challenge: A cost benefit analysis***, Ottawa

create the literacy and numeracy skill supply that is needed to precipitate higher levels of economic growth. Given that none of these market actors appear to be investing in skill upgrading at anyway near the rate needed to satisfy anticipated demand, this can only be an ideological view based on "laissez fair" assumptions about the labour market's ability to adjust to rising skill demand rapidly enough. This is perhaps the only place where additional comparative research is needed, specifically to quantify the economic costs of adjusting less rapidly than one's trading partners.

Research by Murray suggests that none of these market actors have the information to know what levels of skill they need to realize their goals, to know what sort of investment would be needed to give them the requisite skill levels or how to find a reliable training provider. Nor do employers feel that they have a role in financing skill upgrading of skills that they see as basic skills that are the remit of the education system to provide. So, a strong case for the existence of a market failure that only governments have the tools – information and funding - to overcome. Without government intervention, it is reasonable to assume that employment levels and labour income will fall as jobs are lost to more skilled and productive foreign and domestic producers.

Ironically, given the direct relationship between average skill levels and rates of economic growth, publicly funded investments in adult skill upgrading would pay for themselves in as little 4 years in Canada. [61] [62] Longitudinal analysis undertaken by Steve Reder using the Portland LSAL study yield similar results provided that the job gained after literacy skill upgrading allows workers to use their newly acquired skill at work.[63]

A final policy consideration is whether the relationships between literacy skill and macro-economic performance will hold over the next couple of decades. The estimated impact of differences in average literacy skill doubled between 2003 and 2011 in response to fundamental changes in the structure and nature of the global economy. These forces are expected to strengthen over the coming decades in response to further technical advances, so there is good reason to believe that the underlying relationships will only grow stronger.

As described in the next section, it is highly unlikely that the education system will be able to supply the additional literacy skills needed to satisfy exploding demand. The size of graduating cohorts is relatively small by historical standards as a result of falling birthrates and their literacy scores has actually been falling over the past decade. Intervention, in the form of government subsidized adult literacy skill upgrading would seem to be a reasonable bet.

[61] Murray, T.S., Willms, D., Jones, S. Shillington, R., Strucker, J. (2009) ***Addressing Canada's Literacy Challenge: A Cost/Benefit Analysis***, DataAngel, Ottawa
[62] See for example SRDC (2011) Upskill: A Credible Test of Workplace Essential Skills, Ottawa
[63] Reder, S. (2014) ***Research Brief: The Impact of ABS Program Participation on Long-Term Economic Outcomes***, US Department of Education, Washington

3.3 New sources of literacy and numeracy supply

Research confirms that the aggregate supply of literacy and numeracy skills available to the economy at any point is the product of the net impact of a series of skill flows including:

Skill gained through the youth cohorts entering the labour market for the first time either directly from high school or from post-secondary studies

Skill gained through work experience

Skill gained through participation in various forms of adult education and training

Skills gained through immigration

Skills lost through emigration

Skill lost over the course of life through skill loss precipitated by a lack of skill use at work or as a result of unemployment

Skill lost through retirement

The relative size of each of these flows and their average skill level will determine the rate that the aggregate supply will grow.

The next section of this report presents the results of IALS, ALL and PIAAC data analysis that address the question of whether new sources of skill supply will be able to satisfy projected demand.

3.3.1 The skills of youth leaving initial education: Increases in average education levels are not generating the expected increase in the supply of literacy and numeracy skill

The flow of youth entering the U.S. labour market, either directly from high school or from post-secondary study, has traditionally been the most important source of new aggregate skill supply, including the supply of literacy and numeracy. Rates of U.S. high school completion, and of college participation, have been rising steadily over the past 30 years, trends that underlie a steady increase in the average years of schooling in the U.S. working age population.[64] Unfortunately, these increases in average years of schooling in the cohorts entering the labour market for the first time are not translating into increases in the aggregate supply of literacy, numeracy and problem-solving skill available to U.S. enterprises.

As shown in the graphic below time series data from studies such as the OECD PISA study that assesses the reading, mathematics and science skills of 15-year-old students documents that

[64] See https://nces.ed.gov/surveys/piaac/current_results.asp for a general summary of the link between attainment levels and literacy

average literacy and mathematics proficiency scores are not rising as expected in response to improvements in education quality over time.[65] [66]

Figure 3.1 Average difference in average literacy score between ALL and PIAAC by age at the time of the PIAAC study, United States, 2011

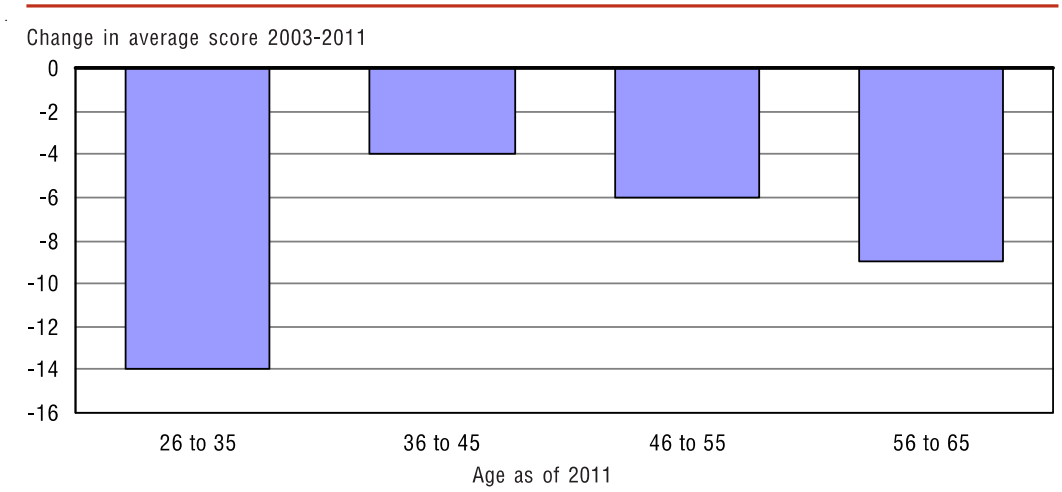


Table 1 Average literacy scores for the synthetically matched survey responses age at the time of the PIAAC survey, United States

	ALL score 2003	Difference	PIAAC score 2011
26 to 35	269	-14	255
36 to 45	271	-4	267
46 to 55	270	-6	264
56 to 65	270	-9	261

Even though current cohorts are relatively small by historical standards, the resulting declines in skill are large enough to erode the national aggregate supply of these key cognitive skills over the next decade.

Again, given the rapid rate at which the global economy is skill intensifying, and the slow rate at which the education system appears to be adjusting to this trend, the key question for policy is "What could government do to induce higher levels of skill formation in initial education?"

While not at odds with markets or skill biased technical change theory, these findings do suggest that the lack of demand-linked incentives in the education system, such as apprenticeships, co-op programs and industry sector councils, might be impairing their ability to adjust rapidly.

