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Slowing Down With Age:

The Ominous Implications of Workforce Aging for Canadian Living Standards

Yvan Guillemette

In this issue...

Population aging has the potential to dramatically lower Canadian living standards. While increases in work effort can alleviate the downward pressure, a strong negative association between an elderly workforce and labour productivity is likely to limit improvements from this source. A policy environment that encourages saving and capital accumulation may be Canada's best hope for escaping the limits on wellbeing that demographic change will otherwise impose.

The Study in Brief

Population aging represents a serious obstacle to maintaining a healthy growth rate in Canadian living standards. The projected decrease in the ratio of working population to total population signifies that Canada will require strong labour productivity growth over the coming decades in order to maintain past rates of growth in output per capita.

At the same time, demographic change may have a negative influence on the productive capacity of the Canadian economy. This is clear from the projected negative effects of population and workforce aging on productivity, labour and capital growth, the three broad historical sources of economic expansion.

After reviewing their relative importance as historical sources of output growth, this paper attempts to preview the direct effect of workforce and population aging on multifactor productivity, hours worked and capital accumulation over the next four decades.

Regression results show that an older workforce will likely be less productive and also contribute less working hours to the economy, increasing the importance of capital accumulation in the future. Public policies that encourage saving and capital accumulation thus appear increasingly important, all the more so because saving is also likely to be negatively affected by population aging.

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The accelerating pace of demographic change will be one of the leading influences on Canadian living standards in this and future decades. Although this is by no means a new insight, to date research has focused mainly on the influence of the old-age dependency ratio, or the ratio of the working population to total population. However, the internal age structure of the population and, more specifically, of the workforce, which are bound to change significantly in the next few decades, may also have important effects on living standards through less-studied channels such as the effects of workforce-age composition on aggregate productivity and on labour- and capital-input growth. In this *Commentary*, I review the relative importance of multifactor productivity MFP growth, labour-input growth and capital accumulation as historical sources of Canadian output growth and I attempt to preview their likely future behaviour in the face of demographic change. In particular, I obtain regression results describing the historical impact of workforce age-composition on MFP in Canada and use them to project future MFP levels. My analysis shows that output will have to grow at a faster rate if we are to maintain past rates of growth in our living standards, but that population and workforce aging will have negative direct effects on the three sources of output growth.

Population Aging and Living Standards

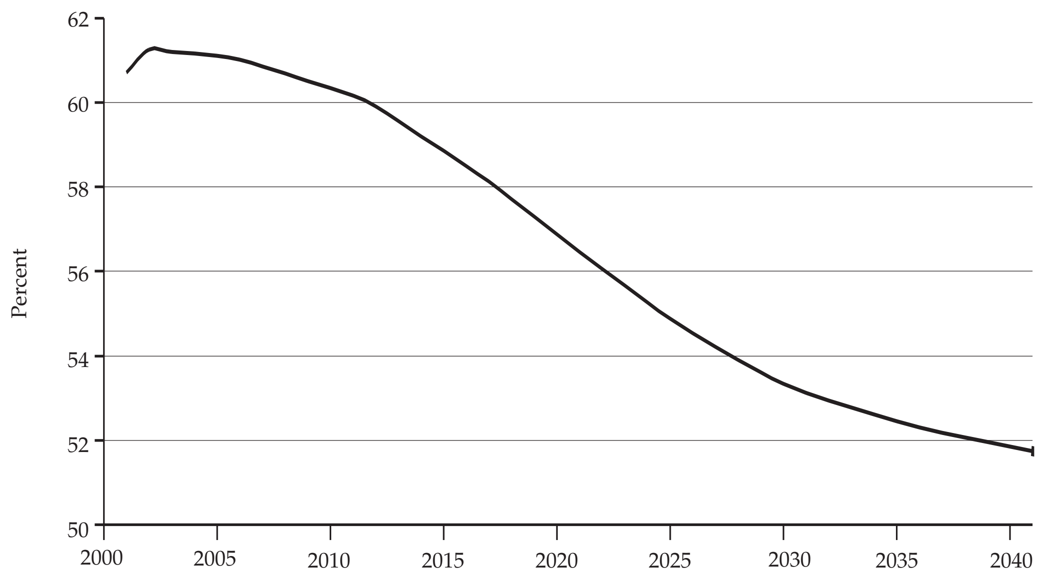
As noted, an often-used indicator of the influence of demographics on living standards is the support ratio, commonly defined as the size of the workforce measured as a share of the working-age population (15 and over). In Canada, under assumptions to be described below, it is projected to fall from 61.3 percent in 2002 to 51.7 percent in 2041, as shown in Figure 1. As a result, in the year 2041, the working population will have to be almost 20 percent more productive than in the year 2002 if it is to produce the same per-adult quantity of consumer and capital goods. This alone would require an annual labour productivity growth rate of around 0.45 percentage points from 2002 to 2041. In other words, as much as a third of historical, average, long-term business-sector labour productivity growth of 1.4 percent (see Table 1) will be eaten up by the relative decrease in the size of the labour force.

