

THE ECONOMIC IMPACT OF AN OLDER WORK FORCE

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Abstract

The world's work force is growing older, bringing a wide array of challenges to all countries especially the more developed countries. This paper reviews macroeconomic and microeconomic studies to investigate the economic impact of an older work force. The macroeconomic analysis indicates that if an older work force has a negative impact on economic growth, it will be small. The microeconomic review reveals that aging has no significant negative effects on work performance, especially with regard to psychological and social factors. The result suggests that an older work force would generate the same outcome as the current one with respect to economic and productivity growth.

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I. Introduction

There can be little doubt that the proportion of the population in old age is rising in the world. According to the United Nations (2002), the estimated percentage of people aged 60 and over within total population only rose slightly between 1970 and 2000 from 8 to 10.¹ But this demographic proportion is expected to increase rapidly throughout the 21st century. The projection is that the elderly will make up 15 percent of world's population in 2015 and 22 percent in 2050. While the pattern of aging is similar in most countries, the timing differs substantially. It appears that the projection of an aging population is particularly acute in developed countries.

As part of the overall aging process, the world's work force is also aging. A smaller and older work force will replace the younger one that exists today in many countries. A report by the UN's population division points out that the world's median age in years will rise from 26.5 in 2000 to 36.5 in 2050. Over the same period, the median age in more developed countries will jump from 37.4 to 46.4². This trend has led to increased research efforts focused on a comparison of the productivity of older workers -- defined as those aged 45 and over, to the productivity of younger workers -- defined as those under age 45. One specific research question is whether an older work force will be as productive as the current one.

Long-term economic growth results in large part from increasing the quantity and quality of the factors of production in the economy. As the labour force is an important source of growth, a shrinking work force is problematic, and an older work force may result in a decline of labour

1 Source: The Sex and Age Distribution of the World Populations: the 1998 Revision, Volume II: Sex and Age (United Nations publication, Sales No. E.99.XIII.8), medium variant projections.

2 See United Nations (2002) "World Population Aging: 1950-2050," New York: United Nations, 2002.

quality if age negatively affects work performance. This situation forces poses policy challenges related to the implications of an older labour force.

Generally there are two ways to investigate this issue: (1) by studying the impacts of the aging process on economic growth by comparing a smaller and older work force to a larger and younger one; and (2) by discussing the differences between an older worker and a younger one in terms of productivity. The first channel of the research falls within a macroeconomic framework, dealing with topics like the movement of capital flows, the change of labor force quality and quantity, and technological progress. The second channel of the research is mainly concerned with microeconomic factors regarding the effects of age on work performance, including work abilities, the level of work experience, physiologic processes, interpersonal skills, and work motivation. Previous research has taken either the macroeconomic approach or the microeconomic approach. In addition, most of the previous literature related to age-work performance has concentrated on only one or two specific variables associated with the aging process, and thus has not developed a more complete and unified view of work performance.

This paper reviews macroeconomic and microeconomic studies to provide a more complete analysis of the economic effects of differences between older and younger cohorts of workers. In particular, it applies a conceptual model to evaluate worker's productivity as an individual ages, for which a wide range of physical, psychological, and social factors associated with the aging process are considered as influential variables for determining workers' productivity. It also discusses the relationship between the productivity of older workers and their compensation levels. The macroeconomic analysis tends to indicate that if an older work force has a negative impact on economic growth, it will be small. The review of the microeconomic literature reveals that the aging process has no significant negative effects on workers' productivity, especially with regards to psychological and social factors. To better understand the complex consequences of the aging process, further empirical research and simulations are necessary. For example, an unresolved

question is under what conditions and to what extent are older workers performing in the labour market.

The next section of this paper briefly describes the worldwide demographic trend of population aging. Based on reviews of numerous literatures regarding the aging process, it is possible to estimate the macroeconomic impact of replacing a younger work force by an older one. This survey is presented in the third section. The fourth section applies a productivity model in which evidence drawn from the empirical labour economics is used to evaluate the effects of age on workers' productivity. The final section discusses the implications of macroeconomic and microeconomic analyses and mentions areas for further research of the relationship between the productivity of older workers and their compensation, as well as the productivity of older workers in the context of aging.

II. Population Aging: An International Demographic Phenomenon

Population aging is the process by which older individuals become a proportionally larger share of the total population. It had become one of the most prominent demographic events by the end of twentieth century, and is expected to continue to press throughout the twenty-first century. As the consequence of the fertility and mortality revolution, population aging was initially experienced by the more developed countries and then spread to the developing world. Eventually it is expected to become an international demographic phenomenon, and almost all countries will be affected.

Table 1 shows the estimated and projected proportions of elderly people (aged 60 years old and above) in the total population by selected regions from 1970 to 2050. According to the projections, the pace and the level of population aging vary by geographic regions and within regions as well. Europe has the highest proportion of the elderly for all of this period, while North American follows. As a whole, the percentage of the elderly aged 60 and over has increased since 1970s and will rise more quickly in the near future. Compared to less developed regions, more developed regions face a more profound and intensive demographic evolution. By 2050, the elderly will make up a projected 22 % of the world population, 33 % in the more developed regions, 21 % in the less developed regions, and 12 % in the least developed countries.

Table1: Estimated And Projected Percentage of Aged 60 + in Total Population by Selected Regions of the

World				
REGION	1970	2000	2025	2050
World total	8	10	15	22
More developed regions	15	20	28	33
Less developed regions	6	8	13	21
Least developed countries	5	5	6	12
Africa	5	5	6	12
Asia	6	9	15	24
Europe	15	20	28	35
Latin America and the Caribbean	6	8	14	22
Northern America	14	16	26	28
Oceania	11	13	20	24

Source: The Sex and Age Distribution of the World Populations: the 1998 Revision, Volume II: Sex and Age (United Nations publication, Sales No. E.99.XIII.8), medium variant projections.

A number of different measurements can be employed to demonstrate the level of aging in addition to the proportion of a population that is aged 60 and over. The most popular tool is termed the Elderly Dependency Ratio (EDR), which is the ratio of aging dependent persons (aged 65 and over) to working age persons (aged 15-64) in a population. Economists usually use EDR as an indicator to explore the dependency burden on work force and society.

According to United Nations' estimates, the world's EDR has increased from 10% (1970) to 11% (2000), but a much higher percentage (26%) is projected for the year 2050 (see Table 2).³ The evolution and the levels are different from country to country, which mostly depends on its historic demographic characteristics and the stage of economic development. In general, between 2000 and 2050, EDR will double in more developed regions and almost triple in less developed regions.

³ United Nations. (1998). World Population Prospects: the 1998 Revision.

Table 2: The Estimated And Projected Elderly Dependent Ratio by Selected World Regions

REGION	1970	2000	2025	2050
World total	10	11	16	26
More developed regions	15	21	33	44
Less developed regions	7	8	13	23
Least developed countries	6	6	6	12
Africa	6	6	6	12
Asia	7	9	15	27
Europe	16	22	33	47
Latin America and Caribbean	8	9	14	27
Northern America	16	19	30	36
Oceania	12	15	23	30

Source: The Sex and Age Distribution of the World Populations: the 1998 Revision, Volume II: Sex and Age (United Nations publication, Sales No. E.99.XIII.8), medium variant projections.

The world's labour force is also aging. Table 3 reports that the world median age of 26.5 years in 2000 is projected to rise to 36.2 years in 2050. A much older work force is expected to exist in the more developed regions. For example, the Canadian median age was 37.2 years in 2000 and is estimated to be 45.5 years in 2050.

