HUMAN CAPITAL LAW AND POLICY

Business Council *of* British Columbia
Est. 1966

VOLUME 8, ISSUE 2, JUNE 2018

SIX PROPOSITIONS ABOUT DIGITALIZATION AND THE LABOUR MARKET

HIGHLIGHTS

- The range of human tasks that can performed by technology is expanding in the digital age.
- Technologies are productivity-enhancing though they do not appear to be large net job creators.
- Technology prices have fallen relative to wages over time, encouraging labour-substitution and dampening real wage growth for the lower part of the skill distribution.
- There is mounting evidence that technologies are skill-biased, contributing to wage inequality; routine-biased, contributing to job polarization; and capital-biased, contributing to a rising share of national income received by owners of capital relative to wage earners.
- The challenge facing policy-makers – in British Columbia, Canada and globally – is how to maximise the productivity gains of technological progress through digitalization, while taking steps to mitigate its intrinsically-skewed distribution of benefits.

> *"In any new regime in which machines and power play a greater role than they do even today, men will not have become useless; but the nature of their tasks will have changed. It is man's destiny to perform those functions which machines can never do—the thinking and contriving ones. We shall be on the way to that destiny for a very long time, with various ups and downs during the transition. Our task is the double one of speeding the process and of taking precautions meanwhile against unnecessary personal and family loss and suffering. We are not excused from these duties in any case; and ways will somehow be found to meet them; they may be better or worse ways, but human revolt against intolerable conditions will insure some sort of action."*
>
> Tugwell (1931, 227)[1]

WHAT IS THE DIGITAL ECONOMY?

How will digitalization of the economy impact the labour market? Rexford Tugwell's prescient quote from 1931 suggests the impact will be profound, uneven and inevitable. Here, I outline six propositions suggested by the evidence on recent technological progress. The challenge facing policy-makers – in British Columbia, Canada and globally – is how to maximise the productivity gains of technological progress through digitalization, while taking steps to mitigate its intrinsically-skewed distribution of benefits.

The "digital economy" refers to the new forms of economic activity – new products, business models and employment specializations – made possible by advances in computer-based technologies. Examples include the Internet of Things (IOT), advanced analytics (big data, artificial intelligence and machine learning), advanced robotics, social media, biotechnology, 3D printing, and virtual and augmented reality. These technologies have in common their ability to lower the cost of connectedness, data sharing and storage, analysis and prediction. They also dramatically increase the feasible scale, and the potential rewards for owners and developers, of networked information platforms.

There is no consensus as to whether digitalization represents a distinct, fourth industrial revolution or an extension of the third industrial revolution that began in the 1960s centred on information and

[1] Rexford Tugwell was a professor of economics at several US universities and an original member of US President Franklin Roosevelt's New Deal "brains trust."

communications technologies (ICTs). For a primer on these debates, see D'Souza and Williams (2017) or St-Laurent (2017). What does seem reasonably clear is that the range of tasks and occupations that could technically be performed by computer-based technologies is expanding in the digital age.

How will this next wave of technological progress impact the labour market? There may be lessons in the recent past. There is now a large body of evidence that the impact of technological progress since the 1980s has been "skill-, routine- and capital-biased." These biases have contributed to "significant shifts in income shares between workers at different levels of the skill distribution, as well as between labour and owners of capital" (Berger and Frey 2016, 8). The evidence suggests six propositions about the impact of recent technological progress on the labour market. These are summarized below and then examined in further detail.

SIX PROPOSITIONS ABOUT RECENT TECHNOLOGICAL PROGRESS

1. Technological capabilities have expanded. The range of human tasks that can technically be performed by a computer-based technology is growing. Many routine or rules-based tasks and basic social interactions can now be automated. Tasks that remain hard to automate tend to involve cognitive skills such as creative or social intelligence, or the perception and dexterity to deal with unstructured, awkward and irregular manual tasks.

2. Technologies are productivity-enhancing though they do not appear to be large net job creators. Industries that intensively use or produce technology have made strong contributions to productivity growth in OECD countries since the 1980s. However, most employment growth has taken place in less technology-intensive industries (e.g. health, education, retail services). The ICT-producing sector itself is a small employer and has made minor contributions to total employment growth over time.

3. Technology prices have fallen or been flat over recent decades. Falling prices for many computer-based technologies, along with ever-improving capabilities, encourage firms to substitute capital for labour in the production process. This dampens employment and wage growth in skill-sets and occupations that compete with labour-substituting technologies.

4. Recent technologies are skill-biased and contribute to wage inequality. There are strong complementarities between human capital and technology. New technology-intensive occupations typically require high skill. New technologies create employment and – when the pace of technological change outruns the growth in high-skill labour supply – raise wages for high-skill workers. Skills-biased technological change is a principal driver of wage inequality.

5. Recent technologies are routine-biased and contribute to job polarization. Technological change appears to be a principal contributor to the polarization of labour markets (the "hollowing out" of jobs in the middle portion of the skill distribution) in advanced economies. Mid-skill occupations that compete with technology have seen little employment growth or real wage growth in recent decades. This seems to be because many rules-based or routine tasks and basic social interactions can now be automated, and also because of falling or flat technology prices (see above). Meanwhile, rising employment and incomes among high-skill occupations have boosted demand for services. This has led to strong job growth in low-skill service-based occupations, but not necessarily much real wage growth as low-skill workers compete with labour-substituting technologies and displaced mid-skill workers.

