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Analytical Studies: Methods and References

Analytical Studies Branch Annual Consolidated Plan for Research, Data Development and Modelling, 2019/2020

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Papers in this series provide background discussions of the methods used to develop data for economic, health, and social analytical studies at Statistics Canada. They are intended to provide readers with information on the statistical methods, standards and definitions used to develop databases for research purposes. All papers in this series have undergone peer and institutional review to ensure that they conform to Statistics Canada's mandate and adhere to generally accepted standards of good professional practice.

The papers can be downloaded free at www.statcan.gc.ca.

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Mandate

The mandate of the Analytical Studies Branch (ASB) is to provide high-quality, relevant and timely information on economic, health and social issues that are important to Canadians. The branch strategically makes use of expert knowledge and a large range of statistical sources to describe, draw inferences from, and make objective and scientifically supported deductions about the evolving nature of the Canadian economy and society. Research questions are addressed by applying leading-edge methods, including microsimulation and predictive analytics using a range of linked and integrated administrative and survey data. In supporting greater access to data, ASB linked data are made available to external researchers and policy makers to support evidence-based decision making. Research results are disseminated by the branch using a range of mediums (i.e., research papers, studies, infographics, videos, and blogs) to meet user needs. The branch also provides analytical support and training, feedback, and quality assurance to the wide range of programs within and outside Statistics Canada.

Partnership and collaborations

ASB researchers currently work with a broad range of collaborators to ensure that our research and data development activities are addressing policy-relevant issues and meeting the needs of users, including the following:

- **Federal government agencies and departments** (Bank of Canada; Immigration, Refugees and Citizenship Canada; Employment and Social Development Canada; Treasury Board of Canada Secretariat; Department of Finance Canada; Privy Council Office; Canada Revenue Agency; Natural Resources Canada; Canada Mortgage and Housing Corporation; Health Canada; Crown-Indigenous Relations and Northern Affairs Canada; Indigenous Services Canada; Innovation, Science and Economic Development Canada; Global Affairs Canada; Public Health Agency of Canada; Transport Canada; Environment and Climate Change Canada; Agriculture and Agri-Food Canada; Canada School of Public Service; Parliamentary Budget Officer; Department for Women and Gender Equality; Canadian Heritage; Veterans Affairs Canada; and regional development agencies)
- **Provincial and territorial governments and organizations** (Newfoundland and Labrador, Nova Scotia, New Brunswick, Ontario, Alberta, British Columbia, Northwest Territories, Atlantic Workforce Partnership) and **municipal governments and organizations** (City of Surrey, Fraser Health Authority, Surrey Fire Service)
- **Non-governmental organizations** (Canadian Apprenticeship Forum, Business Development Bank of Canada, Canadian Partnership Against Cancer, Canadian Institute for Health Information, Canadian Institute for Health Research, C.D. Howe Institute, Canadian Centre for Policy Alternatives, Export Development Canada, Fraser Institute, Canadian Economics Association, Institute of Fiscal Studies and Democracy, Mitacs, Higher Education Quality Council of Ontario, Institute for Research on Public Policy, Centre for the Study of Living Standards, Canadian Association for Business Economics, National Bureau of Economic Research, and Canadian Research Data Centres Network)
- **Academic researchers** (Simon Fraser University, University of Toronto, McGill University, University of Waterloo, McMaster University, Université de Montréal, University of Ottawa, University of British Columbia, Carleton University, Memorial University of Newfoundland, Université du Québec à Montréal, Université Laval, Lakehead University, University of Guelph, Royal Military College, HEC Montréal, Columbia University, Research Institute of Industrial Economics, National Tsing Hua University, New York University Stern School of Business, State University of New York, University of California Los Angeles, Oregon State University, Osaka Medical College, London School of Hygiene & Tropical Medicine)
- **international organizations** (International Population Data Linkage Network, Organisation for Economic Co-operation and Development, International Monetary Fund, World Bank, Washington Group on Disability Statistics, United Nations Economic Commission for Europe, UNICEF, the United Kingdom's Office of National Statistics, and Economic Statistics Centre of Excellence).

Objectives

ASB undertakes activities within three broad and interrelated areas: analysis and research, modelling and predictive analytics, and data and access. The 2019/2020 Consolidated Plan for Research, Data Development and Modelling for ASB encompasses the activities of the Economic Analysis Division (EAD), Health Analysis Division (HAD), Social Analysis and Modelling Division (SAMD), and Current Economic and Social Analysis Group (CESAG).

Analysis and research

ASB engages in an ambitious program of research on economic, health and social issues, as well as the interplay between them. The research is rooted in expert knowledge of diverse fields of study, such as economics, sociology, epidemiology, business, and mathematics and statistics. The research program serves the information needs of federal and provincial policy makers, the academic community, and other stakeholders. It also helps to identify future information gaps. Where appropriate, various lenses are applied to highlight results as they pertain to GBA+, age, regional and sectoral differences, Indigenous communities, and vulnerable populations. The research program highlights the value and potential of Statistics Canada's data to the broader research and policy communities. ASB also leads programs of research that cut across disciplinary and organizational boundaries, drawing on subject-matter expertise across the branch and data across the agency.

Modelling and predictive analytics

ASB engages in multiple activities in the domains of modelling and predictive analytics. These activities range from classic regression models to predictive algorithms and machine learning. Microsimulation models are a cornerstone of the branch's work, with over 20 years of experience in building models that support evidence-based policy making and enable users to conduct what-if scenarios to better understand the short- and long-term impacts of policy options. Recently, the branch has been exploring the creation and dissemination of interactive tools, which were developed as part of the research project and were made available to users to provide more customized, actionable and timely information.