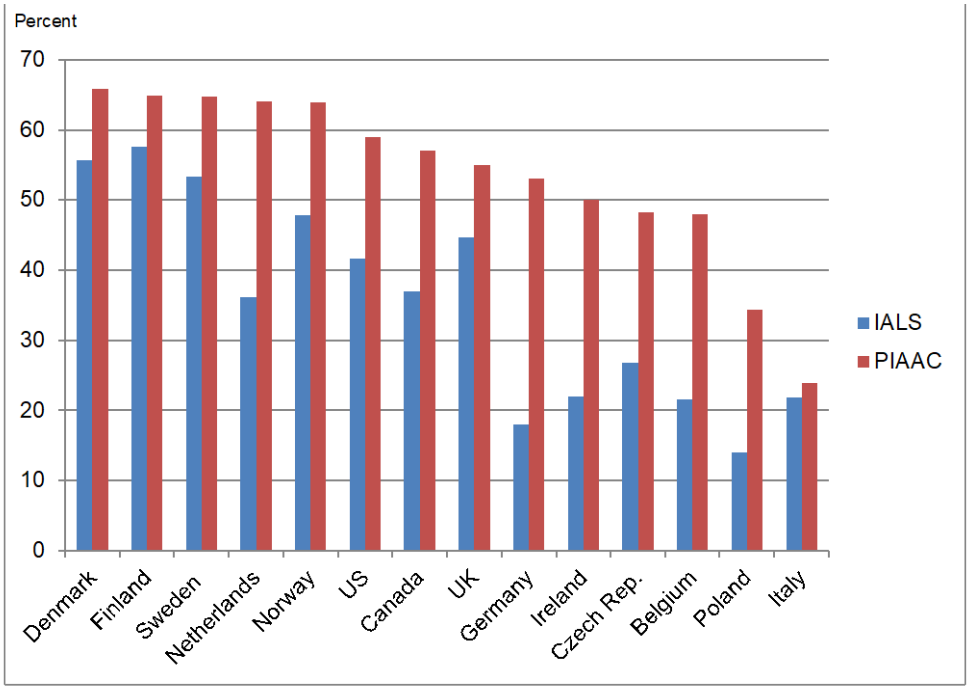
[65] Murray, T.S., Binkley, M. and Shillington, R. (2015) ***Reconstructing the evolution of the American supply of cognitive skills: A synthetic cohort analysis***, American Institutes for Research, Washington, D.C.
[66] National Center for Education Statistics (2018) ***Trends in Student Performance: Trends in U.S. Performance,*** https://nces.ed.gov/surveys/pisa/pisa2015/pisa2015highlights_6.asp

3.3.2 Investments in adult education are rising, but not rapidly enough to have a material impact on the aggregate supply of literacy and numeracy

Individuals have few ways to know they have inadequate literacy and numeracy, to know what level of investment would be required to raise their skills by the needed amount and how to find a reliable training provider.

Nevertheless, as indicated in Figure 2, U.S. adults are increasingly investing in all forms of adult education and training, including literacy and numeracy skill upgrading. The figure compares rates of participation in adult education and training in the 12-month reference year preceding the 1994 – 1996 IALS and the 2012 PIAAC surveys. U.S. participation rates rose significantly in the intervening period.[67] [68]

Figure 3.2 Percentage of adults aged 25 to 65 who participated in adult education in the 12 months preceding the survey, IALS 1994-1998 and PIAAC 2012



Source: Author (Richard Desjardins) based on analysis of International Adult Literacy Survey (IALS), 1994-1998; and OECD Survey of Adult Skills database, 2013.

[67] Desjardins, R. (2013) ***Participation in Adult Education Opportunities: Evidence from PIAAC and policy trends in selected countries***, Los Angeles.

[68] Desjardins, R. (2019). ***Revisiting the Determinants of Literacy Proficiency: A Lifelong-Lifewide Learning Perspective*** https://www.researchgate.net/publication/337448360_Revisiting_the_Determinants_of_Literacy_Proficiency_A_Lifelong-Lifewide_Learning_Perspective Washington, DC.

Unfortunately, these measures include all forms of adult education with an unknown impact on adult's literacy and numeracy skill levels. Analysis of IALS, ALL and PIAAC on the determinants of observed skill distributions reveals that general adult education and training participation rates have a detectable, but limited, impact on the available supply of literacy and numeracy. This finding can be traced to the fact that the likelihood of participation in adult education and training rises dramatically with literacy proficiency. More pointedly, as shown in the following table reproduced from Desjardin's PIAAC analysis, U.S. adults with level 1, 2 and 3 literacy proficiency are far less likely to participate in adult education and training than their more literate peers. More specifically U.S. adults with Level 4 or 5 literacy are 4.3 times more likely to have participated in adult education and training courses and programs than their peers with Level 1 literacy.[69] [70]

Figure 3.3

Table A4 (cont'd). Adjusted odds ratios showing the likelihood of adults aged 16 to 65 participating in adult education programs and courses in the 12 months preceding the survey, by various (youths 16-24 in initial cycle of formal studies excluded)

c	Italy		Japan		Korea		Netherlands		Norway		Poland		Slovak Rep.		Spain		Sweden		UK		US	
Age																						
16-25	3.2	***	1.9	***	2.0	***	5.5	***	7.0	***	4.2	***	3.4	***	5.0	***	3.2	***	1.9	***	2.6	***
26-35	2.1	***	1.3	***	1.3	**	3.2	***	3.3	***	2.7	***	2.1	***	2.6	***	2.5	***	1.6	***	1.8	***
36-45	2.3	***	1.3	**	1.3	**	2.2	***	2.9	***	2.7	***	2.5	***	2.0	***	1.8	***	2.1	***	1.5	***
46-55	2.4	***	1.5	***	1.2		2.3	***	2.3	***	2.2	***	2.5	***	1.7	***	2.1	***	1.9	***	1.3	***
56-65 (ref)	1.0		1.0		1.0		1.0		1.0		1.0		1.0		1.0		1.0		1.0		1.0	
Gender																						
Women (ref)	1.0		1.0		1.0		1.0		1.0		1.0		1.0		1.0		1.0		1.0		1.0	
Men	1.2	***	1.5	***	1.2	*	1.2	**	0.9		1.1		1.2	**	1.1	**	0.8	***	1.1		1.0	
Parent's education																						
Less than upper secondary (ref)	1.0		1.0		1.0		1.0		1.0		1.0		1.0		1.0		1.0		1.0		1.0	
Upper secondary	1.2	**	1.0		1.2	**	1.2	**	1.4	***	2.0	***	1.5	***	1.4	***	1.1		1.5	***	1.4	***
Higher than upper secondary	1.4	***	1.3	***	1.3	**	1.5	***	1.4	***	2.7	***	2.1	***	1.3	***	1.2		1.7	***	1.6	***
Education																						
Less than upper secondary (ref)	1.0		1.0		1.0		1.0		1.0		1.0		1.0		1.0		1.0		1.0		1.0	
Upper secondary	2.5	***	1.3	**	1.9	***	1.7	***	1.6	***	1.0		2.7	***	1.7	***	1.6	***	2.0	***	1.7	***
Professional degree	0.5		2.1	***	3.7	***	3.5	***	3.0	***					2.3	***	2.3	***	2.9	***	3.9	***
BA, MA, research degree	6.7	***	3.5	***	5.7	***	3.5	***	3.3	***	3.8	***	7.8	***	4.7	***	3.3	***	3.8	***	4.5	***
Literacy level																						
Below level 1 (ref)	1.0		1.0		1.0		1.0		1.0		1.0		1.0		1.0		1.0		1.0		1.0	
Level 1	1.2		1.2		2.2	**	0.9		1.1		1.3		1.2		1.8	***	1.0		1.6		1.8	***
Level 2	1.6	***	1.3		2.7	***	1.0		1.5	**	1.6	**	1.7		2.3	***	2.1	***	1.9	**	1.7	***
Level 3	2.3	***	1.7		3.9	***	1.5		1.9	***	2.3	***	2.4	**	2.7	***	2.8	***	2.8	***	2.6	***
Level 4/5	3.3	***	1.9		5.7	***	1.5		2.1	***	2.9	***	3.5	***	4.0	***	4.1	***	3.4	***	4.3	***
Immigration and language status																						
Native-born/native-language	1.4	***	0.2		0.8		1.2		0.9		0.4		0.6		1.5	***	0.9		1.1		1.1	
Foreign-born/native-language	0.8		0.0		1.4		2.0		0.9		0.8		0.4	***	1.8	***	1.6		1.0		1.2	
Native-born/foreign-language	1.7	***	0.3		0.3		0.9		0.5		1.0		0.7		1.1		0.9		1.0		1.1	
Foreign-born/foreign-language (ref)	1.0		1.0		1.0		1.0		1.0		1.0		1.0		1.0		1.0		1.0		1.0	