6. New technologies are associated with a decreasing share of national income share received by wage earners. There has been a four-decade decline in the share of national income earned by labour relative to the share received by owners of capital. The evidence points to technological change as a chief contributor: increasing technological capabilities and declining or flat technology prices incentivize capital deepening and labour-substitution, especially in mid-skill occupations. The shrinking income share for wage earners is a widespread phenomenon. It can be seen across countries (including industrializing economies like India and China), across and within industries, and occurs notwithstanding differences in countries' industrial structures, collective bargaining arrangements or union densities.

RECENT TECHNOLOGICAL CHANGE AND LABOUR MARKETS: *THE EVIDENCE*

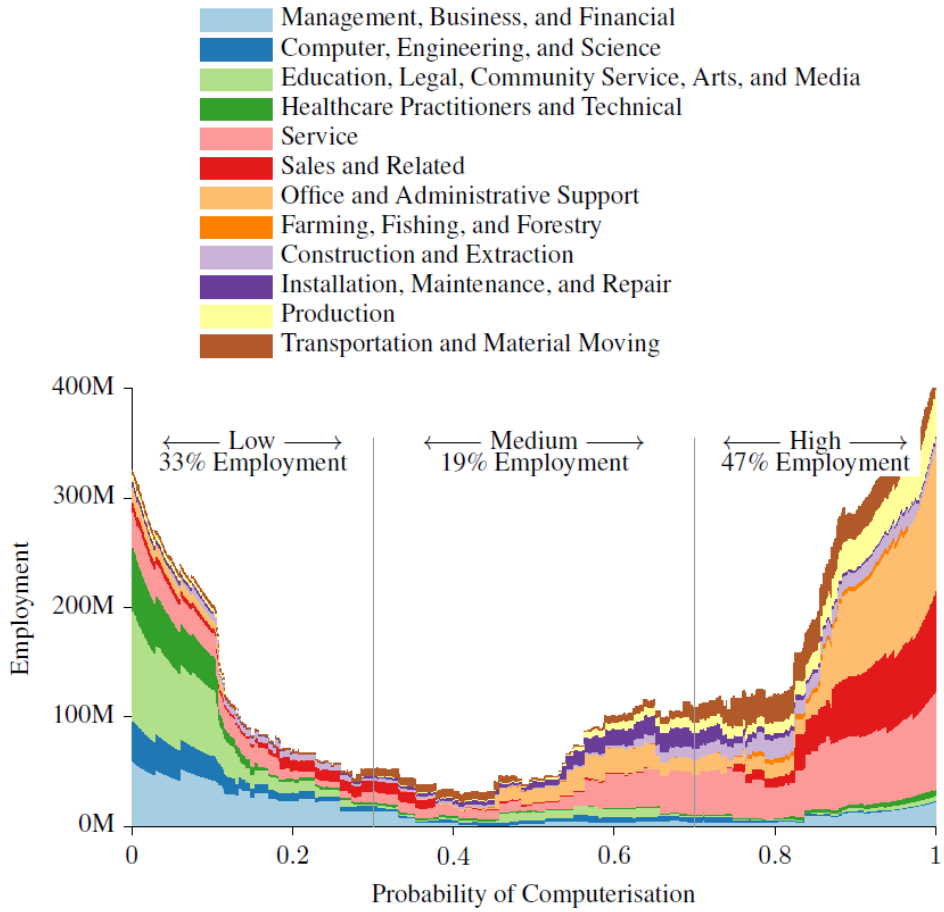
1. New technologies are expanding their capabilities

In a widely-cited paper, Frey and Osbourne (2017) examined the relationship between 702 detailed US occupations and the technical capabilities of current computer-based technologies. They found almost half of US workers face competition from an existing technology that is technically capable of performing their current tasks. They predict that 47% of total US employment faces "high risk" of seeing their current occupation partly or fully automated over the next decade or two.

Jobs most susceptible to automation include those involving rules-based procedures, repetitive tasks and basic social interactions (Figure 1). These characteristics can be found in many sales, service, office and administrative support, production, and transportation and logistics occupations. Occupations least susceptible to automation involve cognitive skills such as creative intelligence (problem-solving, originality, composition and artistic performance) and social intelligence (persuasion, negotiation, social perceptiveness, caring for others), and perception and manipulation (finger and manual dexterity, performance of unstructured, awkward and irregular tasks). Examples include jobs in education, health care (except diagnostic work), management, business, finance, sports and arts, mathematics, science and engineering.

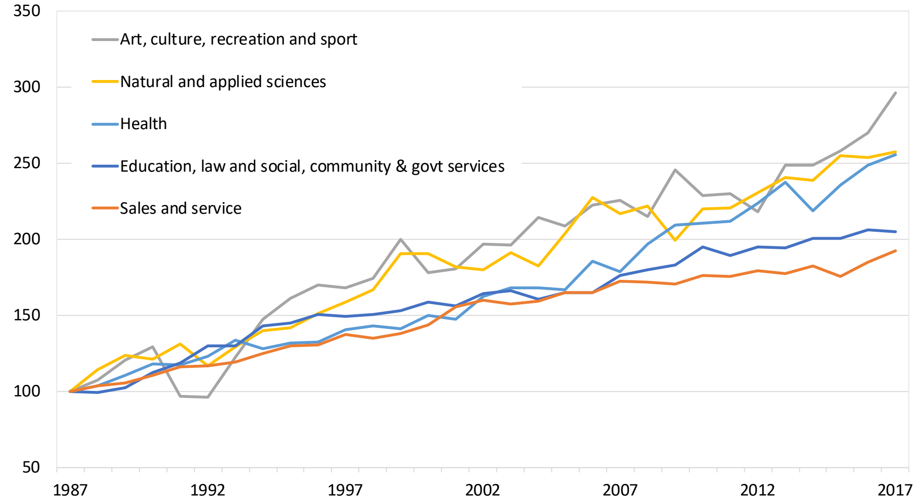
BC employment trends appear broadly consistent with these predictions. Over 1987-2017, the

FIGURE 1: **US OCCUPATIONS THAT COULD FEASIBLY BE PERFORMED BY A CURRENT COMPUTER-BASED TECHNOLOGY**



Source: Frey and Osbourne 2017.

