The Effect of Population Aging on Economic Growth in Canada

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Executive Summary

The proportion of seniors in Canada's population has rapidly increased over the past few decades. Moreover, according to Statistics Canada, the percentage of Canadians 65 years and over is projected to increase even further in the coming years. It is widely recognized that the aging population will significantly strain provincial governments' budgets, with health-care expenditures anticipated to increase rapidly in the coming decades. Canada's ability to finance higher health-care spending and sustain a higher standard of living for the citizens crucially depends on how rapidly output per capita grows in the future.

Recent econometric studies, based on data from other countries, have reached contradictory conclusions about the impact of population aging on economic growth, with some finding that it reduces economic growth, while other studies show a positive effect. As well, there have not been any Canadian econometric studies on this crucial issue. The objective of this study is to fill this gap in the literature by empirically investigating the impact of population aging on Canadian per-capita output and the growth of labour productivity based on annual provincial data from 1981 to 2020.

We find that a 10% increase in the share of the population aged 65 years and older is associated with a reduction of the growth rate of real GDP per capita of 0.23 percentage points. This result implies that, in 2021 dollars, Canada's GDP per capita will be lower by $4,300 by 2043 under Statistics Canada's slow-aging population projection scenario and by $11,200 under its fast-aging scenario. In other words, under the fast-aging population projection, real GDP per capita will be about 13% lower in 2043 than in a no-aging state. Our simulations also indicate that the adverse impacts of population aging on economic growth will vary across provinces. Under the fast-aging scenario, by 2043, real GDP per capita will be lower by between $9,000 in Prince Edward Island to $21,000 in Newfoundland & Labrador. Alternatively, expressed in percentages, real GDP per capita will be 10.7% lower in Saskatchewan and 16.8% lower in Newfoundland & Labrador in 2043, compared to a no-aging scenario.

An important policy implication of these results is that Canadian policy makers need to embrace multifaceted pro-growth policies to offset the adverse economic and budgetary effects of population aging. An effective policy tool that the federal and provincial

governments could adopt is reducing business taxes, such as the corporate income tax. Such a policy choice will help to stimulate private investment and boost labour productivity and economic growth over time. Policy makers also need to expand the country's labour force by increasing the number of working-age immigrants and expediting their successful integration into the Canadian labour market. Governments can also improve seniors' labour-force participation rates by reducing the marginal tax on their earned labour income and providing them with more opportunities to acquire new skills.

1. Introduction

It is widely recognized that the aging of the population will greatly strain Canadian provincial governments' budgets, with health-care expenditures projected to rapidly increase as the share of the population over age 65 increases in the coming decades (Fuss and Li, 2021; Tombe, 2022). Less attention has been paid to the impact of population aging on the potential growth rate of the economy and on Canada's ability to finance higher health-care spending and sustain Canadians' standard of living. While it is generally assumed that population aging will lower growth rates, recent econometric studies based on data from other countries have produced conflicting results, with some finding that population aging reduces economic growth, while other studies show a positive effect.

To dissect the impact of population aging on economic growth, it is important to note that output per capita depends on the average number of hours worked (labour supply) and the output per hour of work (labour productivity). Population aging can affect economic growth through both channels. There are concerns that per-capita output will decline in the future because the average number of hours worked is projected to decline since seniors have relatively low labour-force participation rates. However, this adverse impact of demographic aging on economic growth can be offset if labour productivity increases. If productivity increases are large enough, per-capita GDP might stay the same or even increase.

In this study, we estimate the impacts of population aging on the growth rates of Canadian per-capita output and labour productivity based on annual provincial data from 1981 to 2020. We find that a 10% increase in the share of the population aged 65 years and older is associated with a reduction of the real GDP per-capita growth rate of 0.23 percentage points. We also find that population aging lowers the growth rate of labour productivity by a similar amount, indicating that lower rates of improvement in labour productivity are the primary reason for slower potential output growth as the population ages.

We then use our econometric estimates and recently released population projections from Statistics Canada to simulate the effect of an aging population on real GDP per capita from 2023 to 2043. We find that, in 2021 dollars, Canada's GDP per capita will be lower by $4,300 by 2043 under Statistics Canada's slow-aging population scenario, and by $11,200 under its fast-aging scenario. In other words, under the fast-aging scenario, real GDP per capita will be about 13% lower in 2043 than in a no-aging scenario.

We also investigate how population aging may affect the real GDP per capita of the 10 provinces. The simulation analysis indicates that the adverse impacts of population aging vary across provinces. Under the fast-aging scenario, by 2043, real GDP per capita will be lower by between $9,000 in Prince Edward Island to $21,000 in Newfoundland & Labrador. Alternatively, expressed in percentage terms, real GDP per capita will be 10.7% lower in Saskatchewan and 16.8% lower in Newfoundland & Labrador in 2043, compared to the no-aging scenario.

These findings have important implications for public policy. As an ever larger fraction of the population shifts into the older age group, Canadians' per-capita income will be lower than what it would have been in the absence of population aging. The lower income will reduce the federal and provincial governments' fiscal capacity. As discussed in Fuss and Li (2021), Eisen and Emes (2022), and Tombe (2022), the decline in fiscal capacity caused by population aging and the contemporaneous need to increase healthcare, public pensions, and related spending programs will adversely affect governments' overall budgetary positions. Thus, Canadian governments should prepare for these upcoming fiscal challenges by reducing their current deficit-financed spending.

To offset the adverse economic and budgetary effects of population aging, Canadian policy makers also need to embrace multifaceted pro-growth policies. An effective policy tool that the federal and provincial governments could adopt is reducing business taxes, such as the corporate income tax, to stimulate private investment and boost labour productivity and economic growth over time. Policy makers also need to expand the country's labour force by increasing the number of working-age immigrants and expediting their successful integration into the Canadian labour market. Seniors' labour-force participation rates could be increased by reducing the marginal tax on their earned income (but not their pension and investment income) and providing them with more opportunities to acquire new skills.

The remainder of this study is organized as follows. The second section provides background information on trends in economic growth, population aging, and productivity in Canada. It also reviews some important recent studies on population aging and economic growth. Our main empirical analysis of the impacts of population aging on real GDP growth rate is presented and discussed in the third section. The fourth section highlights the key policy implications of the study. The fifth section concludes the paper.

2. Background on Economic Growth and Population Aging

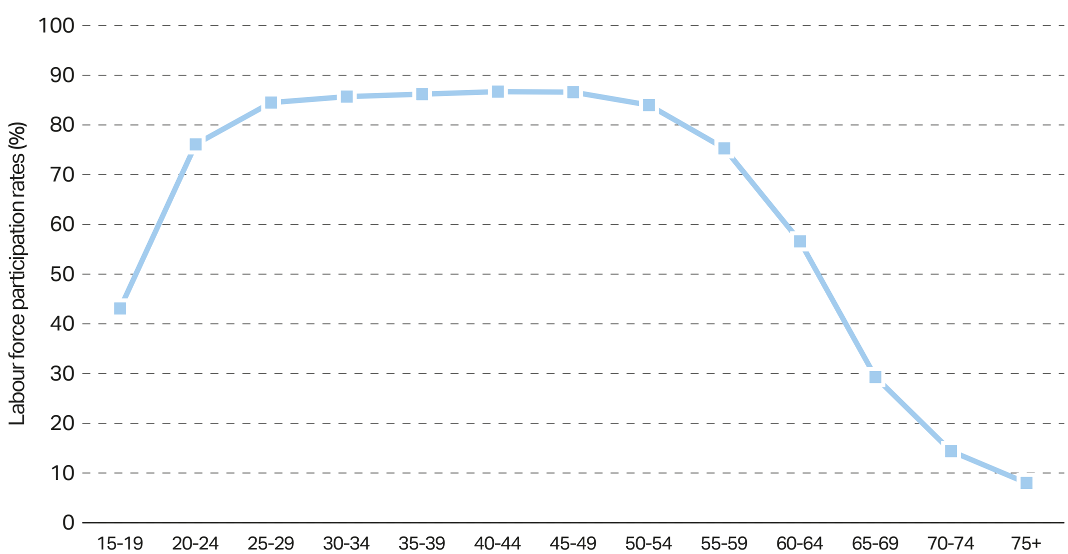
The link between population aging and economic growth can be decomposed into its labour-supply effects and its productivity effects, as captured by the following equation:

$$\frac{GDP}{N} = \frac{GDP}{H} \times \frac{H}{N}$$

where GDP is real gross domestic product, N is total population, and H is the total number of hours worked. GDP/H is output per hour of work, a measure of labour productivity, and H/N is a measure of the per-capita hours of work (labour supply). From this relationship, the growth rate of GDP per capita is equal to the rate of change in labour productivity plus the rate of change in per-capita labour supply.[1]

Population aging obviously affects a country's per-capita labour supply, because the labour-force participation rates of individuals over age 65 are well below the average for the traditionally defined working-age population (**figure 1**).

Figure 1: Labour force participation rates (%), by age group, 2021



Sources: Statistics Canada, 2023d.