Source: Author (Richard Desjardins) based on analysis of OECD Survey of Adult Skills database, 2013.
*Notes: *** p <.01, ** p<.05, * p<.1.*

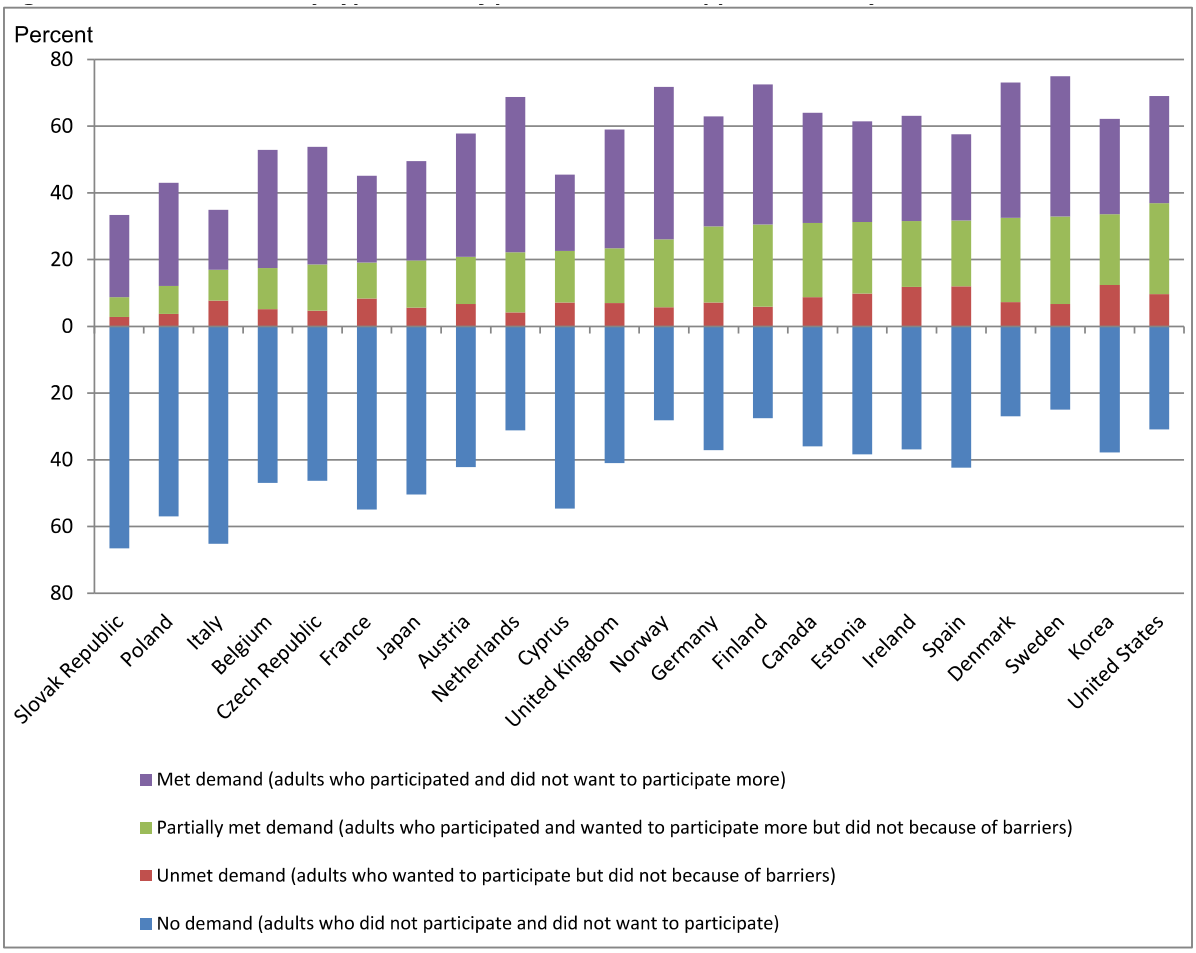
Governments, who fund virtually all of primary and secondary education, have been unable to drive even modest improvement in proficiency scores of successive cohorts of youth.[71]

Governments also fund significant amounts of literacy and numeracy upgrading, but the number of learners is insignificant relative to the incipient need.[72]

Figure 3.4 reveals that the level of unmet need for adult education and training is relatively high in the U.S.

[69] Desjardins, R. (2015). Participation in Adult Education Opportunities: Evidence from PIAAC and policy trends in selected countries, background paper for the Education for All Global Monitoring Report 2015.
[70] Tuijnman, A. and Belanger, P.
[71] Murray, T.S., Binkley, M. and Shillington, R. (2015) ***Reconstructing the Evolution of the American Supply of Cognitive Skills: A Synthetic Cohort Analysis***, AIR, Washington, D.C.
[72] See reports from OCTAE that suggest roughly 1.5 million adults were upgrading their literacy and numeracy skills with federal funding https://www2.ed.gov/about/offices/list/ovae/pi/AdultEd/index.html

Figure 3.4 Unmet demand by type and % of persons without upper secondary



Countries are sorted by the combined proportion of unmet and partially met demand.
Source: Author (Richard Desjardins) based on analysis of OECD Survey of Adult Skills database, 2013.