Data development

ASB engages in a range of activities designed to strengthen and expand Statistics Canada's data holdings and, more broadly, Canada's statistical infrastructure. Such activities primarily include integrating both individual- and firm-level data through record linkage and microsimulation, and integrating contextual data, such as environmental information, using geographic location. New data sources resulting from these activities are made available to policy and academic researchers through the Canadian Centre for Data Development and Economic Research (CDER) and the Research Data Centres (RDCs) in universities across the country.

The following narratives provide an overview of the main programs of research within the broad economic, social and health themes.

1 Analysis and research

1.1 Economic

1.1.1 Innovation and the new economy

Digitalization, intangible assets and artificial intelligence are fundamentally changing the way goods and services are produced and delivered to individuals. It is important that these transformative factors be reflected in the way we measure the economy and included in our analysis of what underlies the movements in aggregate statistics. In addition, there is growing recognition that progress, as measured by traditional measures such as gross domestic product (GDP), falls short of capturing welfare and sustainability in a number of dimensions. Thus, it is important to examine the impacts of innovation on individuals and consider the links between innovation and sustainable growth.

Projects that are aimed at understanding the **impact of digitalization and artificial intelligence on productivity** include expanding the measures of intangible capital to include asset types of growing importance; examining the relationship between digitalization, the productivity slowdown and the increasing gap between the productivity growth of the most productive firms and all other firms; measuring digital intensity, robot adoption and artificial intelligence development at the firm level; studying the impact of participation in the digital economy, robot adoption and artificial intelligence on firm-level performance and employment; and studying the importance of innovation inputs (research and development expenditures) and innovation outputs (intellectual property as measured by patents) to firm performance and productivity.

The projects will also be aimed at understanding the impact of digital technologies on the growing productivity dispersion of firms and on the distribution of employment earnings; studying the impact on local labour markets of participation in the digital economy, robot adoption and artificial intelligence; and studying the business impacts on job satisfaction. These projects will study not only the average impact of technology adoption, but its impacts on firms and workers of different types.

1.1.2 Environment, clean technology and growth

The estimates of productivity growth should take into account all inputs and outputs associated with a production process, including effects on the environment. However, productivity growth is often measured without taking such effects into account. The purpose of the research conducted under this broad theme is **to develop productivity measures that incorporate environmental impacts** and apply them to some of the more significant environmental issues facing Canada, such as greenhouse gas emissions, thereby providing a more appropriate representation of sustainability aspects and more adequate measures of productivity growth.

Projects will also be aimed at examining the **effect of technological advancement in pollution abatement, such as clean technology, on firm dynamics and performance**; studying the relationship between innovation in production and innovation in pollution abatement; studying the effects of carbon pricing on firm-level employment, earnings and job turnover; and measuring digitalization in the energy sector and assessing its impact on firms and workers.

In an effort to derive more granular and locally relevant information, a number of projects will examine how these and other changes are affecting **regional and sectoral economic and labour market performance**, and the potential impact on the volatility of various measures of economic performance.

1.1.3 Global competitiveness

As a small open economy, Canada's economic performance is greatly affected by external factors and by trading and investment relationships with key partners. While competition is said to spur innovation and productivity in general, the links between competition, innovation and productivity are not fully understood. For example, there are questions about the impact of foreign investment on research and development, and on intellectual property and innovation in Canada. There are also questions about why Canada's strong record in scientific innovation does not translate into improved productivity performance. Moreover, the effect of changes in the competitive environment is not equal across regions, firms and individuals, and the strategies that enable certain types of firms to succeed may not be the same for other firms. Finally, trade and investment dollars flow across countries, and workers do as well. Immigrants to Canada bring knowledge about markets in their home countries and may also play a role in trade creation, innovation and technological diffusion.

The **competitiveness of an economic environment** can be measured in a number of ways. Examples include **concentration ratios, market share turnover rates, firm entry and exit rates, job creation and destruction rates, and measures of market power**. A comprehensive study in this area looks at these measures individually and then creates a composite index of them. The impact of the changing competitive environment on investment, productivity and wages is also examined.

Structural factors and policy also play an important role in helping shape the competitive landscape. In this area, there is a study on the **impact of tariffs on Canada–United States trade** at a fine geographical level, and a planned study on **Canada–United States differences in marginal effective tax rates on capital and their impact on investment in Canada**. Past work on the role of industry structure, firm size distribution and public infrastructure investment on Canada's productivity performance will continue to be updated. The work will also be expanded to study the impact on trade in regard to total dollar values and number of products and partners.

To directly address the **impact of multinationals**, there are studies underway that examine the impact of multinationals on firm-level investment, research and development expenditures, intellectual property development, and productivity. There are also studies that examine the impact of participation in global value chains and Canadian direct investment abroad on productivity.

The **contribution of immigrants to building Canada's economic capacity** in the face of the aging population is being studied in a few ways. At the aggregate level, the contribution of immigrants to the stock of human capital in Canada will be integrated into the human capital satellite account and the multifactor productivity accounts, and their contribution to Canadian output growth will be studied. At the micro level, there are studies underway examining the **impact of immigrant business ownership and immigrant employees on trade creation; the impact of workplace diversity**, including of immigrant employees, on firm performance; and **the role of immigrants on intellectual property creation in Canada**.

1.1.4 Dynamism and economic adaptability

Business dynamism (measured by firm entry and exit rates) has been declining in Canada and in a number of Organisation for Economic Co-operation and Development (OECD) countries. Understanding the decline is important because the entry of new firms is an important channel through which innovations, new ideas and new products enter the market. Moreover, reallocating resources from exiting and declining firms to entering and growing firms is an important source of aggregate productivity and trade growth.