FIGURE 2: **BC EMPLOYMENT BY OCCUPATION — THE FASTEST GROWING (1987 = 100)**



Source: CANSIM 282-0142.

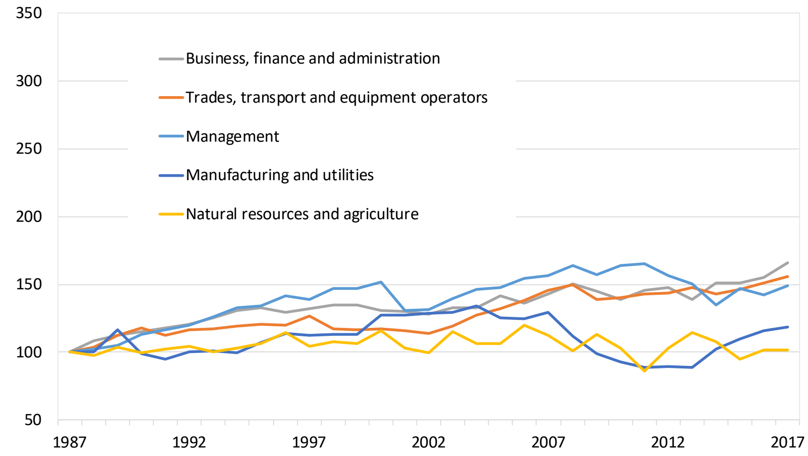
fastest growing occupations in the province were: arts, culture, recreation and sport; natural and applied sciences; health; and education, law and social, community and government services. These would seem to feature creative intelligence, social intelligence and/or perception and manipulation tasks (Figure 2). By contrast, the slowest growing occupations were: natural resources and agriculture; manufacturing and utilities; management (the largest sub-categories are retail and wholesale trade managers and restaurant and food service managers); and trades, transport and equipment operators (Figure 3). These occupations would seem to feature more scope for automation of repetitive and rules-based tasks or basic social interactions, consistent with Frey and Osbourne's (2017) findings.

2. Technologies are productivity-enhancing though do not seem to be large net job creators

Technology creates new job specializations and opportunities. These can mostly be found in high-skill occupations, such as those focused on science, technology, engineering and mathematics (STEM). In the US, roughly three-quarters of the new occupation titles that emerged during 2000-2010 were directly associated with the use of digital technologies (Berger and Frey 2016). Examples include information scientists and technologists, new engineering specialisations (e.g. nanotechnology, solar and bio-energy), digital marketing and public relations specialists, web designers, database architects, biostatisticians and climate change analysts.

ICT-using industries and (in some

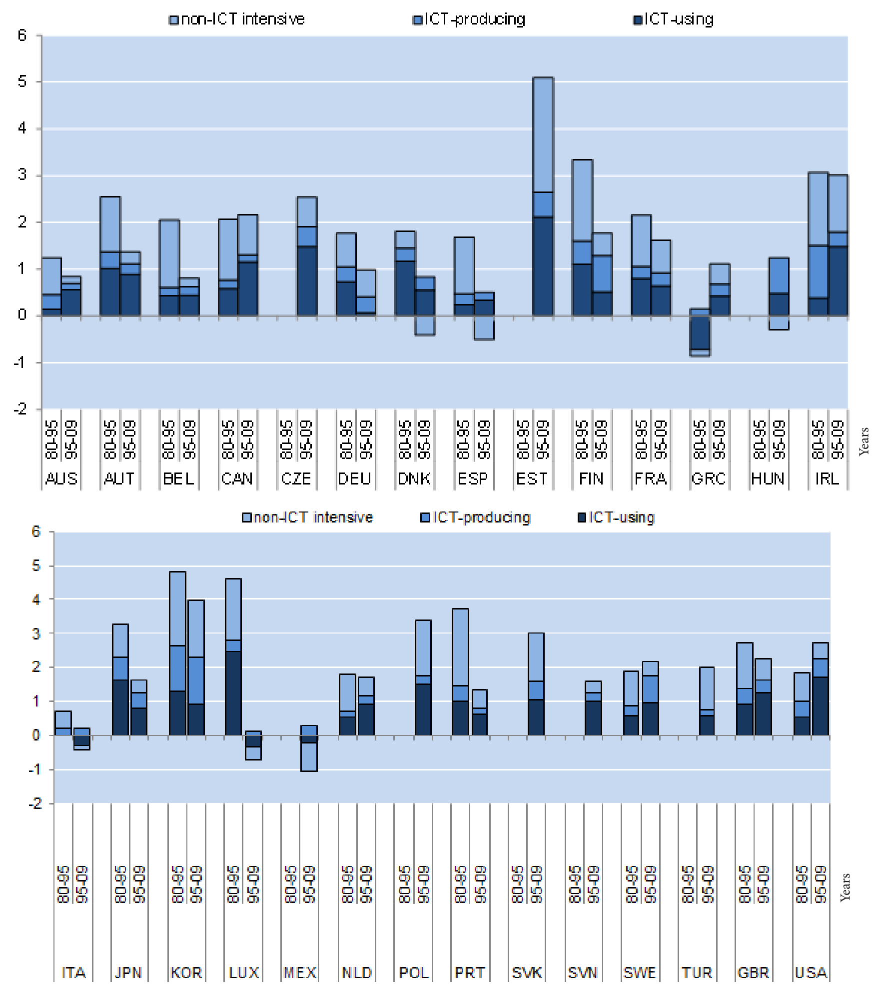
FIGURE 3: **BC EMPLOYMENT BY OCCUPATION — THE SLOWEST GROWING (1987 = 100)**



Source: CANSIM 282-0142.