As a rule, employers do not see themselves as responsible for funding basic education, largely it would seem out of a misplaced fear that, once upgraded, these employees would leave for "greener pastures".

More generally, Desjardins has used IALS and PIAAC data to identify a diverse range of barriers that explains the low supply of, and low demand for, adult education.

On the supply side, he asserts that the institutions and governance mechanisms that underlie the provision and financing of adult education may be weak, left to the market, or in some cases absent altogether. An important tendency is to underinvest in adult education (OECD, 2005). This is especially the case when adult education activity is left to be coordinated by the market. This is because of poor availability of information in the marketplace to coordinate demand and

supply, and also poor information on rewards, as well as generally misaligned incentives among the stakeholders involved (individuals, employers, government).[73]

On the demand side for skills training, Desjardins suggests that prevailing structural relations in society lead to many barriers faced by individuals, and hence the resulting low demand for adult education e.g., no time**,** cost/too expensive, no transportation, childcare responsibilities.,. Whatever the causes of suboptimal levels of investment in adult skill upgrading, the net result is that additions of new skill supply are well below the level to satisfy either current, or anticipated, demand.

If nothing is done to increase investments in skill upgrading, one can expect to see negative economic impacts at several levels.

- First, at the individual level, workers will be less productive than they might otherwise be, will experience more workplace illness and accidents than would otherwise be the case, will waste more material and make more errors and will require higher levels of supervision. They will be obliged to work more hours to offset their lower productivity, will work fewer weeks and will experience longer and more frequent spells of

[73] Desjardins, R. and Rubenson, K. (2013) ***Participation Patterns in Adult Education: the role of institutions and public policy frameworks in resolving coordination problems***, European Journal of Education, Hamburg.

unemployment. Additionally, the rapid growth in skill-based wage and income inequality observed over the past two decades will continue unabated.[74] [75] [76]

- Second, at the firm level, companies will incur higher production and insurance costs and will be less competitive and profitable and will continue to lose market share to lower cost foreign competitors. This despite analysis of wage returns within and between occupation and education levels undertaken by Holzer and Lerman using PIAAC data that concludes that skill differences explain a significant amount of observed variation in U.S. wages. They suggest that programs to increase U.S. adult literacy and numeracy levels would yield significant increases in U.S. productivity and growth. [77]

- Finally, at the macro level, the American economy will fail to realize its full potential. Employment rates, aggregate output and output per hour worked will be below what they might be. The negative impact of low literacy skills on economic performance are material. For every 5 points the U.S. average literacy scores trail those of their

[74] See Macracken, M. and Murray, T.S. (2010) ***The Economic Benefits of Literacy: Evidence and Implications for Public Policy,*** CLLRN, Ottawa, Murray; T.S. and Shillington (2009) ***Addressing Canada's Literacy Challenge: A Cost Benefit Analysis***, DataAngel, Ottawa; and Murray, T.S. and Sjhillington, R. (2010) **Understanding the link between literacy, health literacy and health** each of which documents the social and economic impact that literacy skill has on Canadian working age adults and approximations of the costs and benefits that would accrue to literacy skill upgrading. It is reasonable to assume that 5-year rates of return in the US would be at least as high.

	Return on Investment over 5 years using 100% of earnings	Fiscal Return on Investment over 5 years using 33% of earnings
	Percent	
Newfoundland and Labrador	1446	456
Prince Edward Island	1578	502
Nova Scotia	1381	431
New Brunswick	1279	396
Quebec	1343	419
Ontario	1392	436
Manitoba	1559	495
Saskatchewan	1450	457
Alberta	1611	515
British Columbia	1518	481
Canada	**1406**	**441**

[75] OECD (2016) ***Skills Matter: Further results from the Survey of Adult Skills,*** Paris
[76] McCracken, M. and Murray, T.S. (2010) ***The Economic Benefits of Literacy: Evidence and Implications for Public Policy***, DataAngel Policy Research, Ottawa.
[77] Holzer H. J. and Lerman R. I. (2015). ***Cognitive Skills in the U.S. Labor Market: For Whom Do They Matter?*** AIR, Washington. D.C.

competitors, GDP growth rates will lag 3% and productivity growth rates will lag by 5%.[78]

The fact that the proportions of U.S. adults with literacy skill below Level 3 are higher than observed in many of their key competitors will further inhibit relative rates of economic growth realized over the long term.[79]

Average literacy and numeracy levels have also been shown to have an impact on levels of population health.[80] [81]A related analysis of health literacy data for Canada confirms that the impact that higher proportions of adults with skills below Level 3 is associated with significantly higher health costs. [82]

Analysis of PIAAC data also identifies impacts on social outcomes, including levels of social and democratic engagement and trust.

Common sense suggests that policy should focus on problems that are likely to get worse if nothing is done to remedy them rather than on problems that are likely to get better by themselves. The associated policy imperative demands trend data on skill demand, skill supply, skill utilization and on the impact that skill is having on outcomes, data that allows for an objective assessment of what benefits might accrue to each of the available policy options.

In this case, the combination of general labour market theory and theories of skill-biased technical change paired with PIAAC data provide a means to generate estimates of the comparative disadvantage associated with the U.S. skill distribution when compared to those of key trading partners.

3.3.3 The flow of new aggregate skill supply from immigration is low

Immigration can serve as an important source of new aggregate literacy and numeracy supply.

An analysis by Batalova and Fix used PIAAC data to compare the skills of U.S. workers to their foreign peers[83] Overall, their results indicate that U.S. adults, whether U.S. or foreign born fared worse than most of their counterparts across the participating countries in the tested areas of proficiency (i.e., literacy, numeracy, and problem solving in technology-rich environments). The results are significant because, as noted above, research finds that literacy and other cognitive

[78] Weiderhold, S., Schwerdt, G. and Murray, T.S. (2020) ***Literacy and Growth: New Evidence from PIAAC,*** DataAngel Policy Research, Ottawa

[79] OECD (2013). ***Time for the US to Re-Skill: What the survey of Adult Skills Says***, Paris

[80] Rudd, R., Kirsch, I., and Yamamoto, K. (2004) ***Literacy and Health in America***, Educational Testing Service, Princeton

[81] Prins, E.; Monnat, S. Clymer, C.; and Toso, B. W. (2015). "***How is U.S. adults' health related to literacy, numeracy, technological problem-solving skills, and adult education? A PIAAC analysis,***" Adult Education Research Conference. https://newprairiepress.org/aerc/2015/papers/44

[82] Murray, T. S. and Shillington, R. (2012) ***Understanding the link between literacy, health literacy and health***, DataAngel Policy Research, Ottawa

[83] Batalova, J. and Fix, M (2015) ***The Skills of Immigrants: What PIAAC Tells Us,*** Migration Policy Institute, Washington, D.C.

skills are strong predictors of income, employment, education and health and because differences in skill levels are an important source of widening income inequality.