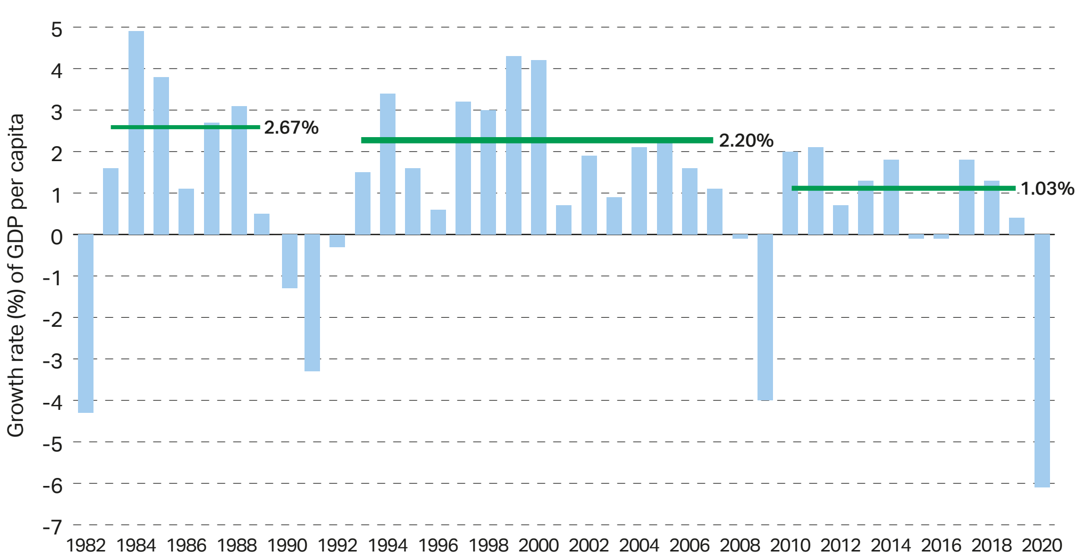
1. See the recent report by Globerman (2023) on the economic challenges that Canada faces from an aging labour force.

However, participation rates, hours of work, and unemployment rates may adjust with increasing pressures in labour markets, along with policies that reinforce these adjustments.[2] Population aging can also have subtle and far-reaching impacts on the productivity of the labour force, depending on whether investment per worker increases or decreases and whether technological change and business innovation accelerate or decelerate. In section 2.1, we provide a brief overview of GDP growth rates in Canada over the last 40 years. In section 2.2, we describe trends in population aging and their implications for the rate of change in labour supply and employment growth. Section 2.3 summarizes trends in labour productivity, while section 2.4 reviews recent econometric studies of the impact of population aging on economic growth and labour productivity.

2.1 Trends in the Canadian growth rate

The Canadian average annual growth rate of real GDP per capita between 1981 and 2021 was 1.13%. As **figure 2** indicates, real GDP per capita declined during the recessions in 1982, 1990/92, 2008/09, and 2020, which brought down the annual average growth rate. To get a better picture of long-run trends, it is useful to examine the "normal" annual growth rates that have occurred in non-recession years, which is shown by the horizontal lines in figure 2. The average annual growth rate was 2.67% in 1983–1989, 2.20% in 1993–2007, and 1.03% in 2010–2019. Much slower average growth rates since the Global Financial Crisis of 2008/09 have also been observed in the United States, the United Kingdom,

Figure 2: Canada's annual growth rates (%) of real per-capita GDP, 1982–2020



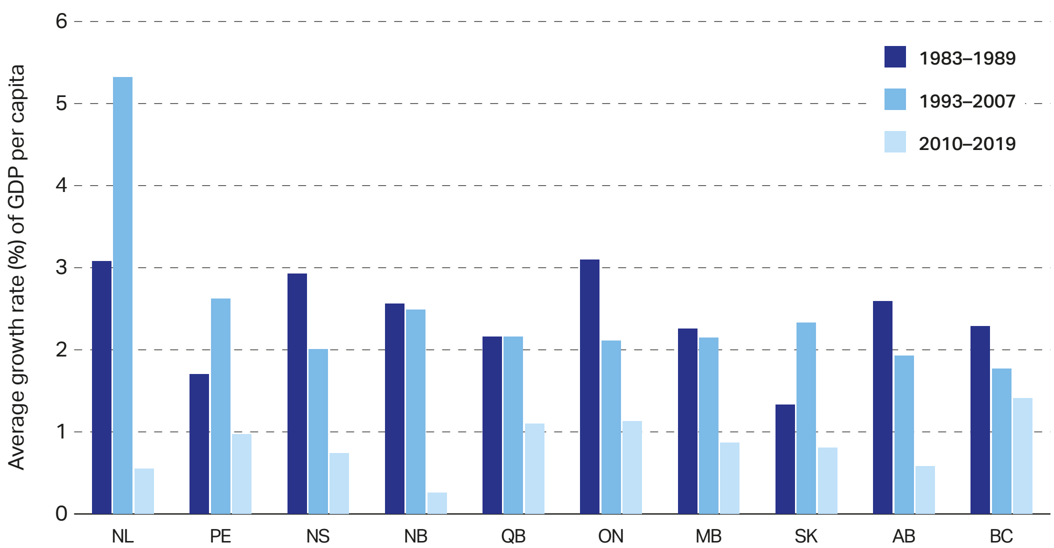
Note: The horizontal lines show "normal" annual average growth rates of 2.67% in 1983–1989, 2.20% in 1993–2007, and 1.03% in 2010–2019.
Sources: Statistics Canada, 2023a, 2023b.

2. See Statistics Canada (2017) on the impacts of population aging on labour-market participation rates.

and many other developed countries. The prominent American economist, Lawrence Summers refers to this period of slow growth as secular stagnation. Various explanations for the slowdown in growth rates have been suggested, including the worldwide savings glut caused by increased savings by aging populations to the slowdown in the pace of scientific discoveries and innovations.

Figure 3 shows the average annual growth rates for real per-capita GDP during these inter-recession periods for the 10 Canadian provinces. In all provinces, the growth rates in the 2010–2019 period were slower than in the two previous inter-recession periods. Note that Newfoundland & Labrador experienced very rapid growth from 1993 to 2007, as result of the development of offshore oil production, but with a subsequent drastic decline to 0.55% over the 2010–2019 period.

Figure 3: Provincial average annual growth rates (%) of real GDP per capita, 1983–1989, 1993–2007, and 2010–2019



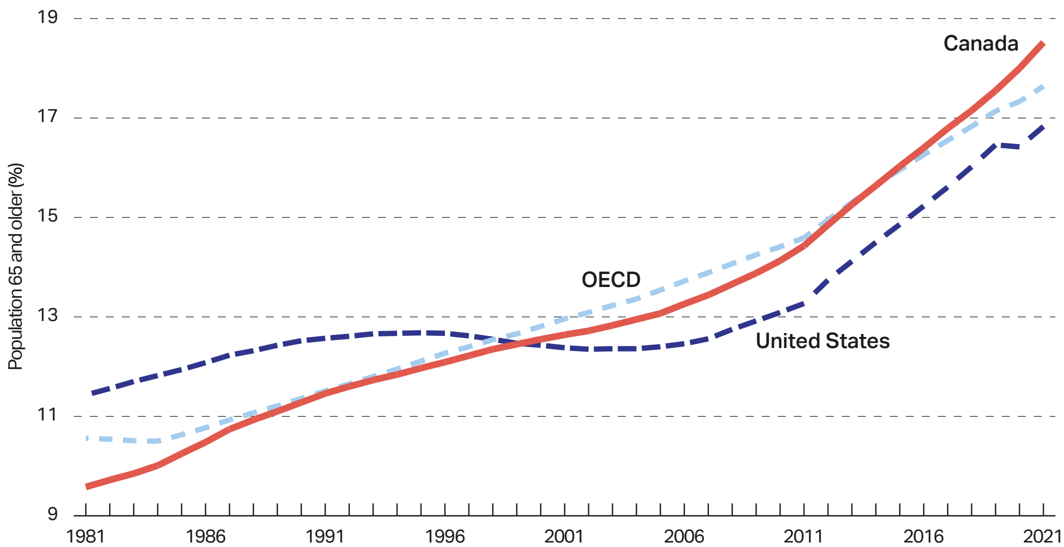
Sources: Statistics Canada, 2023a, 2023b.

2.2 The aging of the population in Canada

The share of Canada's population 65 years and older has been rising steadily over the past four decades. Although the aging of the population is occurring in most developed countries, the rate of increase is quite pronounced in Canada. Figure 4 shows the evolution of the aging population in Canada.