The **declining entry rate of firms** has been examined along a number of dimensions, including industry and region. Thus far, entry rates have been found to be declining along all of these dimensions. New linked databases allow the number of dimensions to be expanded to include owner characteristics, such as age, gender and immigrant status. Furthermore, studies can be conducted that look at firm entry, conditional on past labour market experience. Work will also be conducted to explore the development of business dynamics statistics along new dimensions (e.g., Indigenous) and at a more detailed (e.g., sub-provincial) level.

While the rates of entry of new businesses have declined, the **contribution of the entrant cohorts** over time has not been assessed. It may be the case that, although the number of entrants has been growing smaller, the economic impact of those that survive may not have declined. In this area, there are studies on the long-run contribution of entrant firms by industry and **owner characteristics**, such as gender of ownership.

The focus of the **declining dynamism** debate has been on entrants and exits. However, turnover between incumbents and within-firm adaptation are other aspects of dynamism and growth. As part of the work on measuring the degree of competition in Canada, there is a study on **rates of employment creation and destruction and market share turnover**, followed by a study that examines the increasing **flexibility of businesses** and the decline in business dynamism at the industry level.

Previous studies have focused on the impact of entry and exit on employment creation and productivity. To date, the **contribution of entrants to export growth** has not been examined. This is an area that will be studied since Canada is an open economy and because export participation has been found to be a driver of productivity growth at the firm level.

In regard to resource reallocation, there is a study on **labour migration** and the extent to which migration is due to movement within or between firms, and a study on employment reallocation between industries and provinces and the contribution of that reallocation to aggregate labour productivity growth.

1.2 Social

1.2.1 Immigration

Immigration continues to play a vital role in Canada's society and economy. It is projected that, by 2031, one-third of the Canadian labour force will be foreign-born. Immigration levels and selection criteria continue to be central to policy discussions, and the economic, social and health outcomes and contributions of immigrants continue to be important metrics of settlement and inclusion.

The **role that temporary residents (TRs) play in the Canadian economy** continues to be an important issue. ASB is refining measurement in this area and documenting the extent to which the issuance of open versus restricted work permits translates into **labour supply**. **Labour demand** is another aspect of TR employment, with two projects using employer–employee linked data to document the characteristics of firms that hire TRs and the role that TRs play in the human resource strategies of firms over time. **TRs are also an increasingly important pool from which permanent residents (PRs) are selected**. In this context, the relationships between pre-landing characteristics and post-landing outcomes, including labour market success, are important. Variations in the outcomes of international students across fields of study, level of study and receipt of post-graduate work permits are being investigated.

Research on PRs continues to **examine economic and social outcomes in the years after landing**. Immigrants comprise a large share of labour force participants with university degrees, particularly in science, technology, engineering and mathematics (STEM) fields, and therefore

offer the capacity to contribute to an innovative and dynamic economy. Studies in this area are investigating **Canada–United States differences in mismatches between immigrant education and occupations, skill utilization and earnings of STEM-educated immigrants** in Canada by specific STEM fields of study and degree levels, and the role that supply and demand factors play in skill utilization among recent immigrants and youth in Canada. The economic outcomes of immigrants are also being studied in terms of the wealth of immigrant families and the financial well-being of immigrant seniors.

Refugee intake and settlement have been central for many Western democracies in recent years, and a policy focus in Canada. A historical perspective on the Canadian experience is provided in a study documenting the economic outcomes of major refugee inflows to Canada through the 1980s, 1990s and 2000s. A second study compares the medium- and longer-term outcomes of privately sponsored refugees and government-assisted refugees in Canada.

Research on **immigrant health** examines different health outcomes and the use of health services based on individual characteristics such as type of immigrant, region of origin, time since immigration and location of landing. The linkage between immigration and health administrative data sources has increased the possibilities to look deeper into these topics, including issues such as incidence of tuberculosis by country of origin, social outcomes of mental health among immigrants, birth tourism, and health outcomes for Canadian immigrant girls and women.

1.2.2 Jobs and employment

The Canadian labour market experiences various shocks on an ongoing basis. **Technological changes and movements in international trade** affect employer demand for labour and potentially alter the nature of work and employer–employee relationships. New types of firm–worker relationships, such as those embedded in the “**gig economy**,” may change job quality while providing flexible work arrangements for both workers and firms. Because **digital innovation** allows firms to produce new products and processes based on software code and data at a low marginal cost, it may give rise to “winner-take-all” market structures. Such market structures may change the wage bargaining power of firms in local labour markets and affect wage growth. Increases in computing power allow the automation of a growing number of tasks previously performed by workers. Along with labour demand shocks, **population aging** introduces labour supply movements into the labour market. Assessing the evolving nature of work in light of these changes, including specific job and skill shortages in certain sectors and regions as a result of concurrent labour demand-supply shifts is a priority.

The **implications of the “gig economy” for the employment prospects** and longer-term outcomes of youth in particular continue to be central in public and policy discussions. A first paper in this area will track the earnings trajectories of youth who were initially employed in a contract or temporary position versus a permanent position to determine whether gig employment is negatively correlated with financial outcomes over the longer term. A related project will apply recently developed methods to identify gig workers using administrative tax data, therefore providing new information on the number and characteristics of gig workers in Canada.