Of this 1.4 percent average labour productivity-growth rate over the 1981-to-2000 period, 0.6 percent came from capital deepening, 0.5 percent from an increase in the quality of the workforce[1] and 0.2 percent from growth in MFP (Table 1). The first conclusion to draw from this exercise is that we will almost certainly require very strong labour productivity growth if we are to sustain the pace of output growth to which we are accustomed. More precisely, annual labour productivity

I would like to thank Rick Harris, Jack Mintz, Alice Nakamura, Finn Poschmann, Bill Robson, Bill Scarth, Courtney Ward and an anonymous referee for helpful comments and discussions on earlier drafts of the paper.

1 Changes in the quality of labour are measured here by weighting productivity growth rates for the different classes of workers by their share of total labour compensation. For details on the methodology, see Armstrong et al. (2002), section 1.3 and footnote 11 of this *Commentary*.

Figure 1: Projected Support Ratio for Canada



Source: Statistics Canada, author's calculations.

gains have to increase by a third to maintain the historical rate of growth in our standard of living, as measured by real output per adult.

Historical Sources of Canadian Real Output Growth

Real output growth arises from three sources: MFP growth, increased labour services and increased capital services.[2] Labour and capital services increase when the economy has more workers or more capital at its disposal, or when the quality of these components increases because, for example, of a better-educated workforce. Following growth accounting methodology, multifactor productivity growth is calculated as a residual, that is, growth in real output not accounted for by increases in labour and capital services. In other words, it captures the growth in real output that is not due to measured increases in the factors of production. The level of MFP is defined as the overall rate of transformation of all components used in the production of goods and services. As such, it is a disembodied concept that reflects the joint effects of many factors including research and development (new-idea generation), adoption of new technologies (new-idea adoption), economies of scale, managerial skill and changes in the organization of production.

During the period 1981-to-2000, real output grew at an average of three percent per year, of which aggregate capital services contributed 1.3 percent, labour input 1.5 percent and MFP 0.2 percent (Table 2). The 1.5 percent labour input contribution

2 Capital (human or physical) service indexes are the appropriate input measures to use in growth decompositions because they measure flows of services for a given period of time and thus are directly comparable to GDP.

Table 1: Annual Average Percentage Point Contribution to Labour Productivity: Canadian Business Sector

	1981–2000	1981–1988	1988–1995	1995–2000
Capital Deepening	0.6	0.6	0.9	0.4
Labour Quality	0.5	0.5	0.6	0.3
Multifactor Productivity (MFP)	0.2	0.2	–0.3	1.0
Labour Productivity	*1.4*	*1.3*	*1.2*	*1.7*

Source: Armstong et al. (2002), Table 1.5.

Table 2: Sources of Economic Growth: Canadian Business Sector

	1981–2000	1981–1988	1988–1995	1995–2000
	(average annual percentage point contribution)			
Contribution of Labour Input	1.5	1.7	0.8	2.2
Contribution of Labour Hours	1.0	1.2	0.1	1.9
Contribution of Labour Quality	0.5	0.5	0.6	0.3
Contribution of Capital Services	1.3	1.4	1.0	1.7
Multifactor Productivity (MPF)	0.2	0.2	–0.3	1.0
Output Growth	*3.0*	*3.3*	*1.5*	*4.9*

Source: Armstrong et al. (2002), Table 1.6.

may be decomposed further into a one percent contribution from increased hours worked and a 0.5 percent contribution from a higher-quality workforce. It seems that MFP has historically not been a very important source of real output growth; growth of the labour component has accounted for the biggest share over that period.

However, the importance of MFP growth has increased in recent years. As Table 2 shows, during the post-1995 period, MFP contributed 21 percent of the growth in real output in Canada, compared with 6.7 percent in the 1981-to-2000 period.

The same story can be told in terms of labour productivity, as shown in Table 1: of the 1.4 percent average annual business-sector labour productivity growth over the 1981-to-2000 period, 0.2 percent is attributed to MFP growth; but over the 1995-to-2000 period, a full 1 percent of the 1.7 percent is attributed to MFP growth. Again, although MFP has historically not been a major contributor to economic growth, it has recently gained in importance.