Before 1999, the share of the population aged 65 or older in Canada was lower than that in the United States and below the OECD average. But Canada has been rapidly aging, and the

Figure 4: Share (%) of the Canadian population aged 65 or older, 1981–2021



Sources: Statistics Canada, 2023b; calculations by the authors.

share of seniors in Canada, at 18.5%, was higher than in the United States and the OECD average in 2021 (the latest year for which comparable data is available for other countries).[3]

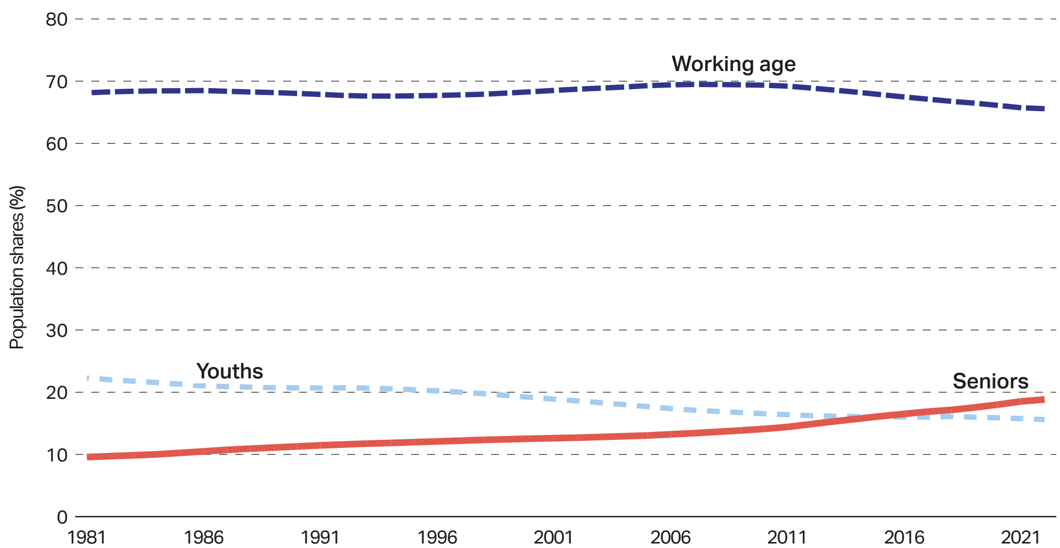
Rapid aging of the population has fiscal and economic ramifications, particularly when it is accompanied by a declining share of the population who are of working age (between ages 15 and 64 years). To shed light on the country's demographic situation, we show the trends in the shares of the population below 15 years of age (young), working age, and 65 years and above (seniors) in **figure 5**.

Since 1981, the population share of the young has been declining while the share of seniors has been on an upward trend. Furthermore, in more recent years, the population share of those of working age has declined from 69% in 2011 to 65.6% in 2022. Future demographic trends may involve even faster declines in the working-age group's share of the overall Canadian population.

There are significant differences among the provinces in the share of seniors in the population, as shown in **figure 6**. Currently, the population share of seniors is highest in Newfoundland & Labrador at 23.6% and lowest in Alberta at 14.8%. In general, Atlantic Canada and Quebec have above average 65+ population shares, while the Prairie provinces have relatively smaller cohorts of seniors. Thus, the challenges that governments

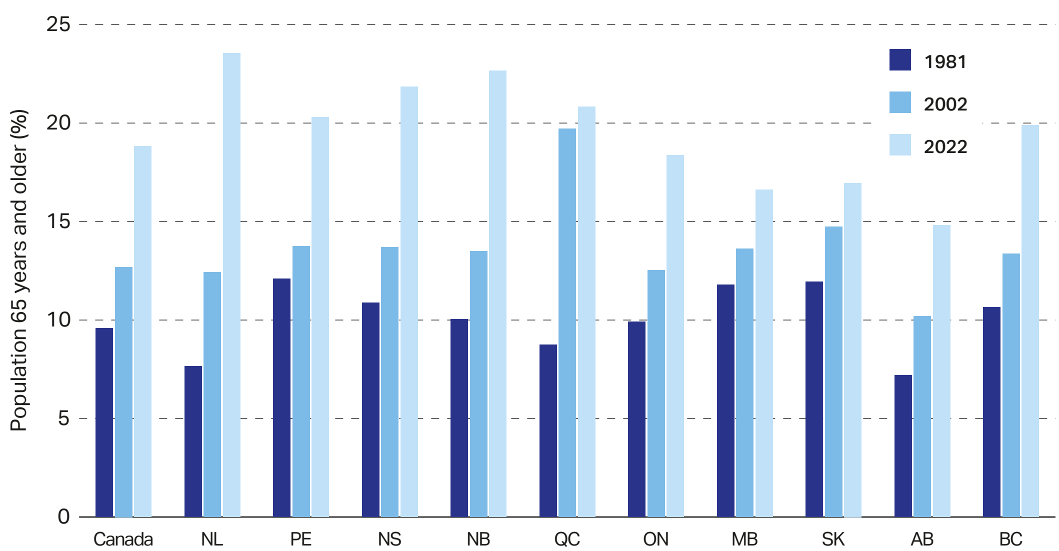
3. There is a lot of variation in population aging among OECD countries. For instance, in 2021, the latest year for which complete data is available, the share of the population 65 and older ranged from 7.9% in Mexico to 28.9% in Japan. Many OECD countries, especially in Europe, have higher 65+ population shares than Canada.

Figure 5: Shares (%) of seniors, youths, and working age in Canada, 1981–2022



Sources: Statistics Canada, 2023a.

Figure 6: Share (%) of the population 65 years and older in Canada and the provinces, 1981, 2002, and 2022



Sources: Statistics Canada, 2023a.

face and will continue to face from population aging are not identical across the provinces and require a close empirical examination of the issue. One important difference is the rate at which the population is aging. In 1981, Newfoundland & Labrador had one of the youngest populations; today, it has Canada's highest population share of seniors. A similar dramatic demographic change occurred in all the Atlantic provinces as well as Quebec. For example, the share of seniors in Quebec increased from 8.8% in 1981 to 20.8% in 2022. Since Quebec has the second-largest population in Canada, this has had a significant impact on the country's overall rate of population aging. In contrast, over the same period, the share of seniors in the Prairie provinces has only increased by between 4.8 and 7.6 percentage points.

While looking at historical trends of population aging provides us with some insight into the demographic challenges the country has been facing, it is the future trend of this demographic change that will present challenges for Canadian policy makers. Statistics Canada (2022a) provides projections of Canada's population, under slow-aging and fast-aging scenarios, out to 2068.[4] However, population projections for individual provinces are only available up to 2043. These projections for 2033 and 2043, along with the 65+ population share in 2022, are shown in figure 7a and figure 7b.

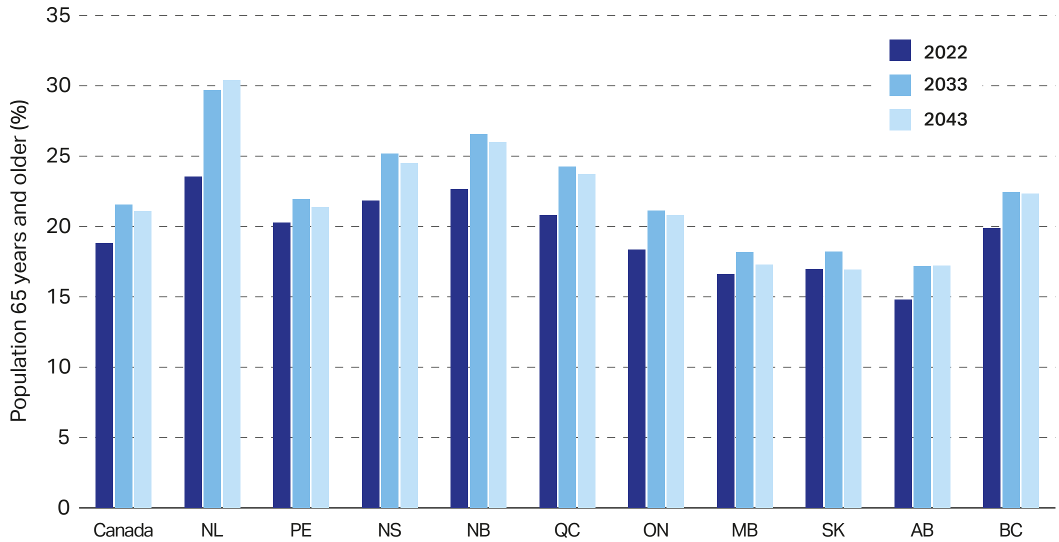
By 2033, the population share of seniors in Canada is projected to increase by 2.7 percentage points under the slow-aging scenario and by 5.0 percentage points under the fast-aging scenario. By 2043, the 65+ shares are projected to increase by 2.3 percentage points under the slow-aging and by 7.5 percentage points under the fast-aging projection scenario. Thus, an important difference between the two scenarios is that under the slow-aging scenario the seniors' population share will peak around 2033 and then slightly decline to 2043, whereas it is projected to continue rising under the fast-aging scenario.

While population aging will occur in all provinces, there are significant variations in the level and rate of increase across the country. Atlantic Canada will have the highest population share of seniors, with an average in the region of about 31% in 2043 under the fast-aging scenario, whereas the average in the Prairie provinces is projected to be about 21%. The population projections also highlight a huge variation across provinces in the rate at which the population ages (see table A6, p. 30). Newfoundland & Labrador faces the largest increase in the 65+ population share, with a 50% increase under the fast-aging scenario. On the other hand, Saskatchewan is projected to experience the lowest rate of population aging at 28% between 2022 and 2043.