Table 3: The Advancing Median Age in Years

Country	2000	2025	2050	Change 2000-2050
World	26.5	32.0	36.2	+9.7
United States	35.5	39.3	40.7	+5.2
Canada	37.2	43.8	45.5	+8.3
More developed regions	37.4	44.1	46.4	+9.0
Europe	37.7	45.4	49.5	+11.8
Japan	41.2	50.0	53.1	+11.9

Source: United Nations, World Population Aging: 1950-2050 (New York: United Nations, 2002)

There is a growing awareness that issues regarding the demographic change will take on increasing importance for economic growth. In addition to the increasingly aging work force as described above, future generations will have to face a shrinking work force due to the dramatic

drop in fertility rates⁴. As the world's work force becomes smaller and older, research on the relative productivities between older and younger workers has received the most attention. The argument focuses on whether the aging process and an older worker force are long term threats to economic performance. This paper will review and synthesize both macroeconomic and microeconomic literature to provide a complete view of this issue. The next section reviews the macroeconomic approach.

⁴ According to the United Nations (1998), world fertility rates were declining dramatically for the last fifty years of the twentieth century. From a high of 5.0 children per woman in 1950, the fertility rate had decreased by 44% to 2.8 children per woman in 1998.

III. Older Versus Younger Work Force: A Macroeconomic View

Many studies predict a deterioration of the future generations' economic well-being as a result of population aging. The central threat is the following: since the aged population obtains much of its income and consumption from government budgets, it is believed that governments will have to either raise taxes or spend less on other public programs to meet the increased expenditures, which in turn will affect potential output growth adversely and result in a reduced standard of living in the future. For instance, Aaron et al. (1989) use U.S. figures to illustrate the social security scheme from 1950 to 1989. According to their calculations, the total revenues earmarked for public pensions were 2,928 million US dollars in 1950, while the public expenditure on pensions was only 961 million US dollars in that year. In 1989, the income approached to 309.5 billion, while public expenditure reached 246.4 billion in the same year. That means that public expenditure increased more rapidly than income over the same period. In order to respond to the fiscal pressure, the government had to raise the payroll tax rates by more than 600 percent from 1945 to 1990⁵. With the baby-boomers reaching retirement age in 2010-2030, the payroll tax may increase to an unsustainable rate. The pressure on pensions is among the arguments of those who view the upcoming demographic shift as "apocalyptic demography"⁶.

However, not all studies share this pessimistic view. Mérette (2002) provides a complete analysis regarding the effects of aging and finds that there are various feedback mechanisms at work within the economies that generate offsetting effects to the demographic transition. There are other studies that suggest although the aging process does pose challenges to the economy, the negative impact of the process is overstated. Economic theories usually set out three channels

5 Disney, R. (1996). "Can We Afford to Grow Older? A Perspective on the Economics of Aging." London, The MIT Press. P.61.

6 Gee, E. M. and Gutman, G. M. (2000). "The Overselling of Population Aging." Oxford: Oxford University Press. P. 5.

through which the aging process affects economic growth: capital accumulation, effective labor force growth, and technological progress. I now analyze them in turn.

Impact on Savings and Investment

Most economists believe that the aging process will have important effects on public and private savings and on the demand for capital as well. As the population grows older, the private saving rates are expected to rise as aging workers save in anticipation of their retirement, but then the reverse will occur as a growing fraction of retirees begin to consume their savings⁷. At the same time, the older work force will require larger public expenditures on health care, public pension plans, and other public programs, putting greater pressure on public spending. Kotlikoff and Burns (2004) use U.S. long-term projection figures by the Congressional Budget Office to demonstrate the rising share of aggregate output spent on social security programs. The share of national output spent on those programs was less than 1 percent in 1950 but rose to 7.6 percent in 2000, and the share will rise to 21.1 percent in 2075 if nothing else changes: “To put these figures in perspective, payroll taxes average about 6.5 percent of GDP, so paying for these transfers would require doubling the payroll tax rate in the short run and tripling in the long run!”(p.54-55). Declining private saving rates will be accompanied by increasing public spending requirements to push government budgets toward deficit, reducing public saving at a time when private saving will also be shrinking. Therefore some studies anticipate that aggregate saving will decline as a percentage of national income and will eventually raise the global interest rate.

On the other hand, studies also argue that the smaller work force will reduce the need for physical capital investment to the extent that capital and labour are complementary factors of

⁷ This is based on the standard life-cycle hypothesis, which argues that individuals will smooth consumption over their lifetime given expected lifetime resources. This theory leads to the prediction that individuals' private saving rate will rise with their income during their work life, and will decline and turn negative during retirement. It also indicates that the aggregate saving rate deeply depends on the relative size of different age cohorts in the population.

production. That is, the slower work force growth rate may offset part or the entire forecasted decline in domestic saving. A crucial question for future capital accumulation is whether population aging will reduce the rate of domestic investment by more than it reduces aggregate saving. If the domestic demand for investment falls faster than national aggregate saving in the industrial economies as a whole, the interest rate may decline, *ceteris paribus*.

Some economists provide empirical evidence on the impact of aging structure on aggregate saving and investment rates in countries with the aging process. For instance, Higgins (1998) developed an empirical framework that allowed for more detailed exploration of the impact of population aging by including the distribution of the population in five-year age brackets, from ages 0-4 up to ages 70 and over. The model treats the national saving rate (or the investment rate and current account balance) as functions of the population age distribution, growth in labor productivity, and interactions among these variables. It also adds the relative price of investment goods to control for its possible effects on savings supply or investment demand. The ordinary least squares estimates suggest the existence of powerful demographic effects on national savings, investment, and the current account balance. The estimates for national savings imply a relatively weak youth-dependency effect, with a significant negative coefficient only for the first period of life (0-5). More generally, the age coefficients appear to describe the "hump" pattern predicted by the life-cycle hypothesis. But they reach a peak rather early, during the seventh period of life (30-34), decline sharply after the 10th period (45-49) and turn negative by the 12th (55-59). He also finds the same patterns of age coefficients for investment rate and current account balance. However, the estimates show that the impact of age on investment peaks at a significantly younger age (15-24), and the impact of age on current account balance peaks at relatively older age (35-59). The estimated age distribution coefficients for current account balance turn negative by age 65 and the effect is statistically significant only for the last period of life (ages 70 years and above). These empirical results suggest the demographic shift will not cause an increase in

interest rates because modest declines in national saving are paired with large declines in demand for investment.

However, research on the relative magnitudes of the changes in rates of saving and investment remains very sensitive to modest changes in the model design and the data employed. Studies have also indicated that there are cross-country differences in the time series patterns of investment and saving rates. For example, Bosworth and Keys (2004) applies the model of Higgins to a panel data set consisting of 88 countries with annual information on the age structure, GDP, national saving, and investment. They also found very large demographic effects on saving rates. The peak impact on saving occurs among people aged 40-55, and the demographic effect on aggregate saving is highly negative by age 70. Unfortunately, their findings were sensitive to the countries included in the analysis. The main results depend heavily on the inclusion of the countries in East Asia and Latin America. The demographic variables were not statistically significant when the sample was limited to the high-income OECD countries.