Population, Labour Force and Employment Projections

In order to look at how demographics may influence living standards in the future, we need a set of population projections.[3] This section briefly outlines the

3 For a discussion of past trends in demographics and their influence on the labour force, see Denton and Spencer (1998).

demographic assumptions I used to derive these projections. The base year for the projections is 2001.

The projections are based on an adapted version of the population projection model developed by the International Labour Organization. I develop a separate set of projections for each province, based on the disaggregated data available, and combine them to form the projections for Canada.[4] I assume that:

- Fertility rates stay constant at 2001 levels;
- Mortality rates decrease slowly in line with past experience;
- Inter-provincial migration levels decrease from 1992-to-2001 average levels to zero over a 10-year period and international migration stays constant at the 1992-to-2001 average level throughout the projection period.[5] These migration assumptions yield a net migration rate that decreases slowly from 0.57 percent of the population to 0.5 percent over a period of 20 years.

To obtain labour force projections and workforce (employment) projections, we need assumptions about participation rates and unemployment rates. I assume that:

- Participation rates stay constant at 2002 levels;
- Unemployment rates decrease slowly to a national level of between 5 and 6 percent over the next 10 years and remain there.

I project population, labour force and employment for the period 2002-to-2041. The population projections are very standard and do not depart significantly from Statistics Canada's medium projections. Total population in Canada increases from 31.3 million in 2002 to 38.9 million in 2041, the labour force rises from 16.9 to 18.5 million over the same period and employment from 15.6 to 17.4 million.

The Direct Economic Effects of Aging

Multifactor Productivity and the Changing Age Structure of the Workforce

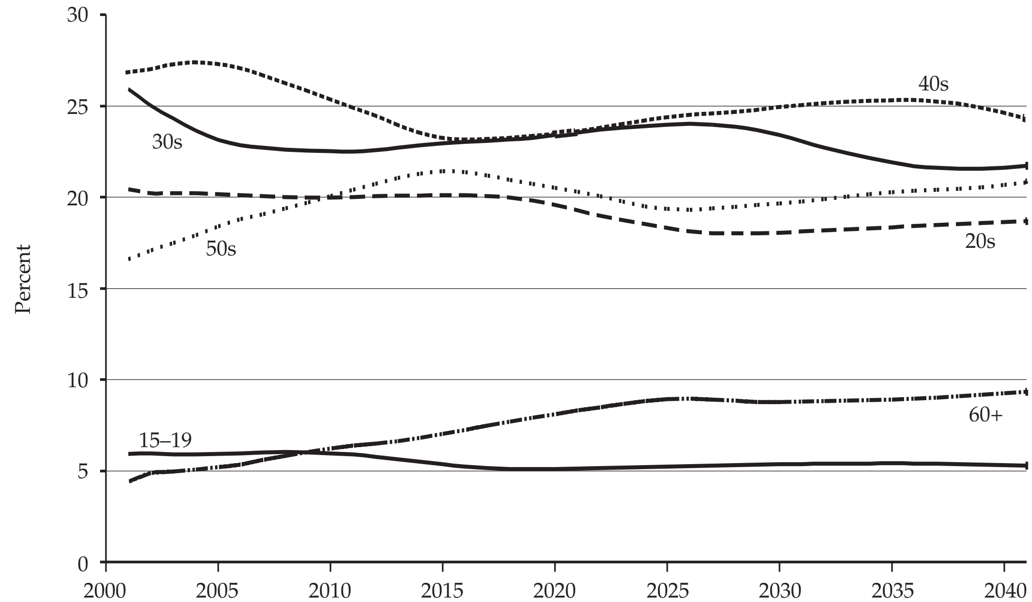
If a worker's productivity is age dependent, a shift in the age structure of the workforce will also bring about a change in aggregate productivity, even if age-specific productivity remains constant. According to micro evidence, worker productivity in the United States rises with age into the fifties then falls somewhat for workers in their sixties. Statistical evidence on compensation relative to age implies that there is about a 50 percent difference between the productivity of 20-

4 For immigration, mortality, participation and unemployment rates, province-, sex- and age-specific assumptions are used and combined with the corresponding age bins of the population projections. Fertility rates are also province- and age-specific.

5 Inter-provincial migration is relevant to national projections to the limited extent that fertility and mortality rates vary slightly between provinces. I make it go to zero over a 10-year period because of the inherent difficulty in predicting future levels and directions in the flows of inter-provincial migrants.