How will the aging of the population affect the supply of labour and the productive capacity of the economy? Denton and Spencer (2019) provide an answer to this question by

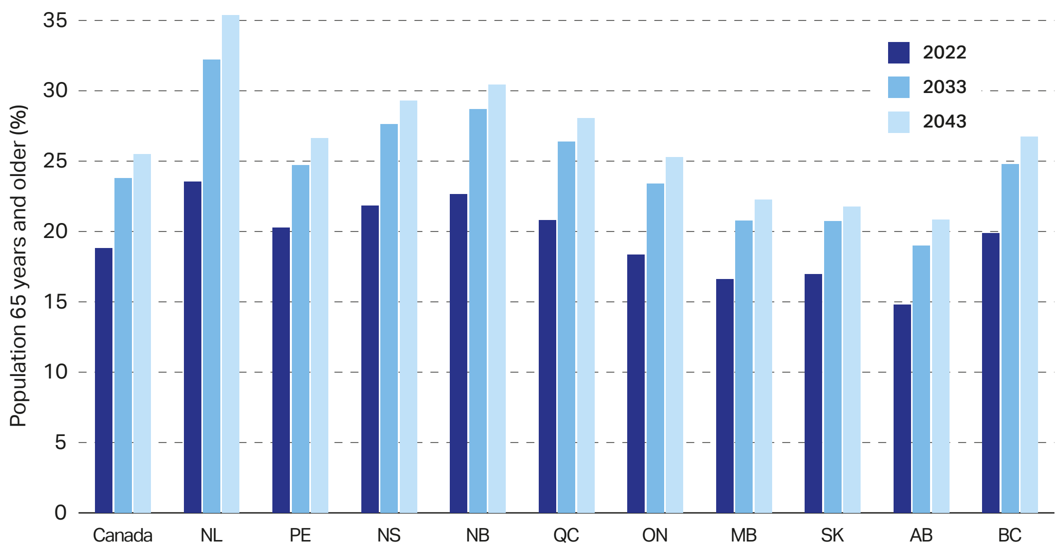
4. Statistics Canada projects Canadian provincial population using various assumptions on the components of population growth. The population projections are done for each province separately, and the figures for Canada are the sum of these individual provincial projections. Thus, the projection implicitly accounts for possible interprovincial migration. Further, Statistics Canada uses the most recent immigration targets obtained from Refugees and Citizenship Canada to incorporate the effects of immigration on population growth (Statistics Canada, 2022b).

Figure 7a: Projected share (%) of the population 65 years and older in Canada an the provinces, 2022, 2033, and 2043—slow population aging scenario



Sources: Statistics Canada, 2022c.

Figure 7b: Projected share (%) of the population 65 years and older in Canada and the provinces, 2022, 2033, and 2043—fast population aging scenario



Sources: Statistics Canada, 2022c.

calculating GDP per capita in the future if (a) labour productivity and (b) all the determinants of the supply of labour (participation rates, hours per worker, unemployment rates) except the age structure of the population remain constant. Using Statistics Canada's medium population-aging scenario, Denton and Spencer project that Canadian output per capita will decline by 3.3% over the period from 2026 to 2033. However, the output losses vary greatly across provinces because of the differences in the population age distributions discussed above. For example, population aging is projected to reduce GDP per capita by 8.2% in Newfoundland & Labrador, 5.9% in New Brunswick, and 5.5% in Nova Scotia. On the other hand, in the Prairie provinces, GDP per capita is only projected to decline by 1.7% in Manitoba, 2.4% in Saskatchewan, and 2.5% in Alberta. The authors also show that doubling the labour-force participation rates for those over age 65 would only offset the projected output loss by about two percentage points, while a general reduction in unemployment rates by one third would offset it by 3.2 percentage points, and a 5% increase in hours of work would offset the output loss by about 5.5 percentage points.

Will increases in labour productivity be sufficient to offset the decline in the supply of labour as a result of population aging? Denton and Spencer found that if labour productivity increases at the highest average rates observed in the past 20 years, per-capita output could be maintained in all provinces except Newfoundland & Labrador. Will the Canadian economy be able to achieve this required rate of productivity growth? To shed some light on this issue, we now review recent trends in Canadian labour productivity and its principal determinants.

2.3 Trends in labour productivity and population aging

Labour productivity—commonly measured by GDP per hour worked—is a crucial determinant of a country's standard of living. A worrying trend, highlighted in various reports, is that productivity growth has slowed in many OECD countries, including Canada. In fact, Canada's productivity performance since 2015 has been below that of the United States and lower than the OECD average (OECD, 2023a).[5]

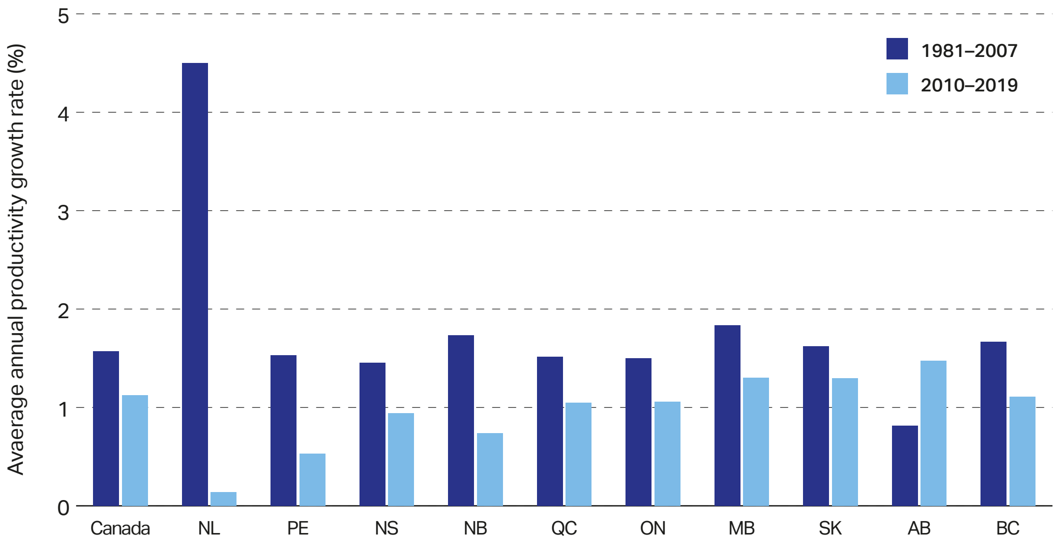
Figure 8 shows the average annual growth rates of labour productivity for Canada and each province from 1997 to 2007 and 2010 to 2019.[6] Nationally, the average annual productivity growth rates declined from 1.57% to 1.13% over these two periods.

At the provincial level, two anomalous trends stand out. First, Newfoundland & Labrador experienced very rapid productivity growth from 1997 to 2007 as a result of the development of the offshore oil-production sector (a high productivity industry), but with a subsequent marked decline to 0.14% over the 2010–2019 period. In the other anomalous case, Alberta's productivity growth bucked the national trend, with 0.81% productivity growth from 1997

5. Employment has shifted from the manufacturing sector to services in many OECD countries, including Canada. More specifically, the share of the service sector in employment has been rising and that of the manufacturing sector declining. Such a structural transformation will likely affect labour productivity since previous studies show that labour productivity is generally lower in the service sector than in the manufacturing sector (see, for instance, OECD, 2018).

6. These periods were chosen to avoid the influence of the recessions in 2008/09 and 2020/21 on productivity.

Figure 8: Average annual productivity growth rates (%), in Canada and the provinces, 1997–2007 and 2010–2019



Sources: Statistics Canada, 2023c; calculations by the authors.

to 2007, rising to 1.48% from 2010 to 2019. These cases show that the growth rates of labour productivity in resource-producing provinces can be either rapid or slow depending on the starting or base level of labour productivity—low in the case of Newfoundland & Labrador, and high in the case of Alberta—and that downturns in investment can either raise (as in Alberta) or lower (as in Newfoundland & Labrador) the growth rates of labour productivity.

It is important to recognize that labour productivity is determined by a host of different factors, such as workers' education, training, and experience, the physical capital stock per worker, the quality of natural resources, the rate of innovation in the technologies used for the production and distribution of goods and services, and the allocation of the labour force across sectors with different levels and rates of productivity growth (for example between manufacturing and services). Population aging can affect some of these determinants of labour productivity directly through workers' decisions and businesses' responses to changing labour-market conditions. With an aging labour force, managerial experience may increase but incentives to innovate may decline. Older workers may fail to upgrade their skills and adapt to new technologies. Labour shortages create incentives to accelerate the adoption of labour-saving production technologies, such as robots and the use of AI.[7] An aging population may lead to a shift of aggregate demand from goods industries to services industries, which exhibit lower rates of productivity growth. The magnitudes of

7. Globerman (2023) argues that it is unlikely, in the absence of major tax and regulatory changes, that the Canadian private sector will increase investment spending sufficiently to offset the pressures from population aging.

these responses to population aging will determine the impact on aggregate productivity and output growth. In the following section, we review some recent econometric studies on the impact of population aging on productivity and output growth.