There is some theoretical research argues that individual's saving behavior does not necessarily correspond with the standard life-cycle view of saving behavior⁸. As I mentioned above, research on the influence of age on saving is mainly based by the standard life-cycle model, which assumes that individuals can perfectly predict their future income. However, the role of uncertainty with respect to future income and lifespan may encourage precautionary saving. Other factors associated with the aging process may also reduce its negative influence on saving rate. For example, younger generations may be aware of the need to provide for more retirement income through their own private savings due to the expectation of longer lifespan and lower level of public pensions. Thus the influence of the aging process on aggregate saving rate may not be that big.

⁸ See Browning and Lusardi (1996) and Browning and Crossley (2001).

Effective Labour Force

As one of the main sources of economic growth, labour can be measured both in quantity and quality terms. The quantity of labour input is defined as the working-age population multiplied by the labour force participation rate and the average number of working hours. The quality of labour input refers to labour productivity- the ratio of economic output to every hour worked.

Generally, an older work force may affect labor input in two ways: first, compared to younger workers, older workers may have a higher opportunity cost of participating in labour market activities, causing them retire sooner or work less if the income effect dominates the substitution effect; second, older workers may suffer from a depreciation of their skills, which in turn, would decrease labour productivity.⁹ Furthermore, they may benefit from a relatively higher wage rate because of seniority rights. Hence they have less of a need to work overtime in order to maintain a given standard of living. In other words, income effects might encourage them to work less. There is no doubt that the size of the work force declines as the population ages. However, there is no sufficient evidence to suggest the existence of a negative effect on labour force participation rate, average working hours and labour productivity among older workers. Conversely, some researchers believe that aging may stimulate labour force participation and enhance labour productivity. I list some of these arguments as follows.

Impact on Labour Force Participation

Mérette (2002) argues that the relative scarcity of labor resulting from the aging process will create higher returns to labour, and thus encourage working-age workers to enter the labor market, or work longer hours than they otherwise would, thus labor force participation should be

⁹ For older workers, the opportunity cost of choosing to participate in labour market activities includes health problems, enjoying less leisure and other things forgone in order to work. Generally older workers value leisure more than younger ones do, and they are more likely to suffer a decline in health if they keep working for a long period. Therefore, older workers are believed to have higher opportunity cost of participating in work activities.

stimulated through a substitution effect. He also points out that since the future generations tend to be much better educated, the accompanying higher returns to education will increase the length of their work horizon, which is another form of substitution effect working in the same direction. Bartel and Sicherman (1993) demonstrate that workers in industries with high rates of technological change would retire later if there is a net positive correlation between technological changes and on-the-job training. Friedberg (2001) uses the US Current Population Survey data and the Health and Retirement Study information to show that computer users retire later than non-users. These studies provide empirical evidence of older workers' longer work horizon in a knowledge-based new environment, where jobs are becoming less physically demanding and workers' health and safety improves.

An older work force is not necessarily accompanied by a lower labour force participation rate or fewer working hours. According to a report by the Organization for Economic Co-operation and Development (OECD, 2004), workforce participation of persons aged 55-64 years old increased from 50.4 percent to 53.4 percent between 1990 and 2003 in the OECD's 30 member countries. In Canada the workforce participation rate of those older workers (aged 45-64 years older) tracks a very similarly upward trend. Table 4 shows the continued increase in the workforce participation rate of older workers in Canada for the period 1976-2004. The workforce participation rate of those older workers in Canada rose from 62.6 percent to 73.6 percent from 1974 to 2004, which is a sizeable increase (11 percentage points). The table shows that the rise in participation by older workers is almost entirely a result of increased workforce participation by older women (rose from 40.8 to 67.2 percent), as male participation in this age group has fallen by 5.1 percentage points at the same time. However, the labour participation rate among older women (67.2 percent) still trailed those of older men (80.1 percent) by 12.9 percentage points. Therefore, there is still room to increase participation rates further, especially among women aged 45-64 years old. Another interesting point in table 4 is the reversal of the trend among older men's

participation rates, which has risen again since 1998. There is a 3.5-percentage-points increase over the period 1998-2004. The wide use of Information and Communication Technology (ICT) in most Canadian industries in the late 1990s may partly account for the resume in labour force participation among old workers. The tendency of absorbing more ICT innovations may encourage more older workers to go back work.

Table 4: Workforce Participation Rate for Workers Aged 45-64 in Canada, 1976-2004

Year	Both Sexes, %	Men, %	Women, %
1976	62.6	85.2	40.8
1977	62.2	84.4	40.8
1978	62.5	84.7	41.2
1979	63.2	84.4	42.8
1980	63.4	84.2	43.4
1981	63.7	84	44.2
1982	63.3	82.7	44.6
1983	63.5	82.3	45.4
1984	63.1	81.2	45.7
1985	63.7	80.4	47.5
1986	63.2	80	46.9
1987	64.2	79.7	49.2
1988	64.8	79.2	50.8
1989	65.3	79.4	51.5
1990	65.7	78.7	52.9
1991	66	78	54.1
1992	66.3	77.5	55.3
1993	66.6	77.1	56.2
1994	66.8	77.1	56.8
1995	66.8	76.5	57.2
1996	66.7	76.5	57.2
1997	67.5	77	58.3
1998	68.2	76.6	59.8
1999	69	77.5	60.7
2000	69.8	77.8	62
2001	70.2	77.9	62.7
2002	71.7	79	64.5
2003	73.2	79.8	66.7
2004	73.6	80.1	67.2

Source: Statistics Canada, Labour Force Survey in CANSIM II: v19650936, v19650937 and v19650938.

Arguments that the aging process decreases labour productivity are also problematic. In the first place, labour productivity may change depending on how individual performance evolves with age. It is commonly assumed that individual productivity follows a quadratic inverted U-shaped age profile (e.g. Miles, 1999). However, in more optimistic age-productivity profiles, labour productivity would stabilize after a certain age up to retirement, or follow a less convex profile. These age-productivity profiles will be discussed in the next section of this paper. Second, labour productivity can be increased with the implementation of better production technologies, better education and training, better public infrastructures, more and higher-quality machinery and equipment, and better social relations. There is little evidence that the aging process would adversely affect all of those factors. In fact, the knowledge-based economy has significantly stimulated the investment in technology, education and high quality public infrastructures, which in turn increases labour productivity.

Changes in Human Capital Investment

There is a consensus view among economists that human capital has both internal and external effects on societies and is one of the primary factors driving economic development. The contribution of human capital to economic growth may be highlighted in the context of the aging process. That is, the aging process may encourage human capital accumulation. According to Mérette (2002), this situation is mainly caused by two tendencies: (1) the rate of return to human capital will increase as the work force becomes smaller due to relative scarcity, which I mentioned above and will emphasize below through some studies on the baby-boom cohort; and (2) the expected decline in the return to physical capital stemming from the aging process will encourage a shift in investment priorities in favor of human capital.

Studies on the baby-boom cohort earnings and educational returns have generated substantial evidence on the relationship between the cohort size and the lifetime earnings. Card and Lemieux

(2000) develop and estimate an empirical model assuming the imperfect substitution of similarly educated workers in different age groups to show that “ cohort specific relative supply can interpret the movement in education-related earnings”. Well-educated workers within a small cohort have high relative earnings compared with those in a large cohort. Due to the world’s declining fertility rate, future young workers entering the work force will become a relatively small cohort in the labor market. That means the future work force will have a relatively higher rate of return on investment in human capital.