6 This type of evidence is sometimes called the Mincer evidence (named after economist Jacob...

Figure 2: Projections of the Proportion of Employed Workers in Different Age Categories for Canada



Source: Statistics Canada and author's calculations.

and 50-year old workers.[6] For the aggregate data, this evidence implies that an economy with a large cohort of young workers will be less productive than an economy with a large cohort of older workers.[7] Figure 2 shows the projected proportions of employed workers in different age groups in Canada for the next 40 years. The most remarkable development shown on this chart is the significant increase in the proportion of workers aged 60 and over, from less than 5 percent in 2001, to approximately 9 percent in 25 years or so.

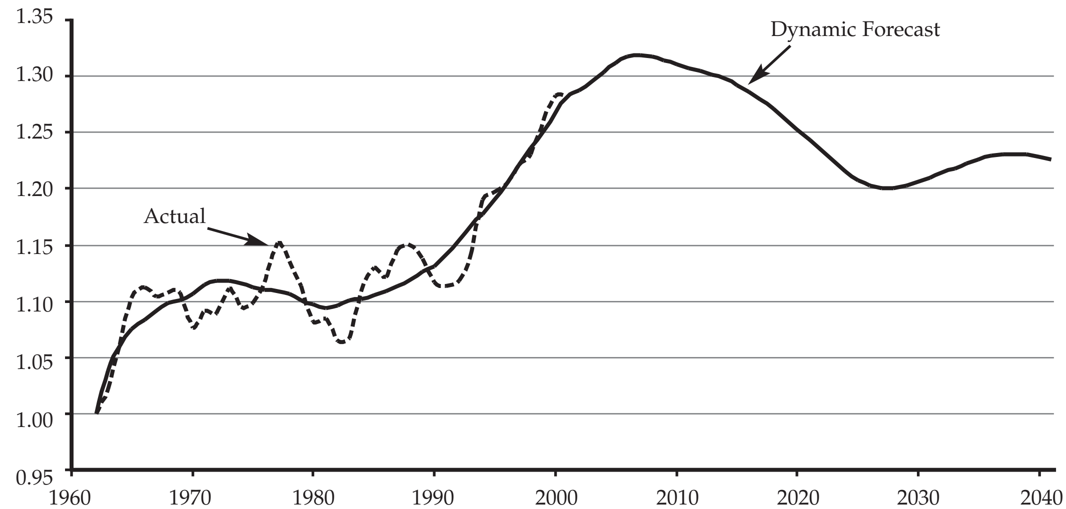
Because Canada is about to undergo important shifts in the composition of its workforce, it is interesting to ask how these changes will affect aggregate productivity levels in the economy. Feyrer (2002) derives econometric estimates of the effects of workforce demographics on productivity. He regresses productivity residuals on the proportion of workers in different age groups using a panel of 85 countries between 1960 and 1990. His results are statistically highly significant and suggest that countries with a large proportion of workers in their teens, twenties and thirties are significantly less productive than countries with large cohorts in their forties. He also finds workers in their sixties to be the least productive of all. In particular, and as described in his working paper, the demographic importance of the baby-boom generation offers a convincing explanation of the historical

Note 6 - continuted

....Mincer). It refers to regressions of wage levels on schooling and experience variables for a cross-section of workers. Such regressions typically show that workers with more schooling and more experience receive higher wages. Under the assumption that workers earn their marginal product, they also inform us about productivity differences between workers. See Feyrer (2002).

7 Assuming, of course, that productivity is measured in a way that does not account for differences in human capital through experience.

Figure 3: Multifactor Productivity Index and Forecast



Source: Diewert (1999) and author's calculations.

productivity experiences of the U.S. and Japan. Certainly, part of the U.S. productivity slowdown of the 1970s is explained by the arrival in the workforce of the baby-boom generation, and part of the productivity revival of the 1990s is explained by the higher productivity of baby-boomers then in their forties. Because of the similarity in Canadian and U.S. demographics, the same analysis also applies to Canada. Out-of-sample predictions on his panel of countries also perform well, lending credit to this type of analysis and forecast.

As explained in the Appendix, I follow a methodology similar to Feyrer's and obtain a regression equation that helps to preview the likely future behaviour of MFP in Canada as it responds to demographic change.[8] The details of this exercise and statistical results appear in the Appendix.