2.4 Recent econometric studies of aging and growth

Population aging is occurring around the world, raising common concerns about its impact on future economic growth. Therefore, it is not surprising that there has been a spate of recent econometric studies on the impact of population aging on growth and productivity, based on data from a mix of countries. These studies have reached sharply different conclusions about the impact of population aging on growth. Here, we provide a brief survey of the recent contributions, focusing on their key results.[8]

We begin by reviewing four econometric studies that concluded that population aging has an adverse effect on economic growth. Aiyar, Ebeke, and Shao (2016) found that the aging of the workforce reduced total factor productivity growth by 0.1 percentage points based on panel data for 28 EU countries.[9] Aging was associated with an increase in investment per worker (capital deepening) but the resulting productivity improvements were small compared to the negative impact of population aging on total factor productivity growth. Furthermore, aging did not result in greater investments in human capital. Overall, they found that an increase in the share of workers aged 55–64 by one percentage point led to a decline in the growth of output per worker of between 0.25 and 0.70 percentage points over the sample period from 1984 to 2007.

Daniele, Honiden, and Lembcke (2019), using data from 363 regions in 19 OECD countries from 2001 to 2014, found that aging had no impact on productivity growth in the manufacturing sector, while it had a negative impact in tradable services. Overall, they estimated that a 10 percentage-point increase in the ratio of old to young population reduced labour productivity growth by 1.5 percentage points.

Ye, Chen, and Peng (2021), based on panel data for provinces in China over the period from 1990 to 2015, found that a 10% increase in the share of the population aged 65+ reduced the

8. Details concerning the datasets used, statistical methods, variables included in the regressions, and key results are summarized and available from the authors upon request (FeredeE@macewan.ca).

9. Another concept often used in empirical analysis is what is known as total factor productivity (TFP). Unlike labour productivity, TFP is multi-factor productivity measured by dividing total GDP by the aggregate input of labour and capital used in the production process. TFP measures how effectively an economy uses its labour and capital inputs to produce output.

growth rate of GDP per capita by approximately 2.0%. Half of the reduction was attributable to the decline in the labour force/population ratio, with the remainder arising from slower productivity growth.

Maestas, Mullen, and Powell (2023), based on state-level panel data from the United States, found that a 10% increase in the population share of those aged 60+ reduced the annual economic growth rate by 1.2 percentage points per year from 2010 to 2020. Two thirds of the decrease in growth was from a decline in labour productivity, with the other third from a reduction in per-capita employment. The decline in labour productivity resulted in an equivalent reduction in wage rates across the age distribution.

While the four studies reviewed above found a negative relationship between population aging and economic growth, two recent influential studies produced the opposite result. Acemoglu and Restrepo (2017), using cross-section data for 169 countries and a sub-sample of 35 OECD countries, found that a one percentage-point increase in the ratio of old to young workers increased real per-capita GDP by 1.70%. They speculate that the positive association between population aging and growth arises because the scarcity of labour induces firms to more rapidly adopt labour-saving technologies such as robots, leading to greater capital deepening.

Eggertsson, Lancastre, and Summers (2019) also used data from a cross-section of 169 countries and found that population aging was associated with faster economic growth from 1990 to 2008, but slower growth from 2008 to 2015. They argue that the positive relationship held for 1990–2008 when real interest rates declined coincident with increased savings from an aging population, resulting in more investment per worker (capital deepening) and higher labour productivity. However, after the Great Financial Crisis period, real interest rates could not adjust in those countries that reached the Zero Lower Bound on nominal interest rates, eliminating or at least dampening the incentive for capital deepening. They conclude that aging is associated with faster, not lower, GDP growth rates.

In sum, there are conflicting results from recent econometric studies on the relationship between population aging, labour productivity, and economic growth. Unfortunately, there are no similar studies based on Canadian data. In this study, we attempt to fill this gap in the literature and provide empirical results that will be valuable in future policy discussions and analyses related to the economic consequences of population aging.

3. How Will Canada's Aging Population Affect Economic Growth?

In this section, we simulate how the projected increase in the 65+ age group will affect Canadian output per capita in the future.[10] Our analysis is based on econometric models of the growth rates of GDP per capita and labour productivity using annual provincial data from 1981 to 2020. A detailed description of the econometric models is contained in Appendix 1 (p. 21). In the empirical analysis, we find that a 10% increase in the share of the population 65 years and older is associated with a reduction of the real GDP per capita growth rate by about 0.23 percentage points.[11] As discussed in Appendix 1, we include the population share of those under 15 years as one of the control variables in the empirical analysis. However, the coefficient of this variable is not significant at the conventional 5% level, suggesting that its growth effect is not statistically different from zero. Thus, our simulation analysis does not take into account the growth effect of changes in the population share of those under 15 years of age. We also find that population aging lowers the growth rate of labour productivity by a similar amount, indicating that the lower rates of improvement in labour productivity are the primary reason for slower output growth as the population ages.

This study uses the empirical estimate of Appendix 1 and Statistics Canada's (2022a) population projections to shed light on how the income of Canadians will be affected by the aging population. We conduct the simulation analysis for all Canadian provinces and the country to see if there is any variation in the effects of aging across provinces. As indicated previously, Statistics Canada (2022a) provides the population projections for all provinces for all years up to 2043. The population projection is also provided for different aging scenarios. As we are interested in highlighting the range of possible impacts of

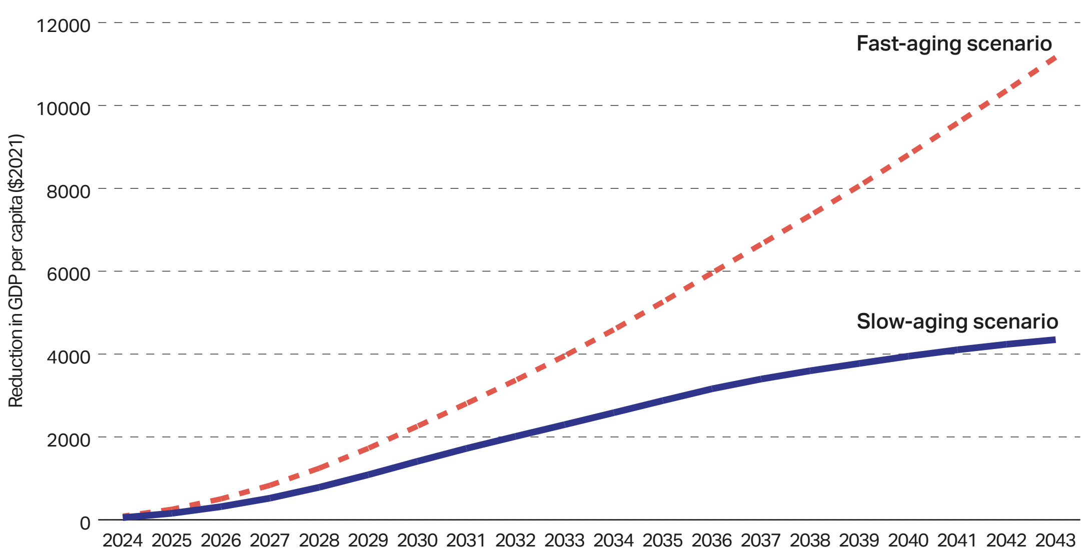
10. It is worth noting a caveat that applies to our simulation analysis. Various tests show that our empirical model satisfies essential statistical properties and is appropriate to explain the relationship between population aging and growth sufficiently. In empirical studies such as ours, it is generally quite common to make forecasting and empirical analysis of future effects of economic policies or events. Such an approach assumes that parameter estimates based on historical data are relevant to future scenarios and that the empirical model captures critical factors related to the studied issue. However, one may question whether past trends and historical data can fully predict future paths of economic variables.

11. It is important to note that our estimates indicate the reduction in economic growth rates from an increase in the share of the 65+ age group assuming that the working-age population declines by an equivalent percentage.

the aging population on income, we conduct the simulation analysis under the slow-aging and the fast-aging scenarios. To put the impact of population aging in perspective, we adopt a no-aging scenario as our baseline, that is, where the population share of seniors is maintained at its 2022 level. Furthermore, as in *Fiscal Sustainability Report 2022* from the Parliamentary Budget Officer (PBO, 2022), we assume that, for our baseline state of no-aging, real GDP per capita will grow at its historical average rate as observed over the 1982–2019 period. We choose this because, according to Statistics Canada, the real GDP data prior to 1981 is not directly comparable with the post-1981 data. Further, we exclude the post-COVID-19 years as the growth rate in these years has been strongly affected by the pandemic. Note also that we conduct the simulation for the period from 2024 to 2043.

Figure 9 shows the simulated impacts of population aging on Canada's real GDP per capita under the slow-aging and fast-aging scenarios from 2024 to 2043. Under the slow-aging scenario, Canada's real GDP per capita will be lower by $2,300 or by 3% in 2033, and by $4,300 or 5% in 2043, compared to the no-aging scenario. Thus, even under the slow-aging scenario, the reduction in real GDP per capita as a result of aging is very significant. The reduction in real GDP per capita increases over time as the population share of seniors rises during the period studied. Our simulation shows that the negative impacts on real GDP per capita become more prominent as population aging continues. This is particularly true under the fast-aging scenario, which indicates that population aging intensifies throughout the projection period.

Figure 9: Reduction In Canada's real GDP per capita as a result of demographic aging ($2021)—slow-aging scenario and fast-aging scenario



Sources: Authors' computation using the empirical estimate and population projections from Statistics Canada, 2022c.