Even though labour productivity is substantially higher today than it was in the early 1980s, median real hourly wages have grown little since the early 1980s. Research will examine the extent to which this **slow growth in median real hourly wages** (relative to productivity growth) can be accounted for by declines in the labour share of GDP, changes in employer social contributions, movements in terms of trade, and changes in wage inequality. To inform discussions about the **middle class**, research on families in various segments of the earnings distribution will also document the degree to which hourly wages and annual hours of work of husbands and wives have increased at a faster (or slower) pace than they did nationwide from 1980 onwards.

Some observers have suggested that the declines in the labour share of GDP observed in several OECD countries might partly be due to a growing **concentration of employment and earnings among a few employers within industries**. Whether earnings have become increasingly concentrated among a few employers within Canadian local labour markets is currently unknown and is the subject of investigation.

As computer-based technologies allow the automation of a growing number of tasks, the task content of jobs and the skills required in various occupations change. To document these movements in skill requirements, information on **occupational skill requirements** drawn from the United States Bureau of Labor Statistics' O*Net files for the 2000s and 2010s is being appended to the Labour Force Survey data from those years. It will be used to assess potential changes in occupational skill requirements in Canada.

As part of a gender-based analysis plus focus, aspects of employment among **women and youth** are also being investigated. This includes a study on the wages and benefits received by female and male apprentices in various trades; the representation, characteristics and outcomes of women in the top 1% of earners; and occupational mobility among women with **STEM** educational backgrounds. Studies of youth focus on the diverse characteristics and outcomes of those who are neither employed nor in education or training (i.e., NEETs), and on earnings trajectories within and across cohorts, and by small geographies.

Every year, thousands of Canadian workers lose their jobs or suffer major health shocks. The financial **impacts of disruptions to employment** because of layoffs or health events, and the roles that public and private insurance programs play in offsetting such impacts, are important to policy makers and Canadians. A new and ground breaking program of research using linked tax and health administrative data is underway. This program documents the impacts of various health shocks on the employment and earnings of Canadians and their families. Building on methods developed to study the impacts of cardiovascular events (e.g., strokes), similar methods will be applied to study severe trauma and various forms of cancer. Related work is underway to document the extent to which earnings losses associated with hospitalization are offset by public programs and the tax system, and the roles that various health conditions play in transitions into non-employment and early retirement among older workers.

1.2.3 Financial well-being

Financial decision making and savings behaviours are important issues in the context of population aging, increasing life expectancy, historically high levels of household debt and rising interest rates. Forthcoming studies examine various aspects of savings behaviours, including the effect of occupational pension plan coverage on investment performance in individuals' non-workplace savings vehicles, the extent to which the labour and taxable incomes of older Canadians respond to predictable changes in marginal tax rates, and the correlation between economic expectations and household indebtedness. Work is also being initiated on the relationships between financial literacy and individuals' savings and retirement decisions.

The employment of **older workers** and **transitions into retirement** will also be a focus of research. Of particular interest are inter-cohort differences in the **income replacement rates** of seniors, joint retirement decisions among couples, and variations in labour supply decisions of older workers with different socioeconomic characteristics.

1.2.4 Education, training and skills

Technological advances could profoundly affect the **demand for occupational abilities, skills and workplace activities**. Recent major achievements in the areas of automation, artificial intelligence and machine learning could displace workers engaged in simple, repetitive tasks, while also increasing demand in complementary areas such as originality, maintenance and repair

of high-tech equipment, and selling or influencing others. To what extent have these changes already taken place in the labour market? Forthcoming work will leverage data newly created by the branch to establish recent trends in workplace abilities, skills and activities. Are workers displaying more complementary skills in their jobs and, if so, is it because the nature of their jobs has changed, or because workers are more likely to be employed in occupations requiring skills that complement the new technology? Also, which workers have been most affected by the new technology? The research will look at how women, Indigenous communities, immigrants, disabled workers, older workers, individuals with no postsecondary education and workers from different parts of the country have adapted.

Skills also affect life outside work. For example, the federal government has implemented several **postsecondary education savings** incentives geared mostly toward lower-income parents. Despite the fact that the government will invest up to \$2,000 in a Canada Learning Bond without any contributions from the parents, only about one-third of eligible families take advantage of the offer. Many have speculated that this may be due to the complexity of the forms required to open an account. Moreover, fully appreciating the investment value of a postsecondary education may require an intuitive understanding of foregone earnings and present value discounting. Applying for grants and loans may also pose similar challenges given the rules around grant eligibility, loan repayment, interest calculations, etc. All of this may require a certain degree of numeracy or financial literacy. Forthcoming research will quantify the **role of literacy, numeracy and financial literacy** in explaining the gap in postsecondary education savings between higher- and lower-income parents.

Government initiatives such as postsecondary education savings incentives, grants and loans are all designed to assist youth with limited financial means to pursue a postsecondary education. Doing so may facilitate income mobility across generations and help reduce poverty in the long term. However, this is all based on research showing that the average postsecondary graduate earns considerably more than the average high school graduate. Because of data limitations, no study has examined the **economic outcomes of postsecondary graduates** by level of parental income. Forthcoming research will fill this policy-relevant information gap by using a combination of postsecondary administrative and tax data.

Of course, investing in a postsecondary education is not a simple binary decision. Students must weigh the pros and cons of universities and colleges, and of the various programs within each type of institution. In recent years, the line between colleges and universities has become more blurred since some colleges have started offering bachelor's degrees. Do graduates of college bachelor's degree programs earn the same as university bachelor's degree holders? Until now, it has not been possible to estimate the **economic outcomes of college bachelor's degree holders** since existing surveys do not distinguish between college and university bachelor's degree programs. New research using integrated postsecondary administrative and tax data will compare the labour market outcomes of college and university bachelor's degree holders in similar programs.