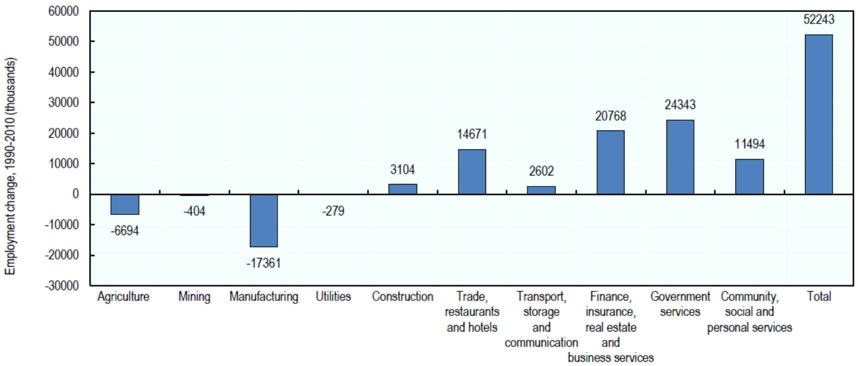
FIGURE 4: **LABOUR PRODUCTIVITY GROWTH IN ICT-PRODUCING, ICT-USING AND NON-ICT INTENSIVE SECTORS**

(PERCENTAGE POINT CONTRIBUTION TO NON-FARM BUSINESS SECTOR LABOUR PRODUCTIVITY GROWTH, SELECTED OECD COUNTRIES)



Source: OECD 2015.

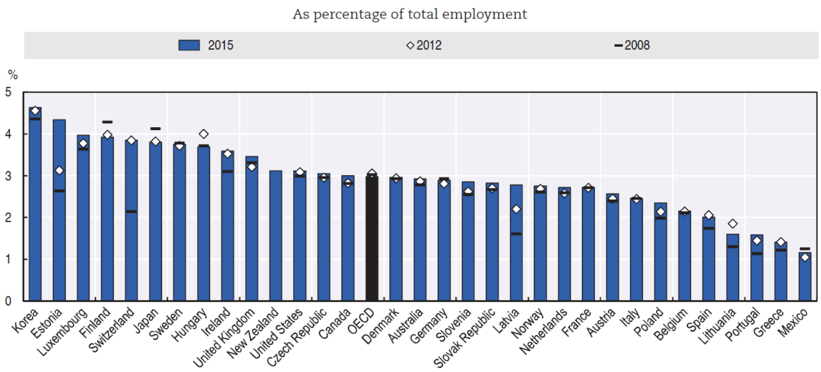
FIGURE 5: **EMPLOYMENT GROWTH IN OECD COUNTRIES 1990-2010 WAS CONCENTRATED IN LOW-TECHNOLOGY INDUSTRIES**



Notes: This figure reports employment changes across 10 sectors in 12 OECD countries (Denmark, Japan, Korea, Chile, Mexico, United States, Spain, France, the United Kingdom, Italy, the Netherlands, and Sweden) between 1990 and 2010, based on data provided by the GGDC 10-Sector Database, http://www.rug.nl/research/ggdc/data/10-sector-database.

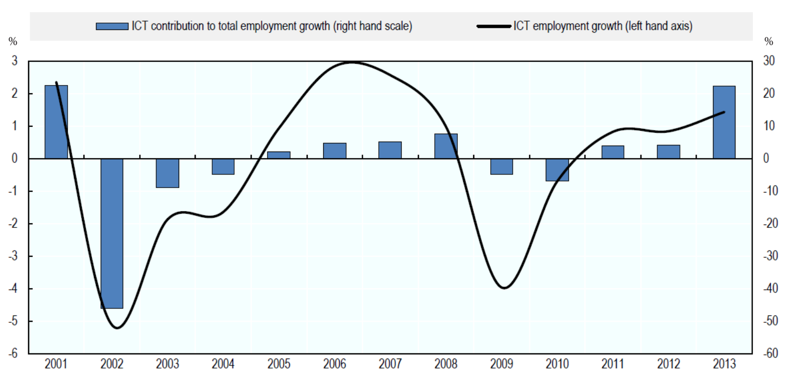
Source: Berger and Frey 2016.

FIGURE 6: **THE ICT SECTOR IS A SMALL AND MOSTLY UNCHANGED SHARE OF EMPLOYMENT ACROSS OECD COUNTRIES**



Source: OECD 2017a.

FIGURE 7: **THE ICT SECTOR HAS MADE MOSTLY SMALL CONTRIBUTIONS TO OECD EMPLOYMENT GROWTH**



Notes: This figure reports the aggregate contribution of the ICT sector to total employment growth for 27 OECD countries for which data is available from OECD (2015a). Data is based on the OECD National Accounts database (ISIC rev.4) and national sources.