As indicated earlier, our empirical analysis finds that population aging adversely affects the economic growth rate. This means real GDP per capita will be lower with an aging population, as compared to the baseline state of no-aging. To shed more light on this vital issue, we compute the reductions in real GDP per capita that is attributable to population aging under the slow-aging and fast-aging scenarios. We report the simulation results for Canada and the 10 provinces separately. Table 1 shows the reduction in real GDP per capita relative to the baseline state of no-aging in 2033 and 2043 under the slow-aging and fast-aging scenarios. Further, to contextualize the decline in real GDP per capita, we also include the corresponding percentage reduction in parentheses.

Table 1: Reductions in GDP per capita under slow- and fast-aging scenarios ($2021); percentage reduction in parentheses

	Slow aging		Fast aging	
	2033	2043	2033	2043
Canada	2,300 (3.0)	4,300 (5.0)	4,000 (5.2)	11,200 (13.0)
Newfoundland & Labrador	5,000 (5.1)	13,500 (10.8)	6,700 (6.8)	21,000 (16.8)
Prince Edward Island	1,100 (1.8)	1,800 (2.3)	2,800 (4.4)	9,000 (11.6)
Nova Scotia	2,000 (3.2)	3,700 (5.1)	3,300 (5.2)	9,200 (12.5)
New Brunswick	2,300 (3.5)	4,700 (6.1)	3,400 (5.2)	9,600 (12.6)
Quebec	2,300 (3.4)	4,500 (5.8)	3,600 (5.3)	9,800 (12.7)
Ontario	2,400 (3.2)	4,700 (5.6)	4,000 (5.4)	11,500 (13.6)
Manitoba	1,300 (2.0)	1,300 (1.7)	3,300 (4.9)	9,600 (12.5)
Saskatchewan	1,500 (1.6)	−0 (−0.0)	4,000 (4.5)	11,200 (10.7)
Alberta	3,200 (3.4)	7,200 (6.7)	5,300 (5.65)	15,500 (14.5)
British Columbia	2,000 (2.7)	4,300 (5.1)	3,700 (4.9)	10,600 (12.6)

Source: Authors' computation using the empirical estimate plus the population projections from Statistics Canada, 2022c.

Table 1 indicates that there is a considerable variation in the reduction in real GDP per capita across the provinces as a result of differences in their rates of population aging. Under the slow-aging scenario, the reductions in real GDP per capita ranges from $1,100 for Prince Edward Island to $5,000 for Newfoundland & Labrador in 2033. By 2043, the range is even greater, with real GDP per capita in Newfoundland & Labrador lower by $13,500, whereas real GDP per capita in Saskatchewan will be higher because of a decline in its share of its 65+ population.[12]

Under the fast-aging scenario, Canada's real GDP per capita will be lower by $4,000 in 2033 and by $11,200 in 2043, or by 13% two decades from now compared to the no-aging scenario. In fact, by 2043, all provinces will have relatively lower real GDP per capita as a result of the aging population. According to the simulation results, the decrease in real GDP per capita ranges from $9,000 for Prince Edward Island to $21,000 for Newfoundland & Labrador by 2043. Alternatively, by 2043, the percentage reduction in real GDP per capita relative to the baseline state of no-aging ranges from about 10.7% for Saskatchewan to 16.8% for Newfoundland & Labrador.

In summary, these simulations indicate that population aging will lead to lower incomes and a lower standard of living for Canadians, compared to a no-aging scenario. While household consumption will be lower, demographic aging will also reduce government's capacity to fund public services. That is, lower incomes will reduce the fiscal capacities of the federal and provincial governments. It is also clear that population aging significantly raises provincial governments' health-care spending. These two effects, taken together, mean that population aging could have a substantial impact on provincial budget balances and the sustainability of public debt over the coming decades. The federal and provincial governments should recognize these challenges and be ready to address the impending fiscal pressures by reducing current deficit-financed spending and pursuing other policy reforms that may help to raise the economy's potential growth rate.

12. Our simulation shows that Saskatchewan's real GDP per capita marginally increases by 2043 under the slow-aging scenario since the province's population share of seniors is projected to fall slightly under this scenario.

4. Policy Implications

The potential adverse effects of population aging on our economy's capacity to produce goods and services means that policy makers need to adopt multifaceted approaches to lessen the economic and fiscal impacts.

As our study indicates, population aging lowers the growth rate of labour productivity. An important policy question is: how can policy makers offset the decline in productivity growth? Our previous research, Ferede and Dahlby (2012) and Dahlby and Ferede (2021), suggests that lowering corporate income taxes could boost labour productivity because it encourages capital inflows, entrepreneurship, and higher private investment. This, in turn, increases the capital-labour ratio and boosts labour productivity.[13] Thus, lowering the corporate income-tax rate can be an important public policy tool to offset some of the decline in labour productivity caused by the aging of the labour force. In this regard, studies by Whalen and Fuss (2021) and Bazel and Mintz (2021) also emphasize the importance of tax reform in raising productivity.

Other researchers also highlight the role of different policy tools in offsetting the adverse effects of population aging on labour productivity. Globerman (2023) emphasizes that policy makers need to adopt policies that encourage innovation and entrepreneurship and make the Canadian economy more competitive to attract capital investment. Other studies, such as that by Guellec and de la Potterie (2013), indicate that research and development (R&D) is a long-term determinant of productivity. Thus, one additional policy tool to raise productivity and attenuate the adverse effects of population aging is to adopt measures that encourage R&D. In this regard, governments can use policies to promote and accelerate the adoption and diffusion of new technologies across the business sector. A meaningful way to achieve this is through government support for R&D in the form of fiscal incentives (see OECD, 2016 and Lester, 2021).

Public-policy responses to minimize the adverse economic and budgetary impacts of population aging can also take many other forms. As Lee (2016) discusses, one such policy is expanding the size of the labour force. In the Canadian context, this can be partly achieved by raising the number of working-age immigrants or with a priority for economic

13. See Vartia, 2008 and McKenzie and Ferede, 2017 for more information.

migration.[14] This is particularly important for Canada as immigration has accounted for almost 100% of the increase in the growth of the country's labour force in recent years (Immigration, Refugees and Citizenship Canada, 2023). An increase in the supply of working-age immigrants helps reduce the old-age dependency ratio and alleviates the decline in employment growth associated with population aging. Concurrent with such a policy, governments need to expedite the integration of the new immigrants and help increase their participation in the labour force through training and other related programs.

Other public policies to lessen the adverse effects upon the labour market of population aging should focus on participation in the labour market by seniors. If suitable labour-market conditions prevail, some individuals 65 years and over can still work and contribute to society in various ways.[15] Seniors' labour-force participation rates could be increased by reducing the marginal tax on their earned income (but not their pension and investment income) and providing working seniors with more opportunities to acquire new skills. As discussed in Gunderson (2022), governments should reduce other barriers to the active participation of older workers in the labour market, such as age discrimination.

14. Such a policy tool is also widely used in other countries. For instance, according to the OECD (2019), over the period from 2005 to 2015, about 92% of the increase in the workforce in the European Union is accounted for by migrants. The comparable figure for the United States over the same period is 65%.

15. The Canadian labour-force participation of seniors has risen over the past two decades. For instance, the participation rate of individuals 65 years of age and over increased from 6% in 2000 to 14% in 2018 (Statistics Canada, 2019). This figure stood at 14.6% in 2022.

5. Conclusions

The potential fiscal and economic effects of the inevitable process of the aging of the population in Canada are an increasing concern. In this study, we investigate the effects upon economic growth of population aging using annual panel data from Canadian provinces from 1981 to 2020. Our results indicate that population aging adversely affects the growth rates of labour productivity and GDP per capita. According to our empirical estimate, a 10% increase in the proportion of the population 65 years and above is associated with a 0.23 percentage point decrease in the growth rate of output. We also find that an aging population lowers the growth rate of labour productivity by a similar amount, indicating that lower rates of labour-productivity improvements are the primary reason for slower output growth as the population ages.

We use our empirical estimates and the population projections to shed light on the future reduction in Canadians' income as the result of an aging population. We find that, in 2021 dollars, Canadian GDP per capita will be lower by $4,300 by 2043 under Statistics Canada's slow-aging population projection relative to the no-aging scenario. However, under the fast-aging population projection, real GDP per capita will decrease by $11,200 by 2043, which is equivalent to a decline in GDP per capita of about 13% relative to the state of no-aging. The simulation analysis suggests that the reduction in real GDP per capita attributable to the aging of the population differs across the provinces because the extent of population aging varies. Accordingly, by 2043, relative to the no-aging scenario, the reduction in real GDP per capita will range from 10.7% in Saskatchewan to 16.8% in Newfoundland & Labrador under the fast-aging scenario.

An important policy implication of this study is that Canadian policy makers should be implementing multifaceted pro-growth public policies to offset the adverse economic and budgetary effects of population aging. Tax policies can be modified to boost private-sector investment and encourage seniors to remain active in the labour market. Policy makers can also expand the country's labour force by increasing the number of new working-age immigrants and expediting their integration into the labour market.

