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The Effects of the Demographic Transition on Economic Growth

Implications for Japan

Bachelor Thesis within Economics

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Abstract

Demographic transition implies severe challenges for high income nations, for instance Japan, as the population decreases due to declines in birth rates as well as the higher rate of elderly population. More women are entering the labor market which affects birth rates. In addition, technological progress has improved health care and standard of living, bringing up life expectancies. However, the elderly population is increasing, elevating the dependency ratio which dampens the economic growth. The changed age structure alters the ratio of labor force negatively relative to population, in spite of the higher female labor participation.

This paper analyzes how the current demographic transition in advanced countries influences economic growth. The paper is focused on Japan that is currently dealing with the consequences from the fastest increase in the percentage share of the elderly population compared to the other high income countries. The empirical analysis is based on a growth accounting model that estimates the impact of demographic factors on growth rates in high income countries. The empirical results indicate that demographic factors such as life expectancy and total dependency ratio have a negative impact on economic growth. The conclusion is that Japan and other rich countries have to make greater efforts in dampening the demographic change by policy making and in-migration.

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1 Introduction

The world economy is currently facing a great challenge as the rate of the elderly population increases while birth rates decrease. This development results in a reversed population pyramid in which the amount of young people is not enough to support the elderly. Since the Second World War, developing countries have experienced highly changed rates of mortality and fertility. During the past fifteen years, population growth rates have been decreasing for almost all OECD countries. In fact, all OECD countries will probably face much slower population growth if not the birth rates or immigration from non-OECD countries increase (Hagemann & Nicoletti, 1989).

Countries such as Germany, USA, Japan and Sweden are recurring essential examples of the reversed population pyramid in studies of demographic change. The country that sticks out the most is Japan. The nation is one of the biggest economies in the world and is in a recession since 2008. As the country is trying to cope with the recession, the economy is also struggling with the demographic change.

The Japanese population has the highest life expectancy in the world raising the numbers of elderly, implying a rise in health expenditure as well as costs in pension and social security programs. The pace of the Japanese aging is extremely high. The extended life expectancies have created an aging problem for Japan where the amount of elderly is excessively large. In other words, the working-age share will fall as the birth rates decline and the elderly population increases. The changed age structure has a significant effect on economic growth as it alters the demand for workers. The question is how sustainable the economic growth is when facing a rising number of elderly leading to an increasing dependency ratio. Currently, the small working-age share is dependent by the elderly who rely on the support of health care institutions and social security (Bloom et al., 2001).

Caused by the falling birth rates, the Japanese population of 127.5 million is estimated to diminish to 95 million people by 2050. In the same year, the population of 65 years and above is predicted to rise by 20 percentage points. This means that for every 2 worker one person is retired. In addition, the Japanese immigration policy is heavily restricted which explains the low immigration rate. As a result, this generates difficulties for workers as they share the burden of supporting the elderly. Consequently, Japan will deal with one of the most severe demographic circumstances in the industrialized world, if not a rise in the birth rates or the immigration rates from other nations increases (Bloom et al., 2001).

The thesis is structured as follows. First, the theories and results from previous research are stated to provide a deeper understanding of the effects of demographic change on economic growth, in the perspective of the Japanese economy. In the second section, theoretical framework is presented along with the empirical model applied in the study. The third section presents the data together with the method. In Section 4, the result is given in the purpose of projecting the demographic transition's effects on the economic growth including the analysis. The last section contains the conclusion of the demographic factors altering the Japanese economy as well as the economies of high income nations.

1.1 Purpose of Study

The purpose of the thesis is to examine how demographic transition affects economic growth with the Japanese economy as an extreme example. Econometric estimates of a growth accounting model, including demographic factors, are used to discuss the effect of demographic change on the growth rate of the economy. The growth accounting framework of this paper is based on endogenous growth theory and is extended with the demographic transition as an additional factor explaining cross-country variations in economic growth. The method of estimating the effect of the demographic transition is to make a regression analysis on cross-country data using the ordinary least squares estimation method.

1.2 Background

Most OECD countries have faced low birth rates in combination with higher rates of the elderly population, which have led to a diminishing population growth rate and rapidly changing age compositions. Keynes (1937) predicted that decreasing population growth affects aggregate demand and output growth negatively (see also Hansen, 1939, and Myrdal, 1940). Previous research has shown that population aging will affect the structure of industrialized economies through its impacts on labor markets, demand, savings rate and capital accumulation (Hagemann & Nicoletti, 1989).