Source: OECD 2015.

countries more than others) ICT-producing industries have made strong contributions to labour productivity growth across the OECD since the 1980s (Figure 4). However, employment growth in the advanced economies has mostly occurred in non-tradable industries with relatively low-technological intensity (Figure 5). The ICT-producing sector is itself not a major employer. Its share of total employment is less than 5% (Figure 6). The sector has also made only small contributions to overall employment growth over time (Figure 7).

3. The price of technology has fallen or been flat over recent decades

As the price of technology declines or grows more slowly than wages, firms are incentivized to substitute capital for labour. This continues to be the case. In the US, a wide range of ICT goods have seen sharp price falls in recent decades (Byrne and Corrado 2017). Canada has likewise seen persistent falls in the price of digital computing equipment (Figure 8, left hand panel).[2] Overall, total ICT prices have been mostly flat over the past 20 years (Figure 8, right hand panel).

4. New technologies are skills-biased and contribute to wage inequality

Dutch economist Jan Tinbergen famously attributed wage inequality to a perennial "race between education and technology." Because new technologies are complementary with human capital, their adoption leads to greater demand for skilled workers (Acemoglu and Autor 2011). When technological change outpaces growth in the supply of

[2] Relative to other countries, Canada's flat rather than falling communications prices can be attributed to the more concentrated and less intensely price-competitive telecommunications sector (Charbonneau et al. 2017).

skilled workers, wages for skilled workers rise faster than for other workers. This is known as a "skill premium" and is a principal driver of wage differentials.

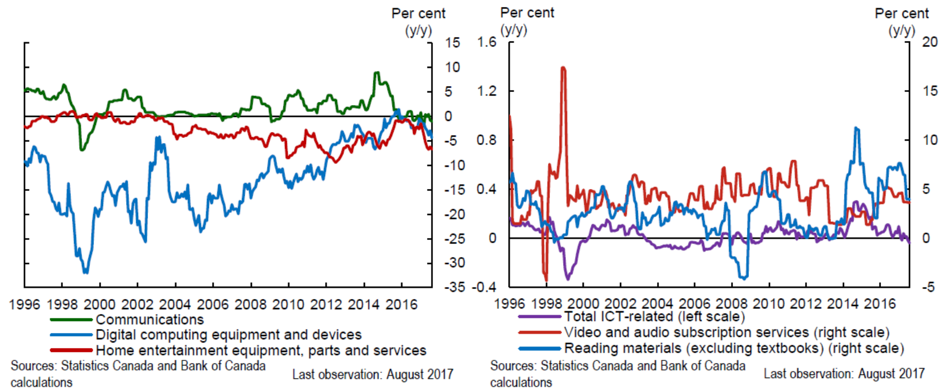
The skill premium is significantly positive across the OECD countries. For example, a one standard deviation increase in numeracy scores translates to a roughly 10-25% higher real wage (Figure 9).[3] Wage inequality has increased since the 1980s. In Tinbergen's analogy, this could be due to faster technological change or a slowing in the pace of human capital formation (the rate at which the workforce acquires skills).

The risk of labour-substitution is borne disproportionately by low-skill and low-wage workers. Frey and Osbourne (2017) found a strong negative correlation between an occupation's susceptibility of automation and, respectively, education and wages (Figure 10). In other words, for workers whose duties could technically be done by a computer-based technology, there is always another factor of production competing for their position and driving down prices to perform the work.

5. New technologies are routine-biased and contribute to job polarization

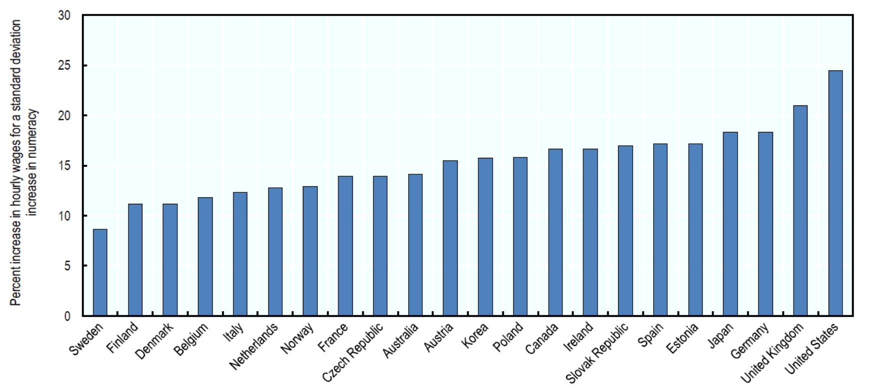
Although skills-biased technological change appears to explain some aspects of labour market trends, it cannot explain the increasing polarization of employment (Berger and Frey 2016). In almost all regions of the world, growth in high-skill and low-skill employment has been strong while growth in mid-skill employment has been weak (Figure 11). An explanation may

FIGURE 8: **ICT PRICES IN CANADA HAVE FALLEN OR SHOWN MUTED GROWTH**



Source: Charbonneau et al. 2017.