My results conform to the micro evidence described earlier. Those findings show that Canadian workers in their fifties are slightly more productive than workers in their forties, while those in their sixties are, as in Feyrer's study, the least productive. Workers in their teens, twenties and thirties are somewhere in-between. More precisely, my estimates imply that a 5 percent shift in the proportion of workers in the 30-to-40 age group results in a 7.1 percent increase in multifactor productivity; a five percent shift from the forties age group to the fifties age group translates into a 2.1 percent increase in productivity; more significantly, a 5 percent shift from the fifties age group to the sixties age group results in a 17.1 percent drop in the aggregate productivity level. As explained in the Appendix, however, the exact magnitude of these differences must be interpreted with care.

8 Feyrer uses a Solow-type productivity decomposition, where output growth is decomposed into its capital and labour component growth, and the rest attributed by definition to a total factor productivity residual, to obtain his productivity measures. His results are therefore not very appropriate for forecasting MFP as measured by Statistics Canada, which uses a very different methodology.

9 In a dynamic forecast, the previously predicted value of the lagged dependent variable, rather than the one actually realized, is entered on the right-hand side of the forecasting equation.

Figure 3 shows the actual MFP index until 2001 along with an in- and out-of-sample dynamic forecast of the same index based on the estimated equation (presented in Table A-1).[9] For the period 2002-to-2041, I obtain the forecast by extrapolating forward the age-productivity patterns given by the regression equation using the workforce projections described earlier. For the in-sample period 1962-to-2001, the dynamic forecast tracks long-term trends associated with demographic shifts, such as the productivity slowdown of the 1970s and beginning of the 1980s and the revival of the late 1980s and 1990s. Consequently, the forecast shown after 2001 should be interpreted cautiously, because it does not use any factors other than demographic ones to project the future behaviour of MFP. While many other factors influence the short and long-term productivity level, the exercise does give an indication of the likely effect of workforce aging on long-term productivity trends. To the extent that past experience is a good predictor of the future, the true MFP level should hover around, but never stray too far away from, the forecast shown in Figure 3 (in the past it has never deviated by more than 4 percent of the forecast value). Deviations around the trend are of course highly cyclical and depend on factors other than demographics.

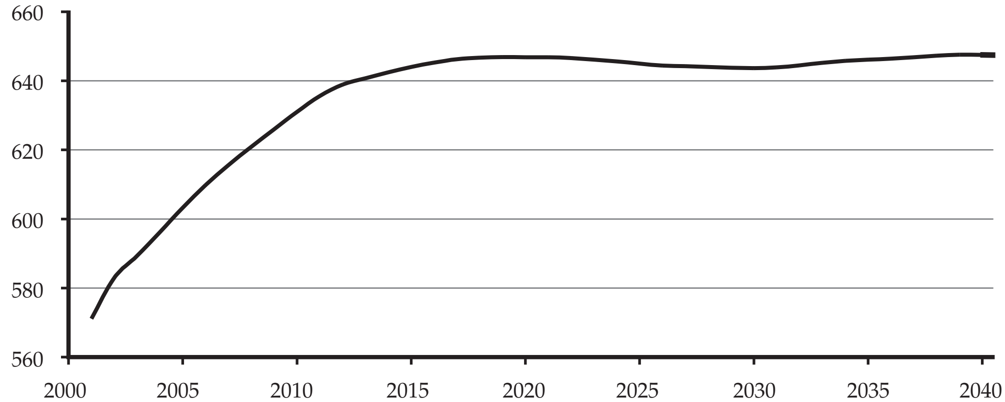
This forecast reveals that the labour productivity growth required to maintain historical rates of growth in our living standards is unlikely to come from growth in MFP. Business sector MFP is projected to increase until the year 2007, while baby-boomers are still in their prime productive years, then decline. Much of the projected decrease in the level of MFP after 2007 comes from the increasing share of older workers in the workforce. However, it is important to understand that the age-productivity differences identified and described above are not due to differences in work contributions between age groups, as the growth decomposition that yields the MFP series already tries to account — however imperfectly — for the variation in total labour input due to demographic change. So it is no quick cure to suggest that all we need to do is to convince older workers to increase the number of hours they work, or stay in the workforce longer. If they did, output would be higher, but the gain would result from labour input increases, which I will discuss in the next section, not MFP increases. Aggregate MFP would be lower, because a higher share of low-productivity workers would now be part of the workforce. Of the three main decomposed sources of real output growth shown in Table 2, MFP can now be said to be an unlikely source of future output growth. It seems that we will instead have to rely on factor accumulation, either capital or labour, in order to keep generating increases in our living standards. I now turn to their discussion.