The age structure of the population has a large impact on the economy. The economic behavior of the population changes at different life stages. If the majority of a country's people are in the working-age population, the extra productivity rate would lead to economic growth. If most of the population is elderly, many resources are required for the less productive, resulting in a slowdown of economic growth. What alters the economic growth is the different behavior of the population, considering that every age group invests and saves differently. Young people invest more in health and education, while the prime-age adults supply labor and savings as the elderly necessitate health care and retirement income. The working-age population has a higher level of economic output and savings than young as well as old people, who consume more than they produce (Bloom, et al., 2001).

About 10 percent of the world population is aged above 60 years. This rate is estimated to increase more than 20 percent by 2050. People who are 85 and over will increase the fastest. Today, the world is moving from a large amount of young people towards a population in which many are above the age of 65, implying less young people will be able to support the old population. (Pollack, 2005) This is illustrated in the three population pyramids of year 1950, 2000 and 2050 in Appendix 4.

At the moment, the population of Japan is expected to live until 81 years. In 1920, the median age[1] of a Japanese person was 27 years. At recent time, that median age increased to over 40 years. The fertility rates of only 1.3 children per woman together with the high life expectancy rate and the increasing of the elderly bring huge consequences to the Japanese economy. In addition, the rapid increase of the retired population leads to a higher dependency ratio[2]. This brings increased costs in terms of health, pension and social security for the economy (Bloom, et al., 2001).

Japan's speed of population aging was below the OECD level in the 1960s, but is estimated to become amongst the highest in the organization by 2025. This distinguishes Japan from the other countries that are experiencing the demographic change as well. The rising life expectancy in Japan creates a new definition of the elderly. In 1990, the limit of the elderly population was people aged 67 or above. In 2025, the definition of the elderly will be at the age 70 or over. In history, no population has ever aged this much and rapidly (Hurd & Yashiro, 1996).

The raised economic insecurity due to the financial crisis has elevated the pressure on the Japanese workers. This fact, among other reasons, has led to a delayed marriage age since people do not have time to spend on families. In turn, it has resulted in decreasing fertility rates. Moreover, the fall in the housewife rate due to the enhanced lack of enthusiasm several young women have for the traditional housewife role, is the result of their willingness to capture the labor market opportunities (Yashiro, 1998).

1.3 Previous Studies

Previous models applied to find the economic effects of population aging have made different conclusions due to different usage of variables such as capital profitability, endogenous technological change and labor supply in response to aging.

The IMF Multi-Country Macroeconomic Model, applied by Masson and Tryon (1990) was used on seven major OECD countries. The conclusion of the changed age structure was the decline of the labor force results in the decline of capital stock and potential output; the decline of the savings rate stimulates the consumption expenditure; the increase in government expenditure expands the aggregate demand; share in GNP of the private saving and gross private investment fall, leading to the net external surplus decline. The Japanese private saving was found to decrease by 4.3 percent during 1995-2025 as the gross private investment declines by 1.8 percent. This Keynesian-type model explains the relation between countries with diverse aging rates, but assumes no adjustments in the labor force participation rate and no technological transitions. The model is Keynesian due to its conclusion that the rise in government expenditure results in an increased aggregate demand (Hurd & Yashiro, 1996).

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[1] The age that is in the middle of the young aged and the elderly aged population
[2] The ratio of population aged 0-14 and 65+ years

Using a neoclassical model, Noguchi (1990) found that the capital return declines with decreasing labor force rate. Also, the household savings rate decreases as the proportion of the elderly in the total population increases since individuals save while they are employed and not save after retirement. The savings rate has a negative relationship to the old-age dependency ratio[3]. Additionally, the high household savings have contributed to a Japanese economic growth. Thus, as the old-age dependency ratio increases, the economic growth is dampened. According to a cross-sectional analysis of the relationship between savings rate and the old-age dependency ratio in OECD countries in the 1980s, Japan's current household savings rate has been estimated to fall by more than one-half in response to the estimated doubling of the old-age dependency ratio. However, Noguchi did not consider labor supply responses to population aging when analyzing through the model. According to him, the Japanese current account surplus was estimated to stay unchanged through 1990s, to increase in 2000-2010 and to decrease in 2010 and later (Hurd & Yashiro, 1996).