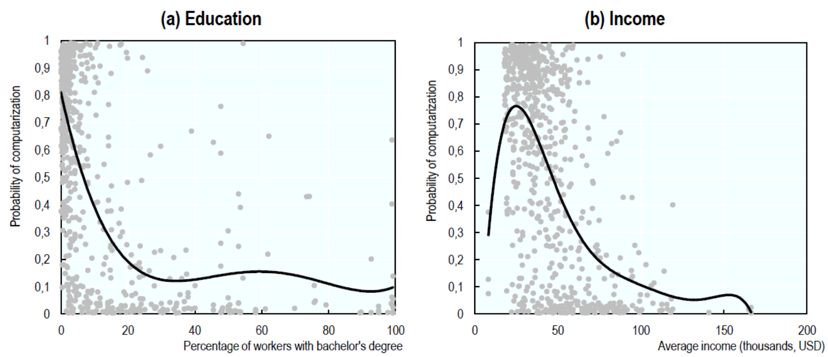
FIGURE 9: **POSITIVE RETURNS TO SKILLS IN OECD COUNTRIES**



Notes: This table reports the coefficients on numeracy scores from country-specific regressions of log hourly wages (including bonuses) of wage and salary earners (in PPP corrected USD) on proficiency scores standardised at the country level. Note that data for BEL and GBR only cover Flanders (BEL) and England/Northern Ireland (GBR) respectively.

Source: OECD 2015.

FIGURE 10: **LABOUR-SUBSTITUTION DISPROPORTIONATELY IMPACTS LOW-SKILL AND LOW-WAGE WORKERS**

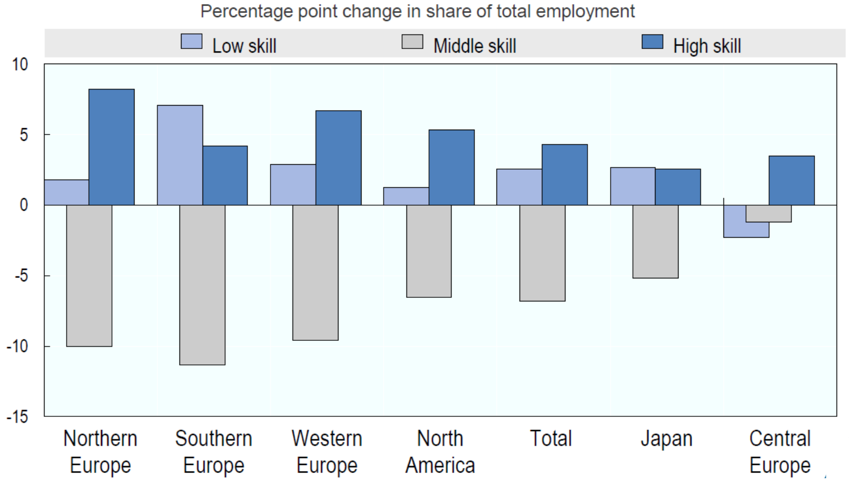


Notes: These figures show the probability of computerisation across 702 US occupations based on data in Frey and Osborne (2013) and the percentage of workers with a bachelor's degree and their average income by occupation. In each figure, a fifth degree polynomial is also shown.

Source: Berger and Frey 2016.

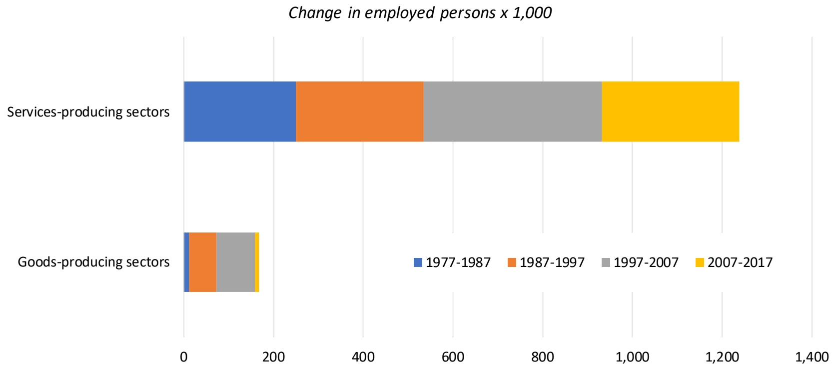
[3] Wage inequality differences across countries can be attributed to differences in the speed of growth in skilled labour supply and to differences in labour market institutions. With respect to the latter, lower levels of wage inequality tend to be associated with higher union density and more generous minimum wage laws, employment protections and unemployment benefits (Machin 1997; Kroeniger et al. 2007).

FIGURE 11: **LABOUR MARKET POLARIZATION ACROSS OECD COUNTRIES BY REGION, 1995-2015**



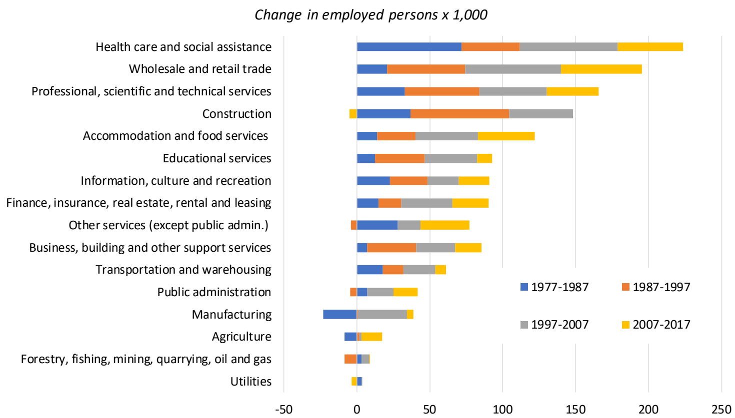
Source: OECD 2017b.

FIGURE 12: **BC EMPLOYMENT GROWTH OVER THE LONG-TERM IS OVERWHELMINGLY IN SERVICES**



Source: CANSIM 282-0008.