Immigrants make up only 15 percent of the total U.S. adult 16-65 population surveyed by the PIAAC, so have a limited impact on the U.S. overall score averages or their international rank. This said, Batalova and Fix found that immigrants lagged U.S.-born adults in terms of literacy and numeracy in English, with both groups scoring below international averages. More specifically, Immigrants to the U.S. accounted for 33 percent of adults with low literacy skills and 24 percent of those with low numeracy skills, something that lowers the aggregate supply of literacy and numeracy skill and that explains are most of the economic disadvantage that they experience in U.S. labour markets.

Little has been published about the literacy levels of U.S. emigrants and the associated loss of literacy skill.

3.3.4 Skill loss may be eroding the supply of workforce literacy and numeracy skill

Much to the surprize of many U.S. and Canadian policy makers, not all flows of new literacy and numeracy skill supply are positive. The available data suggest that both a significant proportion of U.S. recent graduates aged 16 to 24, and of the U.S. occupationally-experienced labour force, appear to be losing a significant amount of skill with time.[84] [85]

Pagnella analysed proficiency in literacy and numeracy in the countries that have participated in the International Adult Literacy Survey (IALS, administered between 1994 and 1998), the Adult Literacy and Life Skills Survey (ALL, administered between 2003 and 2007) and the Survey of Adult Skills (PIAAC, administered in 2012).[86] While many countries experienced small to modest changes in literacy proficiency between IALS and PIAAC, others saw sizeable variations, mostly on the negative side. As documented in the following table, skill loss in the U.S. in the adult population aged 26 -65 was highest between 2003 and 2011 for those holding a Bachelor's degree.

[84] Murray, T.S. (2018) ***Literacy skill gain and loss in Canada and the US: An analysis with policy implications,*** **AERA**, San Francisco.
[85] Murray, T.S., Binkley, M. and Shillington, R. (2015) ***Reconstructing the Evolution of the American Supply of Cognitive Skills: A Synthetic Cohort Analysis***, AIR, Washington, D.C.
[86] Paccagnella, M. (2016) ***Literacy and Numeracy Proficiency IN IALS, ALL AND PIAAC***, OECD Education Working Paper No. 142

Average literacy scores for the synthetically matched survey responses education, adults aged 26 to 65, United States, 2011

	ALL score 2003	Difference	PIAAC score 2011
Less than high school	226	- 3	223
High school	267	- 9	258
Some post-secondary	272	- 0	272
Bachelors	307	-14	293
Post-graduate	300	3	304

Analysis undertaken by John Bynner for the UK using longitudinal data from the British Birth Cohorts, by Steve Reder using the LSAL longitudinal dataset and by Scott Murray for Canada using linked Census records suggests that skill loss is largely the product of low levels of skill use at work and in daily life.[87] [88] [89] [90]

The observed loss of skill at the individual level are material because of the relationship between literacy score and labour market outcomes, including wage rates. On average, each lost point of literacy is associated with an annual loss of $61 in labour income.

The observed loss of literacy skill is more problematic at the aggregate level as it implies a large loss of macro-economic output. available to the economy, ironically at a time when the demand for literacy skill is increasing rapidly. Grossing up estimates of output lost to literacy skill loss for Canada suggests a loss of aggregate output $9.46 billion in the U.S.

In the shorter span that separated ALL and PIAAC, numeracy proficiency clearly declined (except in Italy), while literacy moved less on average (except for the large increase registered in Italy and the large decline experienced by Norway). Changes in the composition of the population have had little impact on observed changes in scores. Larger variations took place within different socio-demographic groups, but these tended to cancel each other out on aggregate. In particular, large variations are observed by age and levels of education. Overall, of the countries in the analysis, older adults in PIAAC are generally more proficient than their IALS counterparts, probably due to the increase in educational attainment that took place over recent decades. On the contrary, tertiary-educated individuals in all countries appear to be on average less proficient than in the past, which may signal that the expansion of tertiary education has been accompanied by a decline in the average quality of university graduates (or of university instruction).

[87] Bynner, J. and Parsons, S. (1998) **Use It or Lose It? The Impact of Time out of Work on Literacy and Numeracy Skills**, Basic Skills Agency, London.
[88] Reder, S. (2014) ***The Impact of ABS Program Participation on Long-Term Economic Outcomes***, Portland State,
[89] Murray, T.S. and Shillington, (2014) ***The Efficiency of Essential Skill Markets in Alberta: Initial Results from PIAAC***, DataAngel, Ottawa
[90] Bynner, J. and Reder, S. (2009) ***Tracking Adult Literacy and Numeracy Skills: Findings from Longitudinal Research,*** Taylor and Francis, London

These results confirm analysis of Canadian 1994 IALS and 2003 ALL data that identified significant loss of literacy skill in adulthood. [91] The largest skill loss was observed in adults who were still without a high school diploma in 2003, a finding that fits with the hypothesis that reductions in the cognitive demands of the lowest paying jobs are a direct result of technical advances that are displacing low skilled workers with machines. As noted above, average losses of literacy points in the U.S. were observed in the population holding a Batchelor's degree. The skill gain observed for adults holding a post graduate degree is most likely to be a selection effect.

Similar results were obtained in Bynner and Parson's analysis of British Birth Cohort longitudinal data.[92] They found that youth with low literacy and numeracy skills at the point of school leaving experienced much more and longer periods of unemployment that precipitated significant and rapid literacy and numeracy skill loss.

These findings also support Reder's analysis of the Portland LSAL longitudinal study that used measures of IALS literacy and numeracy to track skill gain and loss.[93] They found that adults with low literacy skill who participated in literacy skill upgrading only experienced wage growth if they found themselves in jobs that demanded high levels of literacy skill use. Dubbed "Practice engagement theory" by Reder, these results provide unequivocal evidence of the need for policy to pay attention to job quality, particularly to the need to create jobs that demand high levels of literacy skill and skill use.

Murray and Shillington have undertaken a synthetic cohort analysis in an attempt to explore changes in skill levels and distributions over the life course.[94] [95] Their analysis reveals three centrally important facts related to the quality of key sources of new skill supply.

- First, that the average scores of the youngest age group identified on each assessment have been falling with time.

- Second, skill loss is eroding the aggregate supply across the entire life course. The magnitude of skill lost is material, i.e., enough to imply a non-trivial loss of aggregate economic output. And,

- Third, the Murray and Shillington analysis links skill loss to the fact that many workers face very low levels of cognitive demand in their jobs. These workers tend to lose skill with age. A smaller number of workers face high levels of skill demand on the job. These

[91] Willms, D.J. and Murray, T. S. (2006) ***Use It or Lose It: The Effects of Age, Level of Education, and Engagement on Adult Literacy Skills***, Statistics Canada, Ottawa
[92] Bynner, J. and Parsons, S. (1998) Use or lose it? The impact of time out of work on literacy and numeracy skill, London
[93] Reder, S. (2014) ***The Impact of ABS Program Participation on Long-Term Economic Outcomes***, Portland State, Portland.
[94] Murray, T.S. (2018) ***Literacy skill gain and loss in Canada and the US: An analysis with policy implications,*** **AERA**, San Francisco.
[95] [95] Murray, T.S., Binkley, M. and Shillington, R. (2015) ***Reconstructing the Evolution of the American Supply of Cognitive Skills: A Synthetic Cohort Analysis***, AIR, Washington, D.C.

workers tend to gain skill over the life course and, because they are in short supply, are attracting significant wage premia.