Projecting the Future Contribution of Labour

As explained earlier, increased labour services can either come from increases in the number of hours worked or from a general increase in the quality of the workforce.

Could the changing age structure of the workforce mean something for the growth in hours worked? The employment projections described earlier can be

Figure 4: Projected Labour Input — Millions of Hours Worked Weekly in Canada



Source: Statistics Canada and author's calculations.

used to help answer this question. Since hours worked per week by an employee vary throughout an individual's working life, I use age-specific hours data along with the employment projections to estimate the total number of hours worked weekly in the economy over the coming decades.[10] Figure 4 shows the projection until 2041, assuming that age-specific averages stay constant at 2002 levels. The projected average annual increase in total hours worked is only 0.8 percent over the 2001-to-2017 period and virtually zero afterwards, yielding an average growth rate of only 0.3 percent over the next four decades. If labour's contribution is to remain the most helpful source of real output growth, as it was during the past two decades, labour quality will have to increase significantly.

Growth in labour quality occurs, as statistically measured in Tables 1 and 2, when more workers become part of a group with a relatively high compensation rate.[11] This helps to explain why labour- quality growth was higher in the 1988-to-1995 period at 0.6 percent, when baby-boomers were entering their forties with relatively high experience-based compensation, than in the 1995-to-2000 period, when growth was 0.3 percent. Also, according to Table 2, growth in labour quality seems to have been fairly stable over time, at 0.5 percent a year, varying only from 0.3 percent in the 1995-to-2000 period to 0.6 percent in 1988-to-1995. When total hours worked stops growing in about 15 years, 0.5 percent is likely to be the observed overall growth rate in labour inputs, lower than it has ever been over the last 20 years. Until then, adding the 0.8 percent projected average annual increase in hours worked over that period to the stable 0.5 percent increase in labour quality yields a projected overall contribution of labour input of 1.3 percent, a sharp decrease from the 2.2 percent observed over the 1995-to-2000 period and lower than the 1981-to-2000 long-term average of 1.5 percent. As in the case of MFP

10 Here, sex and age-specific (15-to-24, 25-to-54, 55-to-64 and 65+) Canadian averages are used for the projections.

11 Of course, this is a very narrow view of labour quality. According to this methodology, the only good quality workers are highly paid ones, as opposed to the common-sense view which is that good quality workers are simply workers who do their jobs well. I acknowledge the statistical discrimination, but frame the discussion in terms of the actual methodology used by Statistics Canada.

then, we can hardly expect labour to be a very strong output growth contributor in the future, especially after the middle of the next decade.

Projecting the Future Contribution of Capital Input

Capital accumulation refers to investments by businesses in structures, equipment, inventory and land, which are financed, in turn, by domestic savings (private and public) and international borrowing. Over time, net saving in the government and foreign sectors has tended to average fairly close to zero. Saving by individuals as householders (and proprietors of unincorporated businesses) has tended to finance the bulk of capital investment not financed by the internal cash flows of businesses, and has therefore played a central role in building Canada's capital stock over time.

The well-known life-cycle model of consumption and savings informs us about the possible effect of population aging on personal savings. According to the theory, supported empirically in a variety of studies, saving is minimal or even negative during the early working years of an individual, when income is low. Maximum saving occurs when workers are between fifty and sixty, when income is highest. Finally, during retirement there is dissaving, as the consumer draws down accumulated wealth to meet living expenses. Fougère and Mérette (1999) calculate personal saving rates by age group in Canada, excluding private pension income,[12] and find that the saving rate declines rapidly after age 54, turns negative around age 60-to-64 and remains negative or close to zero for older households. This pattern of saving is consistent with the predictions of the life-cycle model. An important implication of this hump-shaped pattern of saving is that the national saving rate depends on the age distribution of a country's population. A worrisome prediction of the life-cycle model is that population aging in Canada may put significant downward pressure on private saving. Since the level of private savings is, for reasons just explained, highly correlated with business investments, this would tend to seriously hinder capital accumulation.