If the benefit could be persuaded that they are likely to enter the labour market in a small cohort, and they stand to reap these benefits, a dramatic rise in human capital will occur in the future. Besides, since the aging process has reduced the rate of return on physical capital, future generations might have less incentive to invest in this asset, which would encourage them to shift to investing in human capital. Bassanini and Scarpetta’s (2001) research on 21 OECD countries over the period 1971-1998 shows a positive and significant impact of human capital accumulation to output per capita growth. This study also reveals that the estimated long-run effect on output of one additional year of the average level of education of the labour force is about 6 per cent, which is consistent with microeconomic evidence on the private returns to schooling. Therefore, in the context of the aging process, a smaller and older work force would increase their investment in human capital if they respond to the price signals and thus increase the human capital stock, which in turn would positively affect economic growth.

An Older Work force and Technological Progress

Stereotypes depict an older work force as more risk-averse and preferring stable work environments to dynamic and innovative ones. Older entrepreneurs are sometimes alleged to be less daring to innovate new products or develop new technological procedures; older responsible

parties and executive officers would be less willing to approve of any high-risk process; and older workers would be less able to learn new knowledge and track the stream of new technology.

However, numerous empirical studies indicate that older workers can adjust to technological progress. A survey conducted by the American Association of Retired Persons and the Society for Human Resource Management in 1998 with 400 major employers in all sectors across the USA has revealed that employers generally perceive that older workers excel or perform as well as their younger counterparts in a number of work-related measures, including keeping on track with technology change¹⁰. Computers are major example of such new technology. Borghans and Weel (2004) use British data to estimate the relationship between the age of workers and computer use and find that computer use does not depend on age when taking into account the tasks to be performed at work. The research does show that older workers embody fewer computer skills than younger workers, but the main distinction lies between the 20-29 year old workers and the others and does not seem to affect the oldest workers (50-60) specifically.

Moreover, researchers believe that the future work force will be more creative and productive due to the increasing accumulation of human capital. The rising knowledge stock should stimulate the possibilities of technology progress, and the more educated and experienced work force should be able to contribute to the improvement of technology and the adaptation to it. However, macroeconomic evidence in support of the positive age affect on technology progress is scant. Some microeconomic studies suggest that older workers are not barriers to technology progress, which I will discuss in the next part. Thus, an older work force may not pose negative effects on creation and innovation.

Futagami and Nakajima (2001) use a general equilibrium model of life cycle savings

¹⁰ The results of the survey are cited in Lommel, J. M. (2001) "The New Definition of 'Older' and the New Dilemmas in the Workplace for the Older Worker".

combined with endogenous GDP growth to investigate how the aging process affects economic performance. The results suggest a positive total effect of longer average life span on economic growth rate and the savings rate. In their model, GDP growth rate is regarded as an endogenous variable, since there is an interaction between growth rate and the aggregate saving rate. In one respect, growth rate is influenced by the change of the saving rate. In another respect, the saving rate is also influenced by the change of GDP growth rate, which has been called “growth effect” in their analysis. The growth effect works in two opposite ways: first, a rise in the growth rate raises life time wage income and thus households will consume more at each point; hence the aggregate consumption-income ratio increases. Second, a rise in growth rate makes older generations consume less in comparison with current income since their consumption largely depends on the past income; in this respect, the higher the economic growth rate is, the larger the difference between the past and the current income; therefore, it has a negative effect on consumption-income ratio. Their model indicates that the second effect will overwhelm the first under the context of population aging. Thus the consumption-income ratio is negative related with the growth rate, and the saving rate is increasing with growth rate.

Overall, the transition process in Futagami and Nakajima’s model works like this: assume the new generations have longer life spans. In the early stages of their life, they consume less. Then the aggregate saving rate begins to rise, through which economic growth is accelerated. When these long-lived generations come to the final stages of life, their consumption then negatively affects the aggregate saving rate. However, since the growth rate is increasing, the negative effect can be weakened by the growth effect. Thus, the saving rate will converge on a new steady-state value which is higher than the old one, and the economy also grows faster than in the initial steady state.

Summary

The above analyses provide a profile of the macroeconomic impact of the population aging process. Table 5 summarizes the direction of changes of a variety of macroeconomic variables in response to an aging population. It shows that most variables adjust to a shrinking and aging labour force with minimal loss of production, although some variables have been adversely affected by the aging process. However, the results of most macroeconomic studies are sensitive to the changes of model design and the data employed. Moreover, there are cross-country differentials in magnitude of economic impacts of aging. Therefore, further research regarding macroeconomic consequences of the aging process is necessary.

Table 5: An Older Work Force and Production Growth

Growth Channels	Variables	The Impact	Source or Evidence	Explanation	Methodology
Capital	Private Savings	Decrease	Futagami and Nakajima (2001)	Use the model with endogenous GDP to show a positive total effect of age on individuals' saving rate	General equilibrium
	Public Expenditures	Increase	Aaron et al.(1989), Kotlikoff and Burns (2004)	Use U.S. figures to illustrate the expansion of public expenditures due to the aging process	Obvious
	Public Savings	Decrease	Higgin (1998), Bosworth et al (2004)	A: Build a model of saving rates as the function of demographic shift and other related variables. OLS estimates suggest a sharp decrease in savings rates after middle age. B: Build a model of investment rates as the function of demographic shift and other related variables. OLS estimates suggest a sharp decrease in investment rates in early life.	Partial equilibrium
	Investment Demand	Decrease	Higgin (1998), Bosworth et al (2004)	C: Build a model of current account balances as the function of demographic shift and other related variables. OLS estimates suggest the decrease occurring in very later life.	Partial equilibrium
	Interest Rate	May Decrease	Higgin (1998), Bosworth et al (2004)		Partial equilibrium
Labour	Working Age Population	Decrease	Pretty obvious	Obvious	Obvious
	Labour Force Participation Rates	Increase	Bartel and Sicherman (1993), Friedberg (2001), CANSIM Labour Force Survey data	Use models to demonstrate that workers in high technology changes and computer users have long work life horizon	Computable general equilibrium
	Labour Productivity	Increase	In Section IV	Compare older workers to younger ones in physical, psychological and sociological factors and show productivity increase with age in most cases.	Theoretical and empirical
	Human Capital Accumulation	Increase	Card and Lemieux (2000), Mérette (2002)	Use partial equilibrium model to show cohort effect in education-related earnings; Explain relative scarcity of labour will create higher returns to human capital and that encourage a shift from physical capital to human capital	Partial equilibrium, theoretical and general equilibrium
Technology	Innovation	May not change	Borghans and Weel (2004)	Use British data to estimate the relationship between age and computer use and not find significant difference between younger and older workers.	Partial equilibrium
	Diffusion	May not change			

IV Age, Productivity and Compensation: A Microeconomic View of the Demand for Older Worker

The increased number of older workers in the work force has led to questions about the employment of older workers in the labour market, which depends upon supply and demand factors. The labour supply of older workers is influenced by their preferences towards leisure, health, pension benefits, tax incentives etc. Assuming that workers face unconstrained choices, they will not enter the labour market if they find that the disutility of providing labour is higher than the benefit. The labour demand for older workers is subject to employers' perceptions of the productivity of older workers. In other words, do employers believe that the hiring or the retention of an older worker is a profit-maximizing decision?

The general principles determining whether or not a firm should hire or retain a worker can be explained by the comparison of the worker's productivity to the level of compensation. From an employer's point of view, a worker with the largest positive difference between marginal productivity and compensation would be worth hiring and employing, no matter whether the worker is older or younger. However, both workers' productivity and compensation are influenced by age. Hence, understanding age-productivity profiles and age-earnings profile is important to analyzing the economic impact of an aging society. If older workers are less productive, an aging workforce can reduce economic growth and decrease fiscal sustainability. If older workers' earnings exceed their productivity levels, then they represent losses for the firms. In that case, profit-maximizing firms would prefer younger workers to older ones, and high unemployment among older workers would occur.