FIGURE 13: **BC EMPLOYMENT GROWTH IS CONCENTRATED IN SERVICE INUDSTRIES**



Source: CANSIM 282-0008.

be that technological change has different impacts across tasks and is routine-biased. That is, technology is a *complement* to labour when performing complex or non-routine tasks, but is a *substitute* for labour when performing routine tasks (Autor and Dorn 2013).

The mechanisms behind these trends might be as follows (Berger and Frey 2017). Complementarities between new technologies and human capital boost employment and incomes for high-skill workers (i.e. skill-biased technological change). This raises demand for consumer products. Production expands to meet this demand. However, the expansion is largely jobless for mid-skill occupations because technology is increasingly used to substitute for workers performing routine production tasks.[4] At the other end of the skill distribution, there is strong employment growth in sales and service occupations that are low-skill and manual, but also non-routine, making them difficult to automate. Yet although demand for low-skill workers increases, these workers do not see higher real wages because they are competing with displaced mid-skill workers and the expanding scope of task automation.

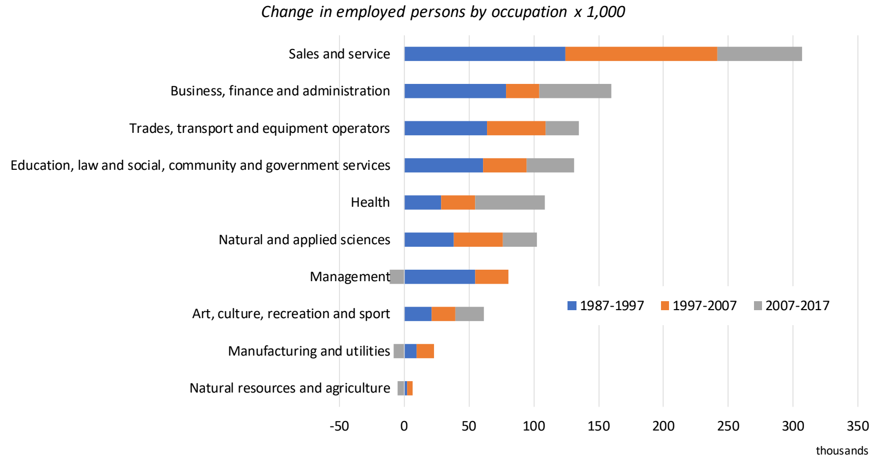
Since the 1970s, Canada, US, UK and Europe have seen rising shares of employment in high-skill management, professional and technical occupations, and in low-skill sales and service occupations (Green and Sand 2015). Meanwhile, there have been decreasing shares of employment in mid-skill occupations in production, crafts and operations and, since the ICT revolution, in secretarial and clerical support occupations. Canada shared these global trends from the 1970s up

[4] For example, the introduction of accounting software in the 1980s was associated with strong employment growth among high-skill management accountants and financial analysts, but a decline in employment among mid-skill book-keepers and accounting clerks (Ip 2017).

until the 2000s. Thereafter, the commodities boom appears to have raised demand for mid-skill workers in resources production, temporarily mitigating technology-induced job polarization (Green and Sand 2015).

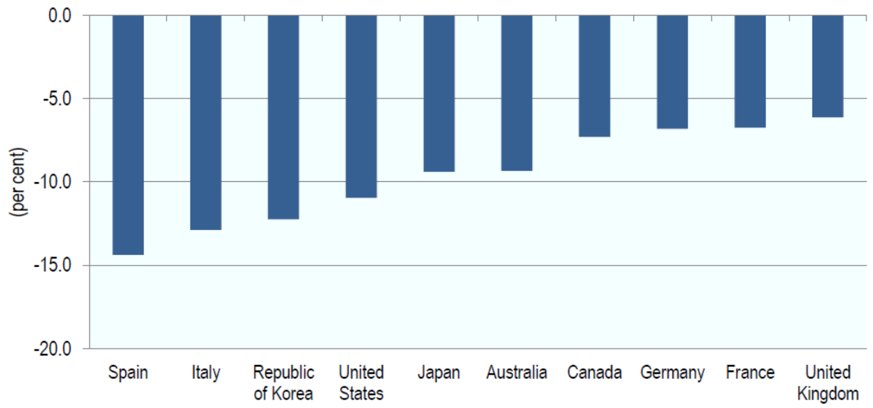
BC employment data seems broadly consistent with these trends. Figure 12 points to only small increases in the number of persons employed in goods-producing sectors where routine and rules-based tasks are prevalent. Over the past 40 years, BC job growth has been overwhelmingly concentrated in services-producing industries (Figure 13). By occupation, sales and service occupations account for two-of-every-seven jobs created in BC in the past three decades (Figure 14). Jobs in business, finance and administration and health have also made large contributions in the past decade. Occupations that might be associated with automatable operations, such as manufacturing and utilities and natural resources and agriculture, have made diminishing contributions to total employment growth.

FIGURE 14: **TWO-OUT-OF-SEVEN BC JOBS CREATED OVER THE PAST 30 YEARS ARE IN 'SALES AND SERVICE' OCCUPATIONS**



Source: CANSIM 282-0142.

FIGURE 15: **THE DECLINE IN THE LABOUR INCOME SHARE IN SELECTED COUNTRIES, 1970-2014**



Source: ILO and OECD 2015.