Appendix 1. Effect of Population Aging on Productivity and Economic Growth

A1.1 Specification

In this study, we are interested in analyzing how population aging affects the rate of economic growth. Thus, we specified a reduced model of the relationship between population aging and economic growth rate. Following the general empirical methodology commonly employed in the economic growth literature, our analysis of the impact of population aging on economic growth is based on the following simple spec-ification:[1]

$$\Delta lnY_{it} = \alpha_{1,i} ln(Y_{it-1}) + \alpha_2 ln(Seniors_{it}) + \alpha' X + \mu_i + \lambda_t + \varepsilon_{it} \quad (1.1)$$

where ln denotes logarithm, Y_{it} is the real GDP per capita in province i in year t, ΔlnY_{it} is the growth rate of per-capita GDP, and *Seniors* is the population share of individuals 65 years and above. In Eq. (1.1) above, μ_i is the province-specific constant term, λ_t denotes province invariant time effects, and ε_{it} is the error term. X includes a vector of other control variables, which are generally considered relevant determinants of the economic growth rate in the literature. A similar specification is used to estimate the impact of growth in labour productivity (where productivity is measured by the ratio of GDP to the number of hours worked).

Note that the dependent variable is the growth rate of real GDP per capita. In the above specification, only the key variables of interest are shown. However, the model incorporates various control variables that are generally deemed important in explaining economic growth. These other control variables are not shown for brevity. In Eq. (1.1), the effect of population aging on economic growth is given by a_2. As discussed in Feyrer (2008), Maestas (2022), and others, population aging can adversely affect economic growth through the labour market and productivity channels. Population aging can have labour-market effects since people are generally less likely to work after the age of 65. Thus, population aging reduces the labour-force participation rate and growth in employment (Hill, Whalen, and Palacios, 2022). If population aging affects the economic growth rate negatively, then we expect a_2 to be negative. The coefficient of seniors can be interpreted as the percentage change in the annual growth rate associated with a one-percent change in the share of seniors in the population.

1. For the theoretical foundation of the empirical model, see for instance Ferede and Dahlby, 2012 and the earlier main references contained therein.

A1.2 Data

For the empirical analysis, our primary data source is the Statistics Canada database (CANSIM). We measure the economic growth rate using the log difference of per-capita GDP measured in 2012 chained dollars. As is common in the literature, we use five-year period values of the growth rate to avoid the impact of the business cycle. More specifically, the dependent variable is the annualized average growth rate of real GDP per capita over the five-year period.[2] Following the approach of earlier empirical studies of growth, the explanatory variables are measured at the beginning of each period to lessen the potential endogeneity problem. The empirical model's key explanatory variable is the seniors' population share at the beginning of each period. We also use the log of initial real GDP per capita, the population share of the young (those below 15 years of age), economic openness, the ratio of private investment to GDP, and the population growth rate as control variables.[3] We show the basic summary statistics for the key variables in table A1.[4]

A1.3 Empirical results and discussion

A1.3.1 Growth regressions

We report the growth regression results in table A2 (p. 24). For the sake of brevity, our discussion of the results mainly focuses on the coefficient of the log of the population share of 65+, which is our key variable of interest. Note that we include provincial fixed effects and time effects in all the regressions. We also use heteroskedasticity and autocorrelation standard errors in parentheses.

A decline in economic activities and job prospects may induce working-age residents to move to other provinces in search of better job opportunities. Such a move, in general, is more difficult for seniors for various reasons. If this is the case, our key variable of interest may be endogenous. As is common in the literature, the log of the initial real GDP per capita is also endogenous in our specification, since the growth rate is calculated as the

2.The non-overlapping five-year periods are 1981–1985, 1986–1990, 1991–1995, 1996–2000, 2001–2005, 2006–2010, 2011–2015, and 2016–2020.

3. Note also that as shown in Mankiw, Romer, and Weil, 1992, we use the log of the sum of the population growth rate, the depreciation rate, and technological progress. We assume that the sum of the depreciation rate and technological progress is 0.05. Thus, the explanatory variable is the log of the population growth rate plus 0.05.

4. The basic summary statistics of the growth rate and population aging (our key variables) are shown for each province separately in table A4 in the appendix 2.

Table A1: Summary statistics, 1981-2020

Variable	Mean	Std. dev.	Min	Max
GDP Per capita growth rate	0.011	0.012	−0.012	0.050
The population share of people 65 years old and above (*seniors*)	0.130	0.026	0.072	0.195
The population share of people below 15 years old (*young*)	0.196	0.032	0.140	0.292
Population growth rate	0.008	0.009	−0.014	0.046
Openness (ration of trade to GDP)	1.099	0.183	0.816	1.771
Ratio of private investment to GDP	0.180	0.047	0.119	0.403
Initial GDP per capita (2012 dollars)	43,338	13,980	21,360	80,598

Source: Authors' computation using Statistics Canada Database (CANSIM)

first difference of the log of real GDP per capita. To address the potential endogeneity problem, we employ the two-stage least squares (2SLS) instrumental variable (IV) estimation method. Following the approach of earlier studies such as Maestas, Mullen, and Powell (2023), we treat the population share of seniors as an endogenous variable and use the variable's one- and two-period lagged values as instruments. As in previous similar studies, such as Ferede and Dahlby (2012), the log of initial real GDP per capita is instrumented with its own one-period lag value. We conduct various statistical tests to check the appropriateness of these instruments.

We begin in column (1) by estimating the impact of aging on the economic growth rate, controlling for the effects of initial income and the population share of those below 15 years of age. The results show a statistically significant negative relationship between population aging and the economic growth rate. According to the empirical estimate, a 10% increase in the share of the population who are 65 years and over, holding the population share of people below 15 constant, is associated with a reduction of the GDP growth rate by about 0.2 percentage points. The population share of the young and the initial real per-capita GDP also have the expected statistically significant adverse effects on the economic growth rate.

Canadian provinces are small open economies, and global events can easily have an impact upon their respective economic growth rates. To capture the potential effects of external factors, in column (2), we include the provincial terms of trade (that is, the ratio of export price index to import price index) as an additional explanatory variable. We also include

Table A2: Population aging and economic growth, 1981–2020

	(1)	(2)	(3)	(4)
Log (population share of 65+)	−0.024*	−0.022**	−0.026***	−0.023**
	(0.012)	(0.010)	(0.010)	(0.012)
Log (population share of below 15)	−0.094***	−0.087***	−0.088***	−0.041*
	(0.025)	(0.026)	(0.025)	(0.024)
Log (initial per-capita GDP)	−0.098***	−0.090***	−0.082***	−0.064**
	(0.022)	(0.025)	(0.025)	(0.030)
Log (ratio of private investment to GDP)		−0.004	−0.004	−0.007*
		(0.005)	(0.005)	(0.004)
Log (terms of trade)		−0.006	−0.007	−0.025**
		(0.010)	(0.010)	(0.010)
US growth × Log (Openness)			0.887*	0.506
			(0.490)	(0.537)
Log (provincial corporate tax rate)				−0.008*
				(0.005)
Log (ratio of government spending to GDP)				−0.031**
				(0.015)
PST × RSTdummy				−0.609**
				(0.277)
Provincial sales tax (PST)				0.073
				(0.125)
Constant	0.835***	0.759***	0.674***	0.493*
	(0.217)	(0.260)	(0.252)	(0.293)
Provincial effects	Yes	Yes	Yes	Yes
Time effects	Yes	Yes	Yes	Yes
Over identification test (p-value)	0.669	0.975	0.881	0.235
Observations	70	70	70	70
Adjusted R^2	0.755	0.754	0.764	0.776

Notes: Asterisks denote significance at the 1% (***), 5% (**), and 10% (*) levels. Heteroskedasticity and auto-correlation robust standard errors are in parenthesis. All estimations are performed using the two-stage least squares (2SLS) method. The dependent variable is the growth rate of real per-capita GDP. The population share of seniors is instrumented with its own one- and two-period lagged values. The initial real GDP per capita is also instrumented with its own one-period lagged value. The CIT is also instrumented with its own one-period value, the weighted average CIT of other provinces, and per-capita federal grants.

the ratio of private investment to GDP as a control variable. The result shows that these variables are statistically insignificant. However, our key variable of interest continues to have a statistically significant adverse effect on the economic growth rate.

Since the United States is Canada's neighbour and largest trading partner, economic events there affect the Canadian economy. Previous Canadian studies such as Ferede and Dahlby (2012) also find that the economic growth rate in the United States has positive effects on provincial economic growth rates. Thus, in column (3), we include the US economic growth rate interacted with provincial openness as an additional control variable. The regression result indicates that, as expected, the US economic growth rate has a statistically significant positive effect on the Canadian econowmic growth rate. Further, column (3) shows that the effect of population aging on the economic growth rate is still negative and statistically significant.