Ironically, analysis suggests that the observed skill loss in both Canada and the U.S. can be traced to an economically perverse behaviour on the part of employers. Faced with shortages of key cognitive skills, and exploding wage premia to these skills, a significant proportion of employers are choosing to reduce the cognitive demands of their jobs. U.S. workers in these reduced cognitive demand jobs are forced to compete directly with as skilled but lower paid foreign workers and with machines, both of which are capable of generating output as efficiently. Ironically, this behaviour also sacrifices a significant amount of output per hour worked.

The strong link between average literacy and numeracy skill levels and rates of Gross Domestic Product and productivity growth over the long term suggests that the lost skill is associated with a loss of considerable economic output. The associated loss of economic output also serves to reduce individual and social rates of return on the educational investments made to generate the skills in the first place. This leads to the question of, "What could be done to attenuate the loss of output by attenuating the magnitude of skill loss?"

While the policy question is clear, the appropriate policy response is more complicated.

Most of the research reviewed to this point has focussed on workers inadequate skills. Analysis of the likely causes of literacy skill loss suggests that it is the product of employers reducing the cognitive demands of their jobs as a means to avoid paying the rising wage premia accruing to literacy skills for workers with the advanced levels of proficiency needed. An analysis of the predictors of skill loss associate's loss with lower levels of skill use, analysis and presentation.[96] This coping mechanism, while viable in the short run, is not sustainable over the long term because it reduces output per $ worked to the level of low-wage but equally skilled foreign competitors.

Judged in policy terms, these findings suggest that any investment in literacy skill upgrading will fail to yield the expected productivity returns unless measures are taken to induce employers to abandon their "dumbing down" of jobs. At current rates of loss new skill supply would evaporate almost as quickly as it was created.

The "open and efficient markets" philosophy that dominates U.S. labor market policies is less comfortable with intervention on the demand side than it is on the supply side. Accelerated depreciation schedules for machinery and equipment and R&D expenditures and related subsidies have unbalanced the incentives for firms to invest in human capital formation.

The likely sources of new literacy skill supply are unlikely to be able to satisfy either current, or projected, skill demand in the U.S. and Canada:

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[96] Murray, T.S., Binkley, M. and Shillington, R. (2015) ***Reconstructing the Evolution of the American Supply of Cognitive Skills: A Synthetic Cohort Analysis***, AIR, Washington, D.C.

- Youth leaving initial education are relatively small by historical standards, and roughly 30% of recent cohorts have literacy and numeracy skills below Level 3 – the level believed by many to compete in the emerging global knowledge economy. The education system has yet to find ways to increase the quality of their output rapidly enough to satisfy expected demand.

- While growing, adult education and training participation rates are nowhere near high enough to have an impact on the aggregate literacy and numeracy supply available to employers.

- The average literacy and numeracy skill levels of arriving immigrants remains low.

To make matters worse, research suggests that some skill flows are actually negative and large enough to erode the available supply of literacy skill. It would appear that employers are responding to shortage-induced rapid increases in wage premia accruing to workers with high levels of literacy and numeracy by reducing the cognitive demands of their jobs. Ironically, this behaviour results in the loss of significant literacy and numeracy skill by workers who are no longer required to use their skills in any meaningful way. The resulting skill loss is large enough to offset all of the skill gain being generated from other flows of new skill. A form of market failure, this coping behaviour sacrifices significant amounts of output per hour worked as a way to avoid higher wage costs.

3.4 Market efficiency measures

Were governments to create incentives for employers to adjust their work organizations and production technologies to become more knowledge and skill-intense, more of the available supply would get put to productive use. Such incentives would also reduce the amount of skill being lost through a lack of use and would ensure that any new skill supply generated by investments in literacy and numeracy skill upgrading actually get put to productive use. Such incentives would put a great deal of pressure on domestic producers who are pursuing low wage/low-tech business strategies.

As noted above, the diffusion of digital technologies throughout the production process, is reducing the demand for workers with low literacy and numeracy levels who only have the skills to apply routine procedural knowledge. Machines can now do many of these jobs less expensively, and more reliably, than human workers.

A failure to increase the rate at which markets are adjusting to the pressures driving skill demand risks significant employment and income loss as comparative advantage is lost. The amounts of loss will depend on the rate at which competitors are able to adjust their own economies to the fundamental changes being experienced in the structure of the economy.

Given the strong link between average literacy and numeracy skill levels and rates of Gross Domestic Product and productivity growth over the long term, the fact that the flow of new

entrants is not increasing the aggregate supply implies the loss of considerable economic potential and serves to reduce individual and social rates of return on the educational investments made to generate the skills in the first place.

The mechanisms that the U.S. labour market uses to match the skills of workers to the demands of work are very inefficient, in the sense that large numbers of workers find themselves with literacy and numeracy skill levels above and below the levels needed to do their job. These inefficiencies serve to reduce the effective supply of literacy and numeracy skill and deny workers, their employers and the economy of a significant amount of aggregate economic output.

Ironically, the available analyses of IALS, ALL and PIAAC data suggest that the means that employers use to recruit new hires and to promote employees are inefficient in that they do a poor job of matching the literacy demands of occupations to the literacy skills of candidates. Researchers have attributed this inefficiency to the fact that employers rely on relatively unreliable signals to rank candidates such as credentials.

A number of researchers have used the PIAAC and ALL data to explore the fit between the skill levels supplied by workers and the skill demands of employers. The shared goals of these analyses have been to quantify the magnitude of occupational shortages and surpluses in the skills assessed in IALS, ALL and PIAAC and their impact on individual, firm and macro-outcomes.

Richard Desjardins undertook an analysis of skill mismatch using ALL data. Table 1, reproduced from Desjardin's PhD. Thesis, provides estimates of literacy skill mismatch for a number of countries, including the U.S.

Table 1 Per cent of adults aged 25-65 employed at time of survey or in 12 months preceding survey at each derived category of literacy match-mismatch

	High-skill match	Surplus mismatch (overskilling)	Deficit mismatch (underskilling)	Low-skill match	Missing
			%		
Canada	42	19	17	22	0
Hungary	16	34	7	41	3
Italy	11	13	17	55	6
Netherlands	42	19	16	24	0
New Zealand	43	18	20	19	0
Norway	42	27	13	18	1
Switzerland	33	15	23	24	5
United States	36	17	23	24	0
Total	33	20	17	28	2

Source: Adult Literacy and Lifeskills survey, 2003-2007.

The analysis suggests that 23% of U.S. workers are in skill deficit, something that reduces their incomes and, by extension, aggregate output. By comparison, the percentage of Canadian

workers in skill shortages is only 17%. Thus, there is more room for supply side skill upgrading measures to have a positive impact on economic growth rates in the U.S. than in Canada.