This section mainly deals with the following two questions: (1) how does age affect workers' productivity (or work performance), and (2) how do firms manage the compensation

strategy towards workers as workers age? The study of the first question focuses on the age differences in individual productivity and its causes. The second question mainly examines several compensation models. By reviewing some important theories drawn from labour economics and surveying supervisors' ratings, matched employer-employee datasets as well as other literature analyses, this section provides empirical evidence on the age-productivity profile that answers the question about whether older workers are attractive for firms to employ.

This section is organized as follows: the first part describes some important facts about the labour market; the second part presents the theoretical backdrop drawn from labour economics, including age-productivity profile and compensation models; the last part provides a detailed literature review to estimate how individual productivity varies by age.

Some Important Facts in the Labour Market

An increasing body of anecdotal evidence shows that older workers experience discrimination in the labour market. For example, some older workers complain that they have been replaced by young workers just before they become eligible for lucrative retirement benefits; Some older workers (in the past) were forced by mandatory retirement provisions to leave their job before they otherwise have chosen to retire¹¹; others who remain on the job claim that they confront a hostile work environment. During 2004, 17,837 complaints of age discrimination were filed with the U.S. Equal Employment Opportunity Commission (U.S. Equal Employment Opportunity Commission, 2005). By comparison, there were 35,726 complaints filed with EEOC for alleged discrimination base on sex or race. In Canada, age discrimination complaints accounted for 12

¹¹ Concern by U.S. policymakers over these types of incidents prompted Congress to enact the Age Discrimination in Employment Act in 1968, which outlawed discrimination in the workplace against workers between the ages of 40 and 65. Later amendments prohibited mandatory retirement before the age of 70 (1978) and then outlawed mandatory retirement altogether in 1986 in the US. In Canada, labour laws do not specify a retirement age for employees and forcing an employee to retire by reason of age is considered to be a human rights issue. However, in Quebec, provisions dealing specifically with mandatory retirement are also contained in labour standards legislation under the *Charter of Human Rights and Freedoms* (1982).

percent of the total grounds of discrimination cited in complaints with the Canadian Human Rights Commission in 2003, ranking above the share of discrimination based on religion, colour or race (Canadian Human Rights Commission, 2005).

Studies on the effect of age on employment decisions have consistently found that interviewers prefer younger applicants to older ones, *ceteris paribus*. When Avolio and Barrett (1987), for example, asked 156 people to view simulated job interviews for a supervisory position and rate the various candidates, participants rated the younger applicants higher, even though the older ones had the same qualifications. Although no actual hiring decision had been made, the results still release how age stereotyping affects participants' subjective ratings of candidates¹². Researchers that reported similar results suggest that younger applicants are preferred because of beliefs that older workers are less flexible or dynamic, and are more difficult to train.

However, the inherent difficulty in measuring age discrimination has been the biggest barrier for economists to providing empirical evidence on age discrimination. By definition, discrimination occurs in the labour market only when factors unrelated to productivity affect the employment relationship. Hence, most economists measure race or sex discrimination by differences in employment opportunities or earnings among different groups which remain after controlling for observable factors that likely affect productivity. This approach is not appropriate for the analysis on age discrimination to the extent that age is an important factor that affects workers' productivity. Nevertheless, there are still some efforts among economists that show evidence on the disadvantage of older workers in the labour market. For example, Huntchens (1988) uses data from U.S. Current Population Survey (CPS) to show that the process of aging leads to a narrowing of the worker's job choice set. In his hypothesis, he assumes that if older workers confront a declining job opportunities, then the distribution of recently hired older

¹² Since the interviewees were randomly selected in the experiment, their personal characters that are not related to age would not affect participants' ratings significantly.

workers across industries and occupations should differ from that of recently hired young workers. His examination of CPS data indicates that workers older than 55 with tenure of less than five years are less equally distributed across industries and occupations among than younger workers (25-34) with tenure of less than five years. They were clustered together in a small subset of industries and occupations.¹³

There is another fact that shows a different type of economic effect. Older workers tend to fare better than younger workers in terms of income and employment rates. They have relatively high labor market earnings, high wealth, and low unemployment rates. Empirical evidence also shows that there is a rising earning profile over the life cycle. This common phenomenon implies that employers perceive that senior workers are, if not more productive, at least as productive as their juniors.

Some evidence reveals that older workers are not attractive to employers. Other facts indicate that older workers have better work environments and receive higher wages. These are opposing propositions that might be difficult to reconcile. However, the basic labour economics theories can help to shed light on these puzzles. I would like to apply these materials to interpret the labour market phenomena mentioned above next.

The Theoretical Backdrop

According to standard human capital theory, investments are made in human resources so as to improve their productivity and therefore their earnings. An investment in human capital can be made either by individuals in themselves (for example, obtaining a university degree) or by employers in their employees (for example, on-the-job training). A significant amount of human

¹³ There are some other empirical studies that purport to show age discrimination among older workers. For example, Johnson and Neumark (1997) assess the effects of age discrimination by comparing labour market outcomes (job separation and spells of unemployment) for older workers who claim that they have experienced age discrimination on the job with outcomes for older workers who do not report discrimination. Their findings suggest that age discrimination may be an important factor in determining job separations and employment status of older workers.

capital investment occurs through on-the-job training. In his classic book *Human Capital* (1964), Gary Becker distinguished between general and firm-specific on-the-job training, which he posits as the main source of human capital accumulation. If human capital is general, wages rise directly with productivity. If human capital is specific, wages rise more slowly than productivity at the beginning of the career. Becker argues that if training were productive, then trainees' value of marginal product (VMP) and wage would rise over time.

This theory also discusses how the cost has been shared, and how the return of training has been divided between workers and firms during and after the period of training. Workers pay for and reap the full return from general training. During the period of training, workers accept a wage that is less than their VMP and then receive a wage that equals their VMP after training. In the case of firm-specific training, firms and workers share both the cost and the return of training. During the period of training, workers receive a wage that is slightly higher than their VMP (that means employers are paying for a portion of the training and investing in human capital), while they receive a wage that is slightly lower than their VMP after training (so employers are paying off as expected).

Therefore, two implications of these human capital explanations for the age-productivity and age-earning relationship deserve emphasis. First, wages grow with age or experience because productivity grows with age or experience. If training did not lead to productivity growth, then there would be no basis for a wage increase. Second, at least for older and trained workers, the spot wage is always less than or equal to the spot value of marginal product. In practice, older workers with high level of seniority fare better in the internal labour market. In the spot market, workers receive wages that are equal to their productivity (VMP)¹⁴. Thus those older workers may receive higher compensation package due to their high productivity.

¹⁴ A spot market refers to the external labour market, where the contract between workers and employers on employment and compensations is largely determined by the worker's marginal productivity at that point. Comparing with internal labour market, workers in a spot market have a relatively smooth compensation profile; either higher than that in internal market (when workers are young) or lower than that in the internal market (when workers have high level of seniority).

However, as I mentioned above, some important phenomena make it difficult to reconcile with the human capital assertion that older workers receive wages that are less or equal to their value of marginal product. As Lazear (1979) points out, the mandatory retirement and actuarially unfair pensions as labour market institutions are puzzling from the perspective of human capital theory.¹⁵ If the wage is less than or equal to the VMP, then it would be irrational for a profit maximizing employer to devote resources to either encouraging early retirement or imposing mandatory retirement.