6. New technologies are associated with a decreasing share of national income share received by wage earners.

A final dimension is that technological change may be increasingly biased toward owners of capital rather than wage earners. This has important implications for living standards, because it means that real wages are not keeping pace with labour productivity growth (Dao et al. 2017). A long-standing and core assumption in macroeconomics is that the shares of national income earned by labour and capital are roughly stable, with labour earning the greater share. A seminal paper by Kaldor (1957, 591) noted "the remarkable historical constancies revealed by recent empirical investigations. ...[T]he share of wages and the share of profits in the national income has shown a remarkable constancy in "developed" capitalist economies." Post-1970s data shows that this assumption is no longer valid. The share of national income accruing to wage earners has declined significantly across many countries (Figure 15).

Contributors to the declining labour share may be the long-term decline in the price (relative to labour) of ICT capital, capital-for-labour-substitution (especially in mid-skill occupations) and the concentration of productivity gains, profits and market share among a small number of technologically-intensive firms. In a recent US study, Autor et al. (2017) found that many product markets increasingly exhibit "winner takes the most" competition. For a wide range of industries, sales are increasingly concentrated among a small number of "superstar" firms. These "superstars" exhibit high capital intensity (low labour intensity) and high-productivity growth. US industries that became more concentrated since the 1980s tend to show higher productivity growth and a more pronounced decline in the labour share.

CONCLUSION

Digitalization, like all forms of technological progress throughout history, offers the potential to raise productivity and improve living standards in the aggregate. Yet there is mounting evidence that the economic gains yielded by computer-based technologies are intrinsically skewed towards owners of capital and workers with high- and complementary skills. Since the 1980s, technological progress has been associated with greater wage inequality, polarization of employment growth across the skill distribution and a declining share of national income received by wage earners. These trends seem only partly mitigated by labour market institutional arrangements. The fundamental challenge therefore facing policy-makers – in British Columbia, Canada and globally – is how to maximise the potential productivity gains in transitioning to the digital economy, while ensuring that its gains are shared.

AUTHORED BY

David Williams
Vice President of Policy

References

Acemoglu, D. and D. Autor. 2011. "Skills, tasks and technologies: Implications for employment and earnings." Handbook of Labour Economics 4: 1043-1171.

Asliturk, E., A. Cameron and S. Faisal. 2016. "Skills in the Digital Economy: Where Canada Stands and the Way Forward." Information and Communications Technology Council, Ottawa.

Autor, D. and D. Dorn. 2013. "The growth of low-skill service jobs and the polarisation of the US labor market." American Economic Review 103 (5): 1553-97.

Autor, D., D. Dorn, L. Katz, C. Patterson and J. van Reenen. 2017. "Concentrating on the Fall of the Labor Share." American Economic Review Papers and Proceedings 107 (5): 180-185.

Berger, T. and C. Frey. 2016. "Structural Transformation in the OECD: Digitalisation, Deindustrialisation and the Future of Work." OECD Social, Employment and Migration Working Papers 193, OECD Publishing, Paris.

Byrne, D. and C. Corrado. 2017. "ICT Prices and ICT Services: What do they tell us about Productivity and Technology?" Finance and Economics Discussion Series 2017-015. Washington: Board of Governors of the Federal Reserve System.

Charbonneau, K., A. Evans, S. Sarker and L. Suchanek. 2017. "Digitalization and Inflation: A Review of the Literature." Staff Analytical Note 2017-20.

Dao, M., Das, M., Koczan, Z. and W. Lian. 2017. "Why is Labor Receiving a Smaller Share of Global Income? Theory and Evidence." IMF Working Paper 17/169.

Dong, W., J. Fudurich and L. Suchanek. 2017. "Digital Transformation in the Service Sector: Insights from Consultations with Firms in Wholesale, Retail and Logistics." Bank of Canada Staff Analytical Note 2017-19.

D'Souza, C. and D. Williams. 2017. "The Digital Economy." Bank of Canada Review, Spring.

Frey, C. and M. Osbourne. 2017. "The Future of Employment: How Susceptible Are Jobs to Computerisation?" Technological Forecasting and Social Change 114: 254-280.

Green, D. and B. Sand. 2015. "Has the Canadian labour market polarized?" Canadian Journal of Economics 48 (2): 612-646.

ILO and OECD. 2015. "The Labour Share in OECD Countries." International Labour Organization and Organisation for Economic Cooperation and Development report prepared for the G20 Working Group, Anatayla, Turkey, 26-27 February.

Ip, G. 2017. "We Survived Spreadsheets, and We'll Survive AI." Wall Street Journal, August 2.

Kaldor, N. 1957. "A Model of Economic Growth." Economic Journal 67(268): 591-624.

Kroeniger, W., M. Leonardi and L. Nunziata. 2007. "Labour Market Institutions and Wage Inequality." Industrial and Labour Relations Review 60 (3): 340-356.

Machin, S. 1997. "The decline of labour market institutions and the rise of wage inequality in Britain." European Economic Review 41 (3-5): 647-657.

OECD. 2017a. "OECD Digital Economy Outlook 2017." OECD Publishing, Paris.

OECD. 2017b. "OECD Employment Outlook 2017." OECD Publishing, Paris.

OECD. 2015. "The Future of Productivity." OECD Publishing, Paris.

St-Laurent, K. 2017. "What To Expect When You're Expecting [Disruption]: The Digital Economy and British Columbia." Business Council of British Columbia, Policy Perspectives 24(4), November.

Tugwell, R. 1931. "The Theory of Occupational Adolescence." Policy Science Quarterly 46 (2): 171-227.