1.3 Health

The health research program uses a comprehensive approach that focuses on health determinants and outcomes across the lifespan, from birth to end of life. Health determinants include the physical environment and socioeconomic conditions, as well as health behaviours such as nutrition, physical activity and substance use. Health outcomes include chronic conditions, mental health, cancer, morbidity, hospitalizations and mortality. When appropriate, a diversity lens is also incorporated to examine health differences and health inequalities by characteristics such as disability, gender or immigrant status, and with a focus on vulnerable populations including children and youth, those living in poverty, the Indigenous population, and the aging population.

1.3.1 Environment and health

The **physical environment** is a well-established health determinant. Geospatial data identify the geographic location of features and boundaries on Earth that can be used to derive information about the physical environment. Associations between health and physical environment characteristics such as the proximity of homes to highways and major roads, air pollution, industrial emissions, road network density, and green space have been demonstrated. A longstanding research partnership with Health Canada and a network of air pollution researchers will continue to develop methods and datasets to better understand these relationships. For example, next year will see the completion of a four-year study examining the relationship between mortality and exposure to low concentrations of PM2.5.

The influence of the **built environment** on health behaviours such as nutrition and physical activity has also emerged as an important area of research. The coming year will see new work on the impact of the food environment on nutritional intake patterns and health, and the associations between neighbourhood walkability and physical activity across the lifespan. In an effort to meet user needs for more granular data, a feasibility study will be conducted to estimate outcomes and indicators at the lowest possible geographic level, starting with a project on Toronto neighbourhoods.

1.3.2 Nutrition and physical measures

Nutrition and physical activity are important and modifiable health behaviours that influence both mental and physical health issues, including obesity, diabetes and cardiovascular disease. Our work will examine the **fitness levels of Canadian children and adults**, and associations between parent and preschooler physical activity levels.

With the upcoming publication of the revised Canada Food Guide, Statistics Canada's unique food intake data, based on 24-hour recall methodology in the Canadian Community Health Survey (CCHS) – Nutrition, offer research opportunities to examine differences in how Canadians have met the old and new food guidelines, and how a **healthy diet** score can be built by incorporating the new recommendations. For example, the consumption of alcoholic and non-alcoholic beverages, the consumption of fruits and vegetables, sugar intake, and changes over time will be areas of focus in coming years.

Important new survey content and physical accelerometer data will offer unique opportunities to use the Canadian Health Measures Survey to quantify sleep duration and movement patterns over a 24-hour period, and to gain insights into the relationship between patterns of measured sleep, sedentary and active behaviours, and associations with obesity and chronic health conditions.

1.3.3 Child and youth health

The early years are a critical time for **child development**, and they have a long-lasting impact on future health, social and economic conditions. Initiatives in this area are linked to international collaborations around indicator development. Work with UNICEF will support the development of measures for reporting on the sustainable development goals being planned in the areas of healthy child development. A **Canadian index on child well-being** is also being developed. Another initiative includes working with the Washington Group on Disability Statistics to measure **child disability** through the Canadian Health Survey on Children and Youth. Finally, an additional collaboration will conduct a Canada–United States comparison of child and youth health.

Indigenous children are among the most vulnerable in Canada, and there are many community programs in place to foster the healthy development of Indigenous children and their families. A set of projects will contribute information necessary for federal program evaluation, including

geospatial mapping to enhance the understanding of nutrition, developmental and school readiness programs located across the nation; characteristics of the municipalities where programs are situated; and the identification of vulnerable communities and program needs.

Maternal behaviours, as well as physical and mental health, are important parts of a child or youth's environment that influence health and well-being. The frequency and implications of behaviours such as bed sharing, caregiver health and service use, and influences on child perinatal health are areas of focus. Maternal employment behaviours will also be explored. Research will use linked data to inform the interplay between family policy, child care choices and parent earnings, as well as the gender wage gap and maternal labour force participation, including impacts on child mental health and economic outcomes over time.

1.3.4 Substance use

Substance use behaviours are intricately linked to physical and mental health. With the legalization of cannabis and the growing awareness of opioid-related overdoses and deaths, substance use is a priority for health policy (also see the next section on multidisciplinary research themes).

In addition to updating previous estimates of cannabis consumption, long-term trends of daily and near daily **cannabis consumption** will be examined. Trends using pre- and post-legalization estimates will inform the potential short-term impact of changes in access to cannabis. Special attention will be given to people aged 45 or older, since their use accounts for the majority of cannabis consumed in the country.

Expertise in substance use will contribute to the development of predictive models and trajectories for **cannabis use and alcohol consumption** that could be integrated into microsimulation tools. To inform the work done on opioid use, methods applied with administrative data will be investigated. Studies could include an evaluation of the minimal core dataset required for overdose event ascertainment, sensitivity analysis and fitness of B.C. PharmaNet data linked to the B.C. overdose cohort for analysis.

1.3.5 Aging

The **aging of the population** is a major demographic shift that will affect all facets of the Canadian economy and society, and thus remains an important pillar of health research. Research in this area has focused on the impacts of chronic conditions, disability, social isolation, frailty, and hearing loss. The research program will look at both the health states and the service needs of the elderly. Going forward, the program will focus on continuing to understand the current and future care needs of seniors, including the transition to formal care and institutions, the met and unmet needs for formal home care, and end-of-life hospitalization. Without an institutional survey, innovative methodology examining transitions to institutions will need to be used.