There are many theories in the labour economics that are established to be compatible with these stylized facts. Lazear's delayed compensation model (1979) is among these theories, providing a comprehensive explanation for relationship between age, productivity and compensation. This model suggests that earnings are below marginal products for young and inexperienced workers, but that wage profiles are steeper than productivity profiles, so that older and more experienced workers are paid more than their VMP. These remuneration policies are included in the so-called delayed compensation contracts to reward seniority and to promote loyalty to the firm. Thus, there must be "a date at which the contract is terminated and the worker is no longer entitled to receive a wage greater than his VMP," and the mandatory retirement or less remunerative positions to the worker occurs. If not, the discounted present value of the wages over the entire career exceeds the discounted present value of the marginal productivity, and the firm would face the loss of profit.

Lazear's delayed compensation contracts only arise in a subset of jobs. There are several other reasons why the age profiles of productivity and wages could diverge at the end of the working life. For instance, wages could continue to increase because firms need to establish implicit contracts to avoid shirking and warrant maximum effort from workers (Shapiro and Stiglitz,

¹⁵ According to Lazear, a pension is actuarially unfair if the expected present value of pension benefits is invariant to the age of retirement. That means workers confront actuarially unfair pensions when earlier retirement yields a larger expected present value of pension benefits.

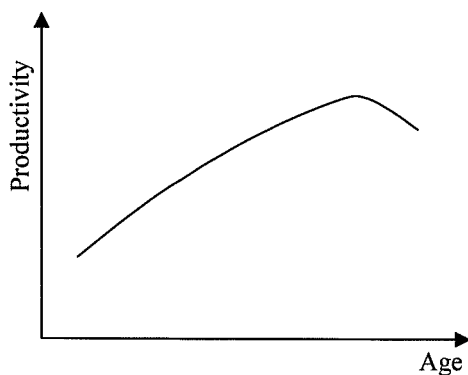
1984), or to sustain workers' motivation by means of continuous wage increases (Salop, 1979).

There are two versions of the efficiency wages hypothesis, according to which wages could be higher than the equilibrium VMP, since employers would like to use the extra compensation to lower their monitoring expenses and reduce shirking by workers.

However, the human capital accumulation rationale (Becker, 1993; Mincer, 1974) also suggests another conclusion about the age-productivity profile: productivity would fall at later ages of working life. This can be explained by two reasons. First, since the firm's outlays on on-the-job training decline as workers age, the associated increase in productivity thus declines. Second, there is depreciation in workers' productivity at the end of the working life, mainly due to the lower physical abilities of older workers. The productivity depreciation, combined with the lesser opportunities of on-the-job training, imposes a downward pressure on the productivity level and might cause productivity fall as workers become older. This decline in productivity is larger when the job requires strength and physical endurance.

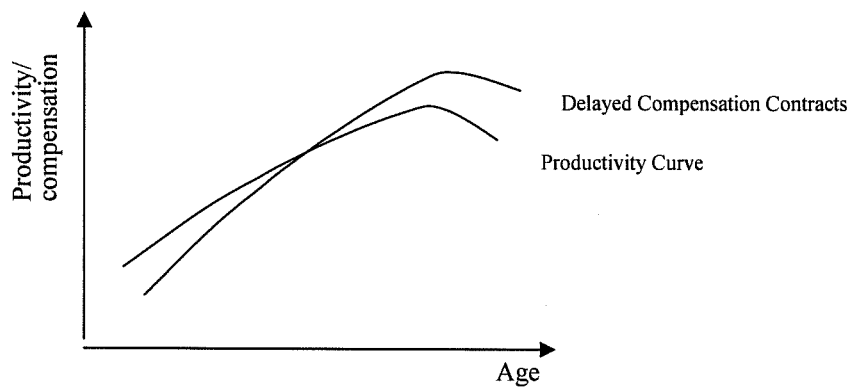
Figure 1 provides a typical life-cycle productivity profile that is mainly based on the reviewing of human capital theory presented above. It shows that workers' productivity follows an inverted U-shaped age profile: it rises sharply with age when workers are young and then reaches a peak when workers are middle aged, and finally it falls slightly as workers become old.

Figure1 Dynamic Age- Productivity Profile



According to human capital theories, workers' compensation packages should track the same movements as the productivity profile. In this respect, the age-compensation profile should also be an inverted U-shape. That means that wages rise with age as the stock of human capital increases, but they should eventually fall when the human capital depreciation exceeds the investment. However, the peak year of the compensation should be a little bit later than that of the productivity profile in the case of the delayed compensation contracts exist. Figure 2 demonstrates the relationship between workers' productivity and compensation in a life-cycle framework.

Figure 2 Dynamic Age- Productivity and Age- Compensation Profile in Delayed Compensation Contracts



Some empirical studies also indicate the existence of an inverted U-shape age-compensation profile. Jean and Nicoletti (2002) report estimates of earning profiles for 12 OECD countries, half of which have wages falling slightly for those aged 55 and over. Only in three countries do they increase in old working age. In their basic framework of estimations, the dependent variable is hourly earnings of full time workers, and the explanatory variables are a set of observable characteristics of workers including age, gender and levels of education. Table 6 presents the coefficient estimates of the age as well as the shares of each group of workers in total employment (the first column of each age group) that result from their sample. Coefficient estimates can be interpreted as the percentage variations relative to the (omitted) benchmark age group (15-24). For instance, regression results indicate that earnings of workers aged 35-54 years are 52 per cent

higher than those of benchmark in Canada. But for workers aged 55 and over, their wages are 49 higher than those of benchmark, which is slightly lower than those of middle aged. Austria, Denmark, Italy, the United Kingdom and United States also have the same downward tendency for older workers.

Table 6: Jean and Nicoletti's Estimates of Earnings Profiles by Age Group in 12 OECD Countries
(Estimated on a hourly basis for full-time workers)

Countries	Age							
	15-24		25-34		35-54		55 and over	
	Estimates	Share	Estimates	Share	Estimates	Share	Estimates	Share
Austria	-	16%	0.19	32%	0.35	47%	0.26	5%
Belgium	-	10%	0.22	36%	0.45	51%	0.54	4%
Canada	-	N/A	0.38	N/A	0.52	N/A	0.49	N/A
Denmark	-	20%	0.22	29%	0.33	43%	0.32	8%
France	-	12%	0.3	31%	0.59	53%	0.77	3%
Greece	-	11%	0.21	34%	0.48	48%	0.53	7%
Ireland	-	22%	0.36	38%	0.58	36%	0.65	4%
Italy	-	10%	0.21	32%	0.48	53%	0.45	5%
Spain	-	9%	0.33	32%	0.62	50%	0.71	9%
Sweden	-	8%	0.16	27%	0.33	54%	0.37	11%
United Kingdom	-	15%	0.33	30%	0.4	44%	0.28	11%
United States	-	17%	0.22	26%	0.35	46%	0.34	10%

Source: Jean and Nicoletti (2002), Table 2.

OECD (1999) reports age-earnings profiles for 20 OECD countries, all of which plateau around the early 50s, decreasing slightly thereafter. The results are consistent with Jean and Nicoletti's estimates, proving the existence of falling compensation in workers' late years.