In contrast, only 17% of U.S. workers are in skill surplus compared to 19% of Canadian workers. Thus, there is less room in the U.S. for demand-side measures to have a positive impact on economic growth rates.

In both cases, higher levels of growth might be induced by improving the efficiency of the markets than match worker skills to the demands of the jobs in which they find themselves.

Two European economists used information from PIAAC to investigate the link between job tasks and cognitive skill demand in 22 advanced economies, including the U.S.[97] They operationalized skill demand by the assessed literacy and numeracy skills of workers with well-matched skills to their job duties. The analysis categorised jobs according to the nature of tasks, including the intensity of abstract reasoning, employee latitude, interactivity or manual work. The analysis confirmed the significant relation between task complexity and higher skill needs. The significant relation holds independently of the endogenous supply of formal human capital, occupational or industrial structure and other job or individual characteristics.

Interestingly, this analysis stands in opposition to the assumptions that sit under the macro-economic conditional convergence models that assume all economies eventually converge to the same steady state. The authors conclude, given the marked heterogeneity in workplace practices adopted by employers, that enterprise level workplace development policies are warranted as enablers of skills matching and higher labour productivity. At a more general level, this calls into question the assumption that employers are rationale economic actors singularly focused on generating wealth for their shareholders. Were this true, employers would have altered their recruitment and selection and training processes to ensure that their workers had all the skills needed to do their jobs. What has emerged from our analysis is a sense that there is no incentive for firms to adjust in cases where all their competitors have the same skill problems. This is a dangerous strategy in an open market in which first-movers accrue huge competitive advantage.

The OECD has analyzed PIAAC data to provide a richer profile of the economic costs of mismatch.[98] Their analysis suggests that the U.S. economy imposes a 23% wage penalty on overqualified, over-skilled or field of study mismatched workers.[99] At 10%, the associated loss of productivity is material.

A related cost-benefit analysis for Canada used PIAAC skill data by occupation and compared skill fit at the individual level to the proficiency level indicated for the occupation in Canada's

[97] Pouliakas, K. and Russo, G. (2015) ***Heterogeneity of Skill Needs and Job Complexity: Evidence from the OECD PIAAC*** Survey, Discussion Paper No. 9392, IZA, Bonn

[98] Quintini, G. (2017) **Skill Use and Mismatch at Work: What does PIAAC tell us? The Imperfect Match: ILO International Conference on Jobs and Skills Mismatch,** Geneva

[99] Quintini, G. (2017) **Skill Use and Mismatch at Work: What does PIAAC tell us? The Imperfect Match: ILO International Conference on Jobs and Skills Mismatch,** Geneva

Essential Skills Demand Profiles. The analysis suggests that 40% of workers have literacy skills below the level notionally demanded by their occupations.[100]

The same analysis revealed that workers with literacy skill deficits lose $61 in annual revenue for each point that they are below the literacy level demanded by their job after controlling for a broad range of other characteristics including age, gender, occupation and education.

On average Canadian workers in literacy skill deficit each lose $1586 in earned income per year for an aggregate loss of $83.7 billion in forgone earned income, $330 million in avoidable Employment Insurance benefits, 2.080 billion in Welfare benefits and $490 million in Worker's Compensation benefits. In addition, annual national health care costs are higher than they could be:

$888 million higher on hospital visits

$42 million higher on physician costs

$42 million higher on dental costs

The related question for Canadian policy makers is "What might be done to attenuate these losses?

Given that higher proportions of U.S. workers are in literacy misfit situations than in Canada, the aggregate losses of annual output in the U.S. are likely to approach $1 trillion. This conclusion is buttressed by work undertaken by Gallup on behalf of the Barbara Bush Foundation that estimates that the potential gain to the U.S. economy of raising all adults to Level 3 literacy could reach $2.2 Trillion.[101] It is worth noting, however, that this analysis likely over-estimates the potential return to the U.S. economy of literacy skill upgrading because it assumes all of the new skill supply will be taken up and put to productive use. The Weiderhold, Schwerdt and Murray analysis cited above uses observed skill utilization rates that tend to be lower than full utilization because of the market inefficiencies enumerated above.

Viewed from a theoretical perspective, the fact that governments have not intervened to correct a market failure that is associated with such large economic costs is troubling.

PIAAC provides the information to define the problems and to weigh possible policy responses. So, the fact that governments have failed to act has to be rooted in misplaced assumptions about the ability of market actors to respond rapidly to competitive shocks.

A comfortable alternative might be for government to adopt measures that improve the matching efficiency of U.S. education and labour markets.

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[100] Murray, T.S. and Shillington, R. (2013) ***Understanding Essential Skill Markets in Alberta: A Market Segmentation Analysis,*** DataAngel Policy Research, www.dataangel.ca

[101] Rothwell, J. (2020) ***Assessing the Economic Gains of Eradicating Illiteracy Nationally and Regionally in the United States***, Gallup, New York

Systems, such as Vametric Corporation's VALID-8 competency assessment and learning support system, provide employers with an efficient way to identify and fill skill gaps in their current workforce and a means to reliably rank job applicants based on an objective assessment of what they know and can do.[102]

The widespread availability of such systems as LinkedIn Learning render access to high quality instruction widely available at low cost.

The improvement in skill supply/demand fit precipitated by the use of such systems yield a low-cost way of increasing growth rates. The U.S. Council of State Legislatures is moving aggressively to adopt VALID-8 as a certification tool with these efficiencies in mind. Utah and Colorado have passed legislation to enable alternative forms of certification and all 37 States in the combine are using the tool to license barbers and hairdressers for practice.

In this case, research undertaken by the one of the authors in Canada (Murray) suggests that neither workers nor firms have the information needed to define the nature of their skill needs and gaps, to weigh the advantages and disadvantages of the available investment options or how to choose a reliable training provider.

[102] See www.vamertic.com

Chapter 4. Summary and conclusions

The foregoing analysis identifies a set of IALS, ALL and PIAAC findings that relate, in a general sense, to economic efficiency, and to the economic potential, of the U.S. economy.

More specifically, Chapter 2 documents the rapid rate at which the U.S. economy is skill intensifying, identifies the forces that underlie this growth in demand and explores whether the supply of literacy and numeracy is likely to satisfy rising demand. Since the answer to this latter question is likely to be "No", the analysis implies a need for U.S. policy makers to act on several fronts, including:

> Demand-pull: To induce employers to intensify their production processes and work organizations so that more of the available supply of literacy and numeracy skill get put to productive use. These measures would drive up rates of GDP and productivity growth, would reduce the amount of skill being lost to low levels of use and would drive up returns to investments in skills acquisition.
>
> Supply push: To induce workers and firms to invest in literacy and numeracy skill upgrading to drive increases in rates of GDP and productivity growth and to reduce the negative impact of growth of literacy and numeracy skill shortages.
>
> Supply push: To fund literacy and numeracy skill upgrading for the unemployed and those not out of the labour force to increase their employability.
>
> Supply push: To demand that publicly-funded primary, secondary and post-secondary education providers ensure that all students leave with at least Level 3 literacy and numeracy.
>
> Market efficiency: To encourage education and training providers to adopt more reliable certification processes, ones that provide more a more reliable way to rank job applicants on the actual skills needed to do the jobs in their target occupations productively
>
> Market efficiency: To encourage employers to adopt more reliable means of assessing candidates in both internal and external labour markets so as to tighten the fit between skill supply and demand and skill utilization

Matters of economic performance are important to U.S. citizens.