The health states of seniors will be studied using global measures such as the Health Utility Index and health-adjusted life expectancy, and through specific health conditions. With the new National Dementia Strategy launched by the Public Health Agency of Canada, the **Alzheimer's and other dementia** components of the Population Health Model Neuro microsimulation tool will be updated and enriched with the newest findings about determinants and age of onset. The impact of social determinants such as education on **cognitive functioning** over the life trajectory will also be studied.

1.3.6 Inequalities

There is a long history of reporting birth, death and cancer outcomes for the Canadian population by age, sex and province. With the recent creation of a series of linked census and vital statistics datasets, it is now possible to examine **inequalities in these health outcomes** for populations

such as Indigenous groups and immigrants, and across socioeconomic strata including education and income. Moreover, these linked datasets will allow for an examination of trends over time. Recent studies using these data have found an increase in relative income-related mortality inequalities from 1991 to 2011; a more pronounced “healthy migrant” effect on perinatal health among more recent migrants; a greater relative risk of thyroid cancer in the immigrant population and certain ethnic groups; and significant gains in life expectancy among First Nations, Métis and Inuit since 1996. Over the next couple of years, these linked datasets will continue to be used to inform policies aimed at reducing health inequalities in Canada.

1.3.7 Mental health

Mental health problems and illnesses have a large impact on individual wellness and a high economic cost because like physical health, mental wellness—which is more than the absence of illness—is a resource that helps us deal with challenges. The workplace is an important context for adults and will be the focus of our work. As a follow-up to the recent hackathon that focused on using Public Service Employee Survey data to measure the **mental health of employees in the public service**, we will look at the empirical basis of psychosocial risk factors, and employee outcomes such as staff turnover. Using newly linked administrative data, the long-term earnings of individuals who were at **risk for mental health problems in their younger years** will also be explored.

1.3.8 Diversity

The role of gender, employment and health is the focus of several new projects. Statistics Canada is participating in a successful, nationally funded Social Sciences and Humanities Research Council team grant with multiple Canadian universities and stakeholders, led by the University of Ottawa. This research will use data from the CCHS to look at the **role of different professions, work stress and mental health using a gender lens**. An additional theme related to women and the workforce will explore parental leave, child care, and maternal employment decisions and earnings using administrative and newly linked data. Work on female genital mutilation has highlighted the use of census and linked census–Discharge Abstract Database data. Estimates of women and girls at risk of female genital mutilation and associated health outcomes will meet stakeholder information needs.

1.4 Multidisciplinary programs of research

Complex social and economic policy issues sometimes require a more comprehensive, multidisciplinary approach. Given the range of subject-matter expertise, the branch is uniquely positioned to lead these types of research programs. In addition to population aging, which has economic, social and health impacts as discussed above, ASB is also undertaking the following multi-disciplinary research programs.

1.4.1 Opioid overdoses and deaths

The number of opioid-related deaths has been steadily increasing, with an average of 10 deaths per day. The crisis is greatest in British Columbia. While there is good information regarding the demographic profile (age, sex) and geographic location of those experiencing opioid overdoses and deaths, little is known about their socioeconomic circumstances and the systems that they use. This information is needed to ensure a diverse action plan is developed that meets the needs of those suffering. Working with partners in British Columbia, ASB, in collaboration with the Statistics Canada Canadian Centre for Justice Statistics, is using linked income, employment, social assistance, health and justice data for those experiencing opioid overdoses and deaths to better understand the experiences of this vulnerable population. The program of research includes focused studies related to employment and income experiences, and the development of comprehensive profiles to clearly identify different population groups. Additional studies will

include trajectory analyses to better understand the interplay of life events (i.e., employment loss, hospitalizations, contact with police) leading up to opioid events, and predictive analysis to better understand the factors associated with death following an overdose. These approaches will be applicable to the study of problematic use of other substances such as methamphetamines.

1.4.2 Early learning and child care

In support of the Multilateral Framework on Early Learning and Child Care, Statistics Canada has convened teams to fulfill information needs. The work has capitalized on the expertise of various divisions in the areas of data development and collection, research and analysis, and dissemination. Feedback was obtained via collaborations with a team of national stakeholders, including federal, provincial and territorial representatives; academics; policy makers; and an expert group. Currently, a wealth of information exists from existing census, survey (General Social Survey, Longitudinal and International Study of Adults), administrative (Business Register, Canadian System of Macroeconomic Accounts, government sector general ledger files), and linked data to inform indicators on child care use, supply and cost, and characteristics of the child care workforce. In particular, research will examine parental leave and child care decisions, and their impacts on parental earnings, employment decisions and child outcomes. These sources will be complemented by a Rapid Stats survey for parents to provide the most up-to-date information (to be released this summer), and a feasibility study assessing the Business Register as a potential frame for a child care provider survey.

1.4.3 Housing and household balance sheets

Stakeholder demand for information on housing, neighbourhoods and communities continues to be high. ASB is working closely with external stakeholders to support Canada's National Housing Strategy. New projects on **social and affordable housing** (SAH) will be undertaken. These projects include identifying dwelling and neighbourhood characteristics associated with positive (and negative) outcomes among residents. New measures of income mixing within neighbourhoods and large multi-unit complexes are being developed, and the implications of such mixing for SAH policies will be examined.

More broadly, ASB work will continue to harness information from diverse sources—including the new Canadian Housing Survey, the census, administrative data and open data—to shed new light on Canadians' satisfaction with their homes and neighbourhoods, the factors that contribute to (or detract from) their assessments, and the role that these factors play in individual outcomes such as health and life satisfaction. Proposed projects in these areas include understanding the relationships between housing conditions, crowding and respiratory hospitalizations; stress, health, and housing affordability; a description of the social, built and physical environments by housing characteristics; and the contribution of satisfaction with housing to overall life satisfaction among **vulnerable populations**.