From a theoretical point of view, both age-productivity and age-compensation curves follow an inverted U-shape. Generally, a profit-maximizing firm would pay workers' wage that equals to or is less than workers' productivity in a competitive labour market or spot market. In this respect,

older workers fare better in terms of compensation only because they have higher productivity than younger workers. However, there are some cases for which the workers' compensation is greater than the level of the worker's productivity, in particular when the worker is older. As discussed, these firms' choices are still reasonable, such as the models of efficiency wage, implicit contracts and delayed compensation contracts. Therefore, there should be no difference between older workers and younger workers for employers hiring or retaining them as long as the compensation does not deviate too much from the productivity.

Now I turn to the empirical evidence. What does the profile look like in the actual labour market? The next section will review some literature on the topic.

Age-Productivity Profile: A Literature Survey

This section focuses on age differences in individual productivity and its causes. First I identify those variables that are influenced by age and also affect an individual's productivity. These variables are placed in a productivity function. Then I use the function to survey those variables listed, providing a broad understanding of the relationship between age and productivity. A summary follows to offer the main findings of this survey.

A Productivity Function

What are the variables that affect an individual's work performance or productivity? Research has revealed that there are many factors that can explain the disparity in the work performance between different age groups, including the level of work experience, education, memory skills, cognitive abilities, health status, work motivation, learning abilities, work habits, adaptability, interpersonal skills, job satisfaction, job involvement, work environment, level of compensation and etc. Although factors associated with workers' working conditions such as work environment and administrative arrangements play important roles in the determination of workers'

productivity, they are not influenced by age. A number of industry and country-specific variables are also important for workers' productivity but not directly related to age¹⁶. Therefore, I only discuss the variables that differ with age in this section. For convenience, I divide all those factors into three categories: physical factors, psychological factors and sociological factors. Thus a productivity function can be presented as:

$$(1) \quad P = F(PH, PS, SO, x)$$

where P is the productivity of an individual worker, and PH, PS, SO are the influencing physical, psychological and sociological factors, respectively. Other variables that affect productivity are treated as the residuals x . The weight of the different causal factors in determining individual productivity is steadily changing, where psychological and sociological factors have long been growing in importance, while physical factors have become less important when economy become more knowledge-based.

Workers in different age groups have different levels of those influencing factors. This can be represented by another three functions:

$$(2) \quad PH = F_1(A, x_1)$$

$$(3) \quad PS = F_2(A, x_2)$$

$$(4) \quad SO = F_3(A, x_3)$$

where A stands for the age of the worker in years, and x_1, x_2 and x_3 are all the other factors that affect the value of PH, PS and SO , respectively.

A Literature Survey

Investigation into how productivity evolves with age is based on combined research from different disciplines, for instance, medical science, social psychology, health economics, and labor

¹⁶ Some firm, industry or country-specific variables may be affected by age. For example, workers in the constructions have a relatively lower median age (Statistics Canada, 2001 Census). However, I will not discuss here due to unavailability of related literature.

economics. Researchers from these disciplines have utilized various approaches to explore the relationship between age and productivity. Medical scientists usually design scientific experiments to test most physical capability variables such as cognitive ability. Psychologists often like to analyze the supervisor's performance rating as the measure of productivity. Economists generally use micro databases to estimate coefficients of characteristic variables. In order to provide a full scenario of this topic, I will review all these approaches.

Physical capability factors

The study of personal health indicates that there are some apparent changes in human body that come with age. As a geriatric medicinal scientist, Hjort (1996) finds that the biology of ageing, which can best be presented and measured as the capacity for maximum muscular work or exercise, falls with age. Similar declines can be measured for all organs in the body. A survey conducted by Statistics Canada (2004) shows that older people report high rates of arthritis, rheumatism, hypertension, diabetes, and heart disease. Experiments also indicate that some of these diseases may lead to a functional limitation on the performance of normal daily role activities.

The risk of poor health and disability rises with age, which may affect the work capacities of older workers. In spite of the seemingly unavoidable age-related deterioration in personal health, targeted training programs may provide a way of halting the decline. Hjort (1996) uses clinical data to show that older persons' muscular capacity can be markedly increased by training. Similarly, cognitive training interventions could improve older workers' mental abilities, such as memory, speed of processing and reasoning. Ball et al (2002) use randomized and controlled trial with 2832 older persons to evaluate whether or not training programs have effects on older workers' cognitive ability. The trial had been conducted from 1998 to 2000 and the follow-up run during 2001. Participants were randomly assigned to four groups, with three of them receiving

cognitive training and the last not. All participants wrote a specific cognitive test at the beginning of the experiment and rewrote it after two years. The three treatment groups demonstrated reliable cognitive improvement comparing to the control group. Other studies also show evidence that the training can stabilize the age specific declines among old workers¹⁷.

Psychological factors

Job loyalty, satisfaction and work motivation are psychological factors that have positive impacts on productivity. Job loyalty is the degree of attachment and commitment that a worker has to a job or an organization. Job satisfaction is a feeling by employees that they feel delighted to stay within current organizations. Work motivation is a drive defined as the desire to work. More quantitatively, it is defined as the amount of effort that an individual puts forth on a job. Research on effects of aging on job loyalty, satisfaction, and work motivation, has produced mixed results.

Slocum, Cron, Hansen and Rawlings (1985) suggest that the deadwood phenomenon often associated with older workers is at least partially attributable to the prevalence of low work motivation among them¹⁸. They believe that the lower work motivation stems from the upcoming retirement and lower degree of supervision associated with the aging process.

Conversely, Rhodes (1983) reviews 185 research studies and found that internal work motivation, overall job satisfaction, and job loyalty were positively associated with age. He reviews research evidence showing tendencies for higher commitment, lower turnover, and less voluntary absenteeism among older employees than among younger ones, suggesting that loyalty level and motivational level were higher for the older employees. A survey documented in Barth et. al. (1993) also makes this point. The survey asked human resource executives in 406 U.S.

¹⁷ See Schaie and Willis (1986a, 1986b) for new experiment evidence.

¹⁸ Deadwood phenomenon refers to a situation when firms have some employees that that is burdensome or superfluous. Those employees perform poorly as their skills are very out of data.

organizations to rate the performance of older workers relative to the average worker. The result shows that older workers were consistently rated as having more positive attitudes and being more reliable than the average worker.

Sociological factors

Sociological factors include the level of experience, education, training, and interpersonal skills, which are viewed as the main attribute to the human capital stock and economic growth. A general belief regarding effects of these sociological factors on workers' productivity is that there is a positive relationship between age and productivity. Saks and Waldman (1998) examine evolutions for newcomers recently hired into entry-level positions in public accounting firms to test hypotheses about age and job performance and obtain opposite results. The job performance measure was based on job analysis information, existing job descriptions and performance evaluation forms used by the participant firms and interviews with personnel managers, supervisors and other faculty. Saks and Waldman divide the job performance criteria into technical and interpersonal performance. Their findings show that age is significantly and negatively related to job technical and overall job performance. However, the age range in their study is very restricted. The young newcomers tended to be in their early twenties compared to older newcomers, who tended to be in their late twenties. The older workers are relatively young. They can not be counted in "the older group" considering their physical characteristics.

The result is in line with the work of Rosen and Jerdee (1976), who report negative age effects for older individuals with regard to overall job performance capacity. However, Rosen and Jerdee also report that no age effects are associated with interpersonal skills. Interpersonal skills appear to increase in importance in most firms as they increasingly attempt to promote teamwork and the more effective serving of clients' needs. Saks and Waldman's research also reveal no significant aging effects in regards to performance pertaining to interpersonal skills.