To quantify this prediction, Fougère and Mérette (1999) estimate an aggregate personal saving rate equation for Canada, which captures the historical effects of the changing age structure of the population. Their results, which account for numerous other factors affecting the saving rate, support the life-cycle hypothesis, at least historically. They then use their econometric estimates to simulate the impact of population aging on the aggregate personal saving rate in Canada until 2050, using OECD demographic projections. Their projections call for a slight increase in the personal saving rate from its 1997 level until about 2010, as the effect of the reduction in the share of young dissavers dominates the effect of the increase in the proportion of old dependants. However, they find that as soon as the increasing share of old dependants begins to dominate after 2010, population

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12 Private pension income is excluded to take account of the fact that household surveys usually count all pension payments as income even though a large proportion is really distribution of capital which depletes the remaining fund, implying no change in wealth. This insight comes from Miles (1999).

aging will contribute to a significant reduction in the personal saving rate. Simulation results from their econometric model suggest that by 2050, the direct effect of population aging may contribute to cutting the personal saving rate in half from a level of 4.9 percent in 1997. Under the likely assumptions that population aging will prevent governments from running huge fiscal surpluses, the projections of Fougère and Mérette (1999) are less than optimistic with regard to future capital accumulation, unless it is financed by foreigners.

This analysis yields a general policy implication: because capital accumulation is the growth contributor that public policies can most easily influence, Canada should strive to make itself attractive to foreign investors by reducing the burden of taxation on business and entrepreneurial capital (Chen and Mintz, 2003). Running fiscal surpluses, or at least balanced budgets, should also be a critical objective for governments, as private savings need to be freed up for productive investments, rather than to finance government deficits.

General Equilibrium Effects

The partial equilibrium methods used in the previous sections ignore many other economic variables that will be affected by population aging. The methods were used to isolate partial effects and to draw attention to their potential magnitudes. There will obviously be some feedback effects accompanying the shortage of labour and the general aging of the population. These effects may partially insulate living standards from the adverse direct effects identified so far. Equilibrium effects might include:

- To the extent that labour becomes a relatively scarce resource in the future, wages should rise and physical capital should increasingly substitute for labour, that is, capital intensity should rise and with it labour productivity (Scarth, 2002). But this effect should be qualified. Higher labour productivity and capital intensity do not necessarily lead to higher output, as both can rise just from a reduction in the size of the labour force if the stock of capital stays constant or diminishes by a smaller proportion than the workforce. After all, the relative scarcity of labour is just the flipside of relatively abundant capital, which would tend to depress rates of return on capital and depress savings necessary to finance capital formation (Ríos-Rull, 2001). Moreover, if an older population saves less, higher capital intensity will be achievable only by importing savings from abroad, which implies that a large part of the resulting higher incomes will flow to foreigners, not Canadians;
- As labour becomes a relatively scarce resource, rates of return on investments in human capital should increase. Even if capital intensity does not rise, higher investments in education and training should make labour more productive (Scarth, 2002). Again, this effect can be qualified by remarking that more time spent learning might improve productivity and labour quality, but it reduces the size of the workforce, because more working-age people are in school;
- People who live longer have an increased incentive to save. Individuals acquire more capital and achieve lower foreign indebtedness as a result. Other things being equal, these developments raise living standards (Scarth, 2002);

- With increased life expectancy and a growing acceptance of flexible working arrangements, baby boomers may choose to remain in the workforce to a more advanced age than their predecessors (Scarth, 2002). While the possibility should not be ruled out, it is unlikely to be automatic, however. Increasing longevity in the past has been reflected in more time in retirement, rather than more time in work (Profeta, 2002);
- Canadian immigration rates may rise, but Denton and Spencer (1998) estimate that very large and unlikely increases in immigration would be required to bring about modest shifts in the proportion of older people. Moreover, Canada will be only one of a number of industrialized countries looking for immigrants to dampen the aging effects — the market for skilled immigrants is likely to become even more competitive.

To sum up, the analysis of previous sections has lead us to suspect that capital input, labour input and productivity all risk being negatively affected by population aging. While there are feedback effects that could mitigate this bleak assessment, evidence on their impact is too weak to give much comfort.

Conclusion

The stabilizing participation rates and limited scope for unemployment rates to fall, combined with the marked decrease in the support ratio, imply that labour productivity in Canada will have to grow at a robust rate if we are to maintain past rates of growth in per capita output. Examining the future demographic impact on the three main sources of real-output growth shows that direct effects are likely to be negative. An aging workforce is projected to slow the growth in both productivity and labour supplied. An aging population saves less and thus other things equal, fewer resources will be available to finance capital accumulation. Various indirect equilibrium adjustments should act to somewhat shelter living standards from these negative direct effects, although exact magnitudes are hard to quantify. Governments can do little to change demographic trends and therefore cannot have much influence on labour input growth and disembodied productivity. Policies to promote capital accumulation, both by encouraging domestic saving and by providing an attractive environment for investment by savers abroad, look like Canada's most promising route to raise output beyond the limits that aging otherwise threatens to impose.