New information from the Canadian Housing Statistics Program will be leveraged to continue work to improve understanding of the demographic profile of the Canadian housing market. Other tools and data will be used to understand Canadian household balance sheets and associated risks and developing a Social Inclusion Index to help inform on the self-reported sense of satisfaction with regard to opportunities and resources in relation to the Canadian communities...

2 Modelling and predictive analytics

ASB is advancing the use of modelling and predictive analytics, including microsimulation, and is exploring the applications of advanced methods such as artificial intelligence (AI) and machine learning (ML) in the context of analysis, research and data integration. The transformation within the branch from the exclusive use of survey data to the development and use of large

administrative, linked and integrated data to address complex policy issues also opens the possibilities of applying new advanced and leading-edge methods. New this year, interactive models developed during research will be disseminated and will allow users to customize their queries to more directly meet their needs in a timely manner.

2.1 Microsimulation models

Microsimulation models are powerful tools for integrating and using data from diverse sources, and for enabling what-if scenarios to assess the impact of policy options on Canadians in the immediate and, in some cases, long term. At Statistics Canada, ASB continues to play a central role in the ongoing innovation and development of microsimulation models, including in areas related to population health, distributional impacts of tax and transfers, and retirement adequacy.

The **Population Health Microsimulation Model (POHEM)** is a microsimulation tool that uses the CCHS as its starting population and provides future projections for a range of health outcomes, including prevalence of risk factors and disease, costs and economic indicators, health status, life expectancy, and health-adjusted life expectancy. POHEM has been used by federal health planners, for example, to estimate the impact of reducing obesity and increasing physical activity on the future rate of diabetes. New updates to POHEM will include the implementation of various multivariate predictive models, including the **Cardiovascular Disease Population Risk Tool** and the **Mortality Population Risk Tool**. These additions will enable decision makers to evaluate the impact of changing risk factor exposures on future cardiovascular disease outcomes and on mortality. A new model will also be developed to project cannabis use. This project is meant to be expanded when more information on cannabis use after legislation becomes available.

OncoSim is a web-enabled microsimulation tool developed at Statistics Canada in partnership with the Canadian Partnership Against Cancer. OncoSim is currently used by healthcare planners across the country to evaluate cancer control strategies, specifically, how screening programs affect future cancer incidence, mortality, resource demands, costs and cost effectiveness. OncoSim includes highly sophisticated models of breast, cervical, lung and colorectal cancer, as well as dynamic risk factor models of smoking, radon, hormone replacement therapy, breast density, family history and transmission of human papilloma virus. New features of OncoSim will include an update of the incidence, staging, treatment and survival components of both colorectal and lung cancer using recent linked provincial administrative data; an update of the lung cancer screening eligibility criteria to align with the criteria used in the Ontario Lung Cancer Screening Pilot, supporting a business case for the province-wide screening being developed by Cancer Care Ontario; an evaluation of emerging breast cancer screening technologies (i.e., tomosynthesis, MRI, ultrasound, biomarkers) based on a variety of outcomes, including over-detection; and a tool to evaluate what-if interventions that shift the prevalence of multiple (27) risk factors and apply population-attributable risk methods to attribute cancer incidence, deaths and costs to 32 different cancer types.

The **Social Policy Simulation Database and Model (SPSD/M)** is a static model used by federal and provincial governments and researchers to assess the distributional impacts of changes to tax and transfer policy on Canadian households. The model is updated annually to reflect policy and tax changes announced in the federal and provincial budgets. For the first time, cannabis taxes and duties were included, enabling the examination of the impacts of cannabis consumption, pricing and taxation rates on Canadian households and on the revenues received by government. The market basket measure (which measures the poverty line) and the core housing need (an indicator of whether housing is inadequate, unaffordable, or unsuitable) have been added to the model as output measures to support policy making related to the Poverty Reduction Strategy and the National Housing Strategy, respectively. In addition to adding any tax and transfer changes that will be announced in the 2019/2020 budget, new developments planned

for the SPSPD/M include adding the Federal Carbon Pollution Pricing System and increasing the timeliness of tax and transfer changes in releases. A new version of the model built using administrative data is also planned, which would allow the impacts of policy changes to be examined on smaller populations, such as at smaller levels of geography (census metropolitan area or census agglomeration) or the top 1% of earners.

ASB has also been working with Employment and Social Development Canada and a consortium of academics to develop a roadmap for **a new dynamic microsimulation model** that would allow users to explore the impacts of policy changes over the life course. This proposed model is being designed to model public pensions and income security, including the Canada Pension Plan (CPP), registered pension plans (RPPs), registered retirement savings plans, tax-free savings accounts, and housing and other forms of savings. The development of this model would take multiple years and would be undertaken in partnership with researchers outside the government. Once built, the model would be able to estimate the impact of changes to retirement income policies (e.g., a change to CPP rules) and changes to various socioeconomic trends (e.g., changes in RPP enrolment) on future retirement cohorts.

2.2 Predictive analytics, artificial intelligence and machine learning

ASB has been experimenting with the use of ML on a range of fronts, including statistical matching to create new synthetic data sources for integrating existing microsimulation models and comparing these new approaches with conventional statistical matching techniques. ML techniques are being used to overcome challenges with traditional regression analyses, for example, with intersectionality to better measure how experiencing multiple dimensions of inequality (e.g., gender, socioeconomic, Indigenous status) affects the risk of mortality. Over the next year, further applications of AI and ML in both the health and the economic programs will be explored. ML techniques will be used to classify and predict opioid overdoses and deaths. Similarly, a range of supervised ML techniques (e.g., logit, decision trees, neural networks) will be applied to better understand the characteristics of high-growth firms and their environment, which will help to build a predictive model that enables real-time predictions of firms that are candidates to grow rapidly over the next three years. ASB researchers working in these areas are members of the Data Science Centre of Excellence at Statistics Canada, established to ensure appropriate application of these techniques. Information learned from these ML projects will advance our understanding of the possible applications of these techniques to other areas and programs of research.