Empirical results of earlier similar studies such as Ferede and Dahlby (2012) and Dahlby and Ferede (2021) suggest that fiscal policy variables are important determinants of the economic growth rate. These studies in particular find that the corporate income-tax rate, government current spending, and provincial retail sales tax have adverse effects on private investment and economic growth. Thus, following Ferede and Dahlby (2012), in column (4) we include the provincial general corporate income-tax rate (CIT), the ratio of government current spending to GDP, and the provincial retail sales tax as additional control variables. Note that in addition to the provincial sales tax (PST), we include an interaction term between the provincial sales tax and a dummy variable (RSTdummy) to account for the effect of the different types of sales tax. RSTdummy is equal to one in the year in which the province uses a retail sales tax (which is not harmonized with the federal GST), and zero otherwise. [5] As column (4) includes all the relevant variables and is consistent with the empirical model of previous studies, it is our main empirical model. This specification also satisfies various statistical diagnostic tests. Note also that the over-identification restriction test is statistically insignificant, suggesting the validity of the instruments.[6] Thus, we will focus our discussion on the results of this column. We also use the coefficient estimate of our crucial variable of interest from this model in our simulation analysis.

Column (4) shows that the population share of seniors has a statistically significant adverse effect on the economic growth rate. The result indicates that a 10% increase in the share of

5. Currently, British Columbia, Saskatchewan, and Manitoba are using a provincial retail sales-tax system that is not harmonized with the federal GST.

6. The first-stage estimation results, which are available from the authors upon request, also confirm the appropriateness of our instruments.

the population who are 65 years and above is associated with a reduction of the economic growth rate by about 0.23 percentage points. This coefficient estimate is comparable and within the range of values obtained by other researchers using data from other countries.[7]

Regarding the other control variables in the model, all the explanatory variables except for the ratio of private investment to GDP and terms of trade have the expected signs. The unexpected negative sign of private investment may be because this variable is treated as exogenous. The population share of the young has a negative relationship with economic growth but it is not statistically significant at the conventional 5% level. This is a common empirical finding in earlier studies investigating the impact of the demographic structure on economic growth. Thus, both population aging and an increase in the population share of the young have adverse effects on growth. Further, the empirical results show that the population growth rate had a negative association with economic growth. Finally, the coefficient of the log of initial real GDP per capita is negative and statistically significant. This is consistent with the existing literature on economic growth and provides empirical support for the presence of conditional convergence. Note also, as in Ferede and Dahlby (2012), our result suggests that fiscal policy can affect the economic growth rate. More specifically, we find that the provincial corporate income-tax rate has a statistically significant negative relationship with economic growth. Similarly, our main result implies that an increase to the ratio of provincial government current spending to GDP has adverse effects on economic growth.

In sum, our empirical analysis shows that population aging adversely affects economic growth. The implication of these results is that real per-capita income would be lower than what it would have been in the absence of population aging. The main empirical model of column (4), which is used in our simulation analysis, is robust to various sensitivity checks.[8] Thus, in the main text, we use the coefficient estimate of our main empirical model of column (4) of table A2 to investigate how real GDP per capita across Canadian provinces will decrease as a result of the projected rise in population aging in the future.

A1.3.2 Labour productivity regressions

As discussed before, population aging can affect economic growth through its effects on labour productivity and labour-force participation rates. While the foregoing empirical analysis finds evidence of the negative relationship between population aging and

7. For instance, using data from the United States, Maestas, Mullen, and Powell (2023) find that a 17% increase in population aging reduces the growth rate by about 0.3 percentage point. Ye, Chen, and Peng (2021) use data from China and obtain that a 10% increase in the share of seniors causes a 2% decrease in the growth rate.

8. The results of the sensitivity analysis are available from the authors upon request (FeredeE@macewan.ca).

economic growth, it may also be interesting to explore the relationship between the growth rates of labour productivity and population aging at the provincial level. To this end, we attempt to shed some light on the effects of population aging on labour productivity by investigating the relationship empirically, using a specification similar to the economic growth model. We measure labour productivity by dividing real GDP by the total number of hours worked. We then estimate the growth rate of labour productivity on its initial value and various explanatory variables that were also included and discussed in our economic growth model. The results are reported in table A3 (p. 28).

As both the empirical model and the included explanatory variables are like those of the economic-growth regression results discussed above, we only provide a brief discussion of the main results here. In particular, we focus on the regression results reported in column (4) as this model includes all the relevant explanatory variables and is our main model for the labour productivity analysis. Consistent with the findings of earlier studies such as Feyrer (2007, 2008), Aiyar, Ebeke, and Shao (2016), Liu and Westelius (2016), Maestas, Mullen, and Powell (2022), our analysis shows that there is a negative association between population aging and labour productivity. The results also show that the corporate income-tax rate has a negative effect on labour productivity. An important policy implication of this is that provincial governments can raise labour productivity through reductions in the corporate income tax.

Table A3: Population aging and labour productivity (2SLS), 1981–2020

	(1)	(2)	(3)	(4)
Log (population share of 65+)	−0.021**	−0.017**	−0.020**	−0.021**
	(0.010)	(0.008)	(0.008)	(0.009)
Log (population share of below 15)	−0.081***	−0.076***	−0.076***	−0.133***
	(0.014)	(0.011)	(0.011)	(0.040)
Log (initial labour productivity)	−0.028*	−0.032**	−0.038**	−0.045***
	(0.016)	(0.016)	(0.016)	(0.014)
Log (private investment to GDP ratio)		0.009**	0.010**	0.001
		(0.004)	(0.004)	(0.005)
Log (terms of trade)		−0.019**	−0.019**	−0.030**
		(0.007)	(0.008)	(0.014)
US Growth x Log (Openness)			0.460	0.109
			(0.378)	(0.316)
Log (provincial corporate tax rate)				−0.005*
				(0.003)
Log (government spending to GDP ratio)				−0.036
				(0.025)
Constant	0.255***	0.252***	0.236***	0.372***
	(0.059)	(0.051)	(0.051)	(0.123)
Provincial effects	Yes	Yes	Yes	Yes
Time effects	Yes	Yes	Yes	Yes
Over identification test (p-value)	0.647	0.579	0.622	0.925
Observations	80	80	80	70
Adjusted R^2	0.447	0.493	0.492	0.621

Notes: Asterisks denote significance at the 1% (***), 5% (**), and 10% (*) levels. Heteroskedasticity and autocorrelation robust standard errors in parenthesis. All estimations are performed using the two-stage least squares (2SLS) method. The dependent variable is the growth rate of labour productivity. In all regressions, the population share of seniors is instrumented with its own one- and two-period lagged values. In column (4), the initial labour productivity is also treated as endogenous and instrumented with its own one-period lagged value.

Appendix 2. Additional Summary Statistics

Table A4: Period average values of key variables, by province, 1981–2020

	Economic growth rate	Real GDP per capita ($)	Seniors
Newfoundland & Labrador	0.0187	44886	0.1216
Prince Edward Island	0.0137	31215	0.1420
Nova Scotia	0.0123	33303	0.1399
New Brunswick	0.0113	34655	0.1363
Quebec	0.0098	37442	0.1278
Ontario	0.0096	44680	0.1256
Manitoba	0.0101	39049	0.1341
Saskatchewan	0.0099	58285	0.1400
Alberta	0.0077	67624	0.0964
British Columbia	0.0072	42242	0.1353

Source: Statistics Canada, 2023a, 2023b.

Table A5: Baseline (no-aging) parameters

	Economic growth rate	Population shares of seniors (2022)	Initial real GDP per capita (in 2021 dollars)
Canada	0.0126	0.188	67275
Newfoundland & Labrador	0.0248	0.236	76516
Prince Edward Island	0.0180	0.203	54420
Nova Scotia	0.0156	0.218	54004
New Brunswick	0.0161	0.227	55718
Quebec	0.0127	0.208	60103
Ontario	0.0124	0.184	66128
Manitoba	0.0133	0.166	59236
Saskatchewan	0.0150	0.170	77151
Alberta	0.0109	0.148	86129
British Columbia	0.0102	0.199	68619

Source: Statistics Canada, 2023a, 2023b.

Table A6: Projection of population aging (for selected years)

	Actual	Projection Slow-aging scenario				Projection Fast-aging scenario			
	2022	2028	2033	2038	2043	2028	2033	2038	2043
Canada	0.188	0.207	0.215	0.215	0.211	0.220	0.238	0.248	0.255
Newfoundland & Labrador	0.236	0.275	0.297	0.307	0.304	0.288	0.322	0.345	0.354
Prince Edward Island	0.203	0.214	0.219	0.218	0.214	0.230	0.247	0.259	0.266
Nova Scotia	0.218	0.242	0.252	0.252	0.245	0.255	0.276	0.288	0.293
New Brunswick	0.227	0.255	0.266	0.266	0.260	0.266	0.287	0.299	0.305
Quebec	0.208	0.233	0.242	0.240	0.237	0.244	0.264	0.273	0.280
Ontario	0.184	0.202	0.211	0.212	0.208	0.214	0.234	0.246	0.253
Manitoba	0.166	0.180	0.182	0.178	0.173	0.194	0.208	0.216	0.223
Saskatchewan	0.170	0.184	0.182	0.175	0.170	0.197	0.207	0.213	0.218
Alberta	0.148	0.167	0.172	0.173	0.172	0.176	0.190	0.200	0.208
British Columbia	0.199	0.215	0.224	0.227	0.223	0.229	0.248	0.261	0.267

Source: Statistics Canada, 2022c.

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