Besides experience, education is another important sociological factor that affects work productivity. Generally, today's older workers are less educated compared with the younger cohorts because many of them had more limited educational opportunities available in the earlier years. However, future older workers will have an improved educational profile as a result of increased education opportunities offered to today's workers. The differential in productivity caused by the educational difference between older and younger workers may be not significant in the future.

Other comprehensive research has demonstrated that performance levels of older and younger workers are not significantly different. McEvoy and Cascio (1989) review studies spanning a 22-year period that examined the effect of age on job performance and report some important factors such as sample size, age-job performance correlation coefficient, job type, compensation of the sample by age and type of performance measure. They found a total of 96 independent studies (sample sizes ranging from 11 to 5,594) that reported age-performance correlations with a broad cross-section of jobs and age groups (from 17 to 60 and over). Correlations between age and job performance ranged from -0.44 to $+0.66$. According to their survey, 58 per cent of studies reported a positive correlation, 40 per cent a negative correlation and 2 per cent a correlation of 0.00. After they gathered the studies, they applied the meta-analysis to estimate the sample size weighted mean correlation across studies, which was 0.06. The results show that job performance does not decrease with age as typically believed.

Analyses on the Use of Data

Studies involving age-productivity relationships are either based on cross-sectional data, which describe the population's current abilities comparing individuals of different ages at the same point in time, or longitudinal data sets, which follow the one or more cohorts in order to observe

the same individual at different points in time. Cross-sectional analyzes typically find the evolution in ability, as shown in the “Seattle Longitudinal Study” where age-differences are examined both by longitudinal and cross sectional approaches (Schaie 1996)¹⁹. The longitudinal data suggest that work productivity peaks at later ages of the career, while according to the cross-sectional data, the ability peaks take place at younger ages.

Both cross-sectional and longitudinal approaches for measuring age-productivity differences have some weaknesses. In the Seattle Longitudinal Study, more than half of the initial sample was lost by the time of the third wave, which is called sample attrition. This loss of respondents is likely to create an upward bias in the age-productivity estimates, since the remaining sample is likely to be positively selected. A second source of error stems from test practice, meaning that individuals in subsequent waves perform better simply because they have more exercise in taking these types of tests. Thus, productivity decrements found in longitudinal data will most likely underestimate the true physical declines.

Cross-sectional data may also produce biased results, since ability levels can differ between cohorts. Willis and Schaie (1998) analyze primary physical capacity test results for 1924, 1945, 1952 and 1959 cohorts, and find increasing test performance in reasoning and verbal memory, but decreasing results in tests of vocabulary and numerical ability. They explained that the impact of social structures and environments might play an important role on issues of cohort differences. Furthermore, the fact that physical ability levels rise may be due to the improvement of levels of education, which is not explicitly controlled for in these studies, can be an important factor in explaining the rise in abilities. Another argument for this observation is that such tests have

¹⁹ The Seattle Longitudinal Study (SLS) was begun by K. Warner Schaie in cooperation with the U.S. Group Health Cooperative of Puget Sound (GHC). The purpose of the research is to study various aspects of psychological development during the adult years. In 1956, five hundred Group Health members were randomly selected to participate in the first study. They ranged in age from their early 20s to late 60s. The study has continued in seven-year intervals since 1956: 1963, 1970, 1977, 1984, 1991, and 1998. At each interval, all persons who had previously participated in the study were asked to participate again. In addition at each seven-year interval, a new group of people randomly selected from the Group Health membership have been asked to participate. Approximately 6000 people have now participated at some time in this study. Of the original participants, 38 people remain who have now been in the study for 49 years.

become more commonplace in candidate-selection processes in recent years (Jenkins 2001), which means that individuals from more recent cohorts will prepare more and be more motivated at taking such tests.

Analyses on the Measurement of Productivity

There are two main approaches to measure individuals' job performance, namely performance's rating (subjective measurement) and output rating (objective measurement). Supervisors or personnel managers' ratings have been widely used as the measurement of productivity by psychologists who conduct research to explore the relationship between age and performance. In McEvoy and Cascio (1989)'s survey, 71 per cent of studies that they searched used this subjective performance criterion. Studies based on this approach typically find an unclear systematic relationship between age and productivity. A general disadvantage with the use of supervisors' ratings to rank individuals' productivity by those psychologists is that managers may wish to reward older employees for their loyalty and past achievements. This can lead to an overestimate of senior workers' job performance. Saks and Waldman (1998) investigate performance evaluations from combined sources as mentioned above, which can be viewed as a way to decrease the productivity inflation among older workers.

The use of piece-work rating is another approach to measuring the impact of age on job performance. That is, researchers usually use the quantity and quality of a worker's output to represent the worker's productivity. Studies based on this approach show that older employees have lower productivity levels. But the objectivity of the approach may suffer from the fact that the workers may be limited to selected occupational types. The output of some specific occupations, such as managers, teachers, can not easily be measured.

Summary

This section is devoted to microeconomic analysis regarding to the age-productivity and age-compensation profile. The theoretical review of the relationship between age and productivity reveals an inverted U-shaped age-productivity life-cycle profile. The literature survey also shows that productivity increases with age due to the accumulation of human capital in the psychological and social aspects, and finally falls due to the physical factors influenced by age. However, a problem with most estimates of how productivity varies by age is that older individuals who remain in the workforce are positively selected and have a higher productivity than that of those who leave the workforce, which can bias the estimates.

V. Concluding Remarks

An aging work force is a worldwide phenomenon. A smaller and older work force has posed and will continue posing challenges for economic growth and welfare. However, these challenges may be manageable.

Taking a macroeconomic view, I find that a smaller and older work force can replace a younger one to maintain productivity growth and to persistingly improve living standards. First, the older work force may coincide with a decreased physical capital stock and investment demand at the same time, and this dynamic change may lower world interest rates. Second, a future smaller cohort may invest more in human capital thus can improve labour productivity continuously, while the labour participation rate may not be adversely affected. Third, the higher human capital accumulation in work force may promote innovation and contribute to technological progress.

From a microeconomic point of view, older workers differ from their younger counterparts in a variety of physical, psychological, and sociological ways. I use classic human capital theory to describe how age affects worker's productivity, providing a comprehensive discussion of age-productivity profile. A survey of the empirical literature follows the theoretical review to offer some important findings for the age-productivity profile. Both approaches reveal an inverted U-shaped age-productivity curve. The microeconomic survey also discovers that the productivity-age profile is fairly similar to the age-remuneration profile. Therefore, there are no major losses in efficiency that might occur from firms retaining older workers.

The combined analysis suggests that a smaller and older work force generates the same outcome with respect to economic and productivity growth. However, two major issues related to

the research should be noted.

First, this paper only provides a generalized review regarding the relationship of an older work force and a younger work force, and some uncertainty remains for two reasons. First, the empirical evidence employed here is very sensitive to modest changes in the model design and the data collected. Most of what we know about the future old work force is based on economic projections or simulations with restricted macroeconomic assumptions. Second, some of the research is restricted to very specific sectors of the economy. Further research is needed to investigate the impact of older workers on the economy.

Second, an optimistic outcome may depend on active human resource strategies regarding older workers. An increased investment in training of older workers can not only improve their job performance related to psychological and sociological factors, but also raise their physical capability. In this respect, there is room for older workers improving their individuals' productivity as long as firms take actions to establish incentives to attract and retain more experienced older workers.

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