Analysis of IALS, ALL and PIAAC support a compelling case for government action to invest in literacy and numeracy as a means to realizing higher levels of economic growth through increased supply.

Analysis of IALS, ALL and PIAAC also support a compelling case for government action to reduce the rate at which skill-based education, labour market, social and health inequalities are growing. More directly, literacy and numeracy-based inequalities are growing to socially and economically levels in response to the skill-biased nature of digital technologies that are being amplified by skill shortages. Given the fact that the Canadian Upskill and Skilling Up experiments demonstrate that the instructional technology exists to raise literacy and numeracy skill in efficient and effective ways through workplace-based skill upgrading, the growth of skill-based inequality is both unfair and unnecessary and ignores the potential of higher literacy to simultaneously raise GDP per capita and make it more equitably distributed.

Working age adults with literacy skills below the level demanded by their job are less productive, make more errors, waste more material, work more hours, are more likely to experience a spell of unemployment and to take longer to return to work, are paid less per hour, are more likely to be out of the labour force, are less socially engaged, are less likely to vote and to have trust in social institutions and experience more workplace illnesses and accidents. Adults below Level 3 literacy and numeracy bear a disproportionate share of the burden of poor outcomes.[103]The loss of aggregate economic output is material. Workers with literacy skills above the level demanded tend to lose skills with time. Failing to put available literacy skills to productive use sacrifices significant aggregate output. Measures to improve the fit between literacy skill demand and supply would yield material economic benefits for workers, their employers and precipitate material increases in economic performance.

It is clear from the analysis presented above that focused action by U.S. policy makers on literacy would make America wealthier, healthier and more competitive. What remains to be determined is what the optimal actual mix of measures might be. Determining the optimal mix depends on the conduct of a systematic analysis of the costs, benefits and estimates rates of return associated with each measure and a parallel analysis of the impact that each measure has on the social distribution of benefits. Data from these analyses would allow for U.S. policy makers to strike an appropriate and evidence-based balance between economic efficiency and equity goals.

Annex A: The development of macro-economic growth modelling

During the post-war period, economic policy makers initially relied on the early neoclassical model of Robert Solow (1956) that predicted that economic growth was driven by the improvement of productivity *via* technological advances determined outside the model (exogenous). Although appealing, Solow's model could not be tested due to the lack of reliable data on financial and physical capital stocks and flows.

By the mid-1980s the availability of internationally comparable data on income and price levels (Summers and Heston, 1988) rekindled interest among policy makers in exploring the determinants of economic growth quantitatively.

[103] See Murray, T.S. (2020) ***The case for Level 3 as a national standard***, DataAngel Policy Research, www.dataangel.ca

This interest was also fed by the rise of a second approach – namely the endogenous growth models - pioneered by Romer (1986) and Lucas (1988). These models posited that the long run growth rate of productivity emerged endogenously from the model variables.

Empirical studies conducted through the 1990s to better understand wealth differences between countries appeared to be best supported by neoclassical models as synthesized in the work of Barro and Sala-i-Martin (1995). However, the basic Solow model had to be refined to explain observed cross-country differences in living standards. Most importantly, the concept of capital had to be extended to account for *human* capital (Mankiw, Romer and Weil, 1992).

The development of comparable cross-country data on GDP, productivity and human capital indicators (Summers and Heston, 1988, and Barro and Lee, 1993, 1996) allowed economists to test both the endogenous growth and the growth empirics approaches. The concept of human capital ended up being at the centre of influential studies (Lucas, 1988, and Mankiw, Romer and Weil, 1992).

Importantly, these initial studies relied on quite weak measures of human capital, i.e., educational attainment and average years of schooling. Nonetheless, the inclusion of even these basic proxies for the quantity of education both reduced the relative importance of differences in physical capital investment and in financial capital investments and added significantly to the amount of variance in aggregate growth rates explained by human capital. These findings pushed up the relative importance of human capital to growth and, by extension, policy makers interest in policy measures that might increase the stock of human capital enough to drive up growth rates.

Mankiw, Romer and Weil (1992) subsequently modified the early neoclassical Solow model to allow for the accumulation of human capital. Cross-country regressions led them to conclude that, instead of reaching a common steady state, each country reached its own steady state due to differences in rates of investment, rates of population growth and in stocks of human capital as measured by differences in the quantity of education.

Notwithstanding the apparent importance of human capital in the macro-economic models, the estimated impacts of differences in the quantity of education on growth rates were well below the levels indicated in Mincer-style wage regressions run at the individual level.

This lack of agreement troubled policy makers and increased their interest in getting access to more informative direct measures of the quality of education.

The conduct of the 1985 U.S. Young Adult Literacy (YALS) provided the first direct evidence that objective measures of three key cognitive skills – prose literacy, document literacy and quantitative literacy – captured significantly more variation in actual skill than implied by conventional measures of educational attainment.

The 1987 Canadian Literacy Skills Used in Daily Activities Survey (LSUDA) study offered the first reliable and comparable data on three key dimensions of human – prose literacy, document

literacy and numeracy. Importantly, LSUDA was the first study to offer cross-country comparisons of results in two languages (English and French).

The U.S. 1990 National Adult Literacy Survey (NALS) established a baseline against which all future adult skill data would be compared.

In 1994, Statistics Canada and the National Center for Education Statistics in the U.S. fielded the first comparative assessments of adult literacy and numeracy, the 1994 International Adult Literacy Survey (IALS), followed by the 1996 Second International Adult Literacy Survey (SIALS) and the 2003 Adult Literacy and Life Skills Survey (ALL).

The U.S. has participated in a series of international comparative adult skill assessments, including the 2005 International Survey of Reading Skills (ISRS) and the Organization for Economic Cooperation and Development's 2012 Program for the International Assessment of Adult Competencies (PIAAC) assessment and prospectively the PIAAC 2021 assessment.

Analysis of the YALS, NALS, IALS, ALL, ISRS and PIAAC datasets has added greatly to our collective understanding of how skill supply is generated in the U.S., how U.S. skill demand is evolving, how efficiently U.S. markets for skill work and what impact skill has on a broad range of individual, institutional and macro labour market, social, health and educational outcomes on U.S. adults.

Going forward it will be important to include reliable measures of non-cognitive skills such as collaboration and communication in macro-models as it is believed that these skills will become more important determinants as the fraction of jobs requiring the non-routine application of procedural knowledge in teams grows.