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Appendix: An Econometric Analysis of the Effect of Workforce Age-Composition on Multifactor Productivity in Canada

This appendix presents the equation I used to generate the multifactor productivity (MFP) level forecast shown in Figure 3.

The MFP level series used as a dependent variable was constructed by taking Diewert's (1999) *G4* business sector MFP index series. Diewert derives this index using a methodology similar to the one used by Statistics Canada's productivity program. The index covers the period 1962-to-1996 and thus allows me to extend the sample period to before 1981, the earliest year for which Statistics Canada publishes its current MFP index. However, to get as long a time span as possible, I prolong Diewert's series from 1996-to-2001 by making it grow at the business sector MFP growth rate published by Statistics Canada.

I assembled workforce composition data dating back to 1962 using a variety of Statistics Canada sources. I then regressed Diewert's updated MFP index on a constant (C), a lagged dependent variable (MFP(–1)) and five workforce composition variables measuring the proportion of the Canadian workforce in different age categories, as shown in Figure 2. The variable W10 gives the proportion of the workforce between the ages of 15 and 19. W20 gives the proportion of the workforce between 20 and 29 and so on for W30 and W50. W60 gives the proportion of the workforce over 60 years of age. The age-composition of the workforce is implicitly assumed to have a level effect. Changes in the age structure of the workforce are assumed to have a growth effect.

The results of this exercise are shown below:

Table A-1: Regression Results Used for the MFP Level Forecast Presented in Figure 3

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.775615	0.536904	1.444607	0.1583
MFP(-1)	0.648260	0.122876	5.275716	0.0000
W10	–0.828371	0.860788	–0.962341	0.3431
W20	–0.350267	0.323785	–1.081787	0.2874
W30	–0.641751	0.852499	–0.752788	0.4571
W50	0.198926	1.053810	0.188769	0.8515
W60	–1.490525	0.993654	–1.500044	0.1434

Test Statistic	Value	Prob.
Obs	39	—
R-2 adj.	0.9102	—
Chi-2 age	15.540	0.008
RESET	0.1244	0.940
White	12.531	0.404
B-G LM	3.7347	0.155
Q-stat 1	2.0549	0.152
2	2.4593	0.292
3	3.9961	0.262
4	5.3548	0.253
Jarque-Bera	0.8978	0.638

Notes: R-2 adj. is the R-squared adjusted for the number of variable in the regression. Chi-2 age is a joint Wald test of the insignificance of the age coefficients. RESET and White are the Ramsey misspecification and White heteroskedasticity test, respectively. B-G LM is the Breusch-Godfrey test for second-order serial correlation. Q-stat *n* is the Box-Ljung *q*-statistic for serial correlation up to the *n*th order. Jarque-Bera is a test for the normality of the residuals.

The magnitude and signs of the age coefficients, which represent the relative productivity of different age categories, are generally consistent with the hump-shaped age-productivity profiles usually obtained using other methods, such as company-level studies or earnings data.[13] But imprecise estimation persists, as indicated by the high *p*-values associated with individual age coefficients. This imprecision is due in part to the small sample size used, but is mostly the result of the high collinearity between the demographic regressors. This is a general problem when using measures of the age distribution, a problem that has been dealt with in different ways in the literature.[14] Here, of course, perfect multicollinearity was avoided by excluding the 40s age group from the regressors, but a high level of collinearity still persists in the remaining age-group regressors. Although they appear to have the right signs and to show a familiar age-earnings profile, the exact magnitude of their coefficients should be interpreted with caution.

However, what really matters here is not so much the statistical significance of individual age-group regressors, but rather the joint significance of the demographic regressors taken together. According to a standard *Wald* test, the joint restriction that the 5 age coefficients are equal to zero can be rejected at the 1-percent level with a *p*-value of 0.008. The overall effect of the demographic composition of the workforce therefore seems to be highly statistically significant. This low *p*-value for the joint test is further evidence that the low statistical significance of individual coefficients is mainly due to multicollinearity. For forecasting purposes, however, this high collinearity should not unduly concern us, as it is expected to persist in the future.

Apart from collinearity, tests of the residuals for functional form (RESET), heteroskedasticity (White), normality (Jarque-Bera) and serial correlation (Breusch-Godfrey and Box-Ljung) do not indicate any major problems with the estimated equation.

13 See, for example, Boersch-Supan (2001), Borland and Wilkins (1997), Sarel (1995) and St-Pierre (1996).

14 For a discussion of this econometric problem and of some ways around it, see Andersson (1998).