2.3 Interactive models and tools

Research produces a range of products, including peer-reviewed publications, data tables and models. ASB is committed to continuing to make the results of the research programs available through open publications and open data. In addition to these products, ASB is leading the production of interactive tools, taking complex models generated through the research process and transforming them into interactive tools available to produce customizable and actionable insights that more directly meet users' needs in a timely way.

ASB, in collaboration with the Business Development Bank of Canada, created a business performance tool that allows firms to compare their performance with that of their peers in the same industry. In the nine-month period after its 2016 launch, over 17,000 firms accessed the tool. A similar tool was developed for the Survey of Innovation and Business Strategies to provide respondents with immediate, enterprise-specific feedback on firm performance, focusing on the impacts of innovation and business strategies. This tool provides a range of program benefits, including increased response rates, improved data quality and lower response burden. This initiative provides a model that could be applied to a range of surveys to better meet user needs, delivering customizable and actionable information in a timely manner.

A new interactive model that will be applied to the multifactor productivity dataset produced by ASB will be developed. It will allow users to examine relationships in the productivity data, provide customized outputs by changing parameters of interest (e.g., time periods, base years, variables, industries), build simple regression models, produce heat maps and make distributional comparisons. With this tool, users will be able to address a range of questions, including what industries and provinces are contributing the most to aggregate productivity growth and which source of output growth is the most important (productivity, capital accumulation, hours worked, capacity utilization, labour quality). This project will help to better understand how this app can be modified to use alternative data to provide near-term forecasts, provide now-casts, or introduce any analytical tool necessary. Importantly, as an open-source project, the code can be published, and more technical clients can then customize the app to their purposes or contribute directly to its evolution.

To build on the very successful interactive data visualization of regional domestic trade flows (<https://www150.statcan.gc.ca/n1/en/catalogue/11-627-M2016005>) disseminated by ASB in 2016, an econometric model is being developed to provide insight on Canada–United States cross-border travel flows based on changes in exchange rate, income, unemployment, costs of travel and border security measures.

3 Data development and access

While Statistics Canada has been linking data for decades, ASB researchers pioneered the use of linked and integrated data to support research programs addressing complex policy questions and deriving new insights on the Canadian economy and society. As a result, record linkage is a key element in ASB's ambitious program of data development. This program is informed by ASB analysts' deep subject-matter expertise and knowledge of data holdings available across the agency. This allows analysts to identify data development opportunities early that will yield large analytical returns on investments over the medium term. These linked databases are available to the wider academic and policy community to support a range of research initiatives through the Canadian Centre for Data Development and Economic Research (CDER) (<https://www.statcan.gc.ca/eng/cder/index>) and research data centre (RDC) (<https://www.statcan.gc.ca/eng/rdc/index>) programs.

The Patent Research Database is a linked data file that brings together the European Patent Office's PATSTAT database on the worldwide patenting activities of Canadian inventors and firms with other Statistics Canada data holdings, including the Business Register and administrative data on firm performance and workers. This database will allow the study of topics such as the impact of foreign direct investment on Canada's intellectual property, the importance of intellectual property to firm performance, and knowledge diffusion through the movement of inventors. The economic research program is supported by a range of linked data sources currently available to researchers through CDER, including the Longitudinal Employment Analysis Program (LEAP), T2-LEAP, the Annual Survey of Manufacturing and Logging Industries General Index of Financial Information, the environmentally adjusted multifactor productivity micro database, the National Accounts Longitudinal Microdata File, and the Longitudinal Census of Agriculture.

A linkage between the Canadian Financial Capability Survey and tax data is facilitating new research on the financial literacy of Canadians, their investment decisions and their financial outcomes. Linkage between the Postsecondary Student Information System, Temporary Residents file, Immigrant Landing File and tax files is being used to examine the characteristics and outcomes of both international and domestic students. Linkage between the Pediatric Oncology Group of Ontario and tax data is being used to examine the employment decisions of parents who have a child with cancer. These new linked data sources add to the following existing data sources to better understand employment and income: the Intergenerational Income

Database, the Canadian Employer–Employee Dynamics Database, and the Longitudinal Worker File. The linked Longitudinal Administrative Database–Discharge Abstract Database will become available in the RDCs in 2019/2020 to support research related to the economic impacts of hospitalizations.

Research on health and the environment, as well as the study of health inequalities, was made possible through the creation of the Canadian Census Health and Environment Cohort (CanCHEC). CanCHEC is a series of nationally based census cohorts that follow the health outcomes of individuals (mortality, cancer, hospitalizations) over time. The 1991, 1996 and 2001 CanCHECs are currently available in the RDCs, and the 2006 and 2011 CanCHECs are expected to be released in the RDCs in 2019/2020. Immigrant health research is supported by the linked Longitudinal Immigration Database–Discharge Abstract Database, which was recently released in the RDCs in January 2019. Other health-based linked databases created by the branch to support health research include the Canadian Birth–Census Cohort 1996 and 2006, the linked CCHS–Discharge Abstract Database and the linked CCHS–Canadian Vital Statistics Database.