Auerbach et al. (1989) applied the Overlapping Generations Model on Germany, Japan, Sweden and the United States. The model concluded that the increasing rate of elderly population will lead to a general decline in the savings rate. The speed of the decline will be faster in Japan and will approach 0 in 2025, when the ratio of elderly to the total population arrives to a platform. Assuming an "open economy" (the perfect international capital mobility), the increase in capital-labor ratio coming from the rapid demographic shift in Japan results in a capital outflow for the purpose of preserving the preexisting return on capital. This will increase the current account surplus. The decline in labor supply reduces the investment proportionally and will therefore not lead to a decline in the current account (Hurd & Yashiro, 1996).

Economic Planning Agency (1991) proved with the Turnpike "optimal growth" model that the national savings rate and the aggregate investment will decrease in Japan. In addition, the labor efficiency will develop with increasing labor scarcity, especially in the service sector, where relative labor productivity is mostly low. In turn, the current external balance will become a deficit after year 2000. The decline in the labor force will result in a decreasing rate of economic growth. This was based on the assumption of free mobility of labor across industries (Hurd & Yashiro, 1996).

By using the Cobb-Douglas function and neoclassical factors, IIASA[4] applied the Economic-Demographic Simulation Model in 1992. The conclusion was that the Japanese demographic transition slows down the growth of GDP per capita and the savings rate, while raising the expenditure on social security, assuming no change in labor force participation rates or pension-, health-, and long-term care benefit calculations. According to IIASA, the disposable income of the elderly and the working-age population are estimated to increase, i.e. the living standards will progress. Nevertheless, the living standards of the young relative to those of the elderly will worsen the most. Due to the changed age structure, the declining savings

[3] The amount of the population aged 65 years and above divided by the population aged 15-64 years
[4] International Institute for Applied Systems Analysis

rate will give implications for Japan and also the world economy (Ermolieva, et al., 2003)

Bloom (2009) and Finlay (2009) applied a growth accounting framework connecting the working-age share with economic growth. By estimating factors contributing to the demographic change, such as life expectancy and working-age population growth they could forecast the negative effects on economic growth in the future. They concluded that Japan among other countries will meet economic challenges in the future if they do not support the working-age population by increasing the in-migration from other countries.

The previous studies show that the national savings rate, the investment rate and output fall as population ages. The relative speed of aging is critical in determining the future path of the economy. As the structures and assumptions of the models differ, the differences in the projections of the saving, investment, and output depend on the extent to which these models account for feedback effects of demographic shifts. The effects of the increase in the elderly population influence the changes in the labor productivity, saving and investment. The associated decline in growth rate of labor force is important to look upon when estimating the economic performance. Previous studies have assumed that the labor force participation and technological change are independent of population aging; thus the outcomes have shown negative effects on Japan’s currently high savings and investment rate. As the labor supply declines while the fertility rate does likewise, more rapid technological change may be stimulated and moderately counterbalance the negative impact of population aging on savings and investment. Therefore, using the labor supply and technological change factors as endogenous instead of exogenous will modify the projections of savings and investment patterns (Hurd & Yashiro, 1996).

2 Theoretical Framework

Thompson (1929) developed a model of demographic transition which explained stages of different birth and mortality rates in order to demonstrate how the economy affects the demographic transformation. Solow (1956) specified the neoclassical growth model showing how labor, capital and technology influence economic growth. Models of the new growth theory have extended Solow's idea by assuming endogenous growth in different factors of production. In order to understand how demography affects economic growth, these theories are presented below.

2.1 Demographic Transition

The formation of a population and its labor force is due to demographic factors such as birth rates, death rates and the age structure influencing the number of workers. The current demographic change is affecting economies in the sense that labor supply diminishes as the population pyramid turn from a small share of the elderly and a large amount of the young to the extreme opposite of that structure. The transformation of the population pyramid, from year 1950 to 2050, can be found in Appendix 4.

In theory, the demographic transition takes place when countries develop from an establishment of the first stage, high fertility and mortality to the last stage, low fertility and mortality. Currently, Japan as well as USA and Sweden are in the last stage. There are several main reasons for the demographic change in the countries. Technological improvements have enhanced the health care which has reduced the death rates. In addition, the female labor participation is increasing as countries become more modernized which brings consequences for family sizes. For industrialized countries, having children implies more costs, i.e. higher incomes result in lower birth rates (Kirk, 1996).

The demographic transition model is based on five stages. The first is the pre-industrial or the high stationary phase. This stage is characterized for its high birth rates and high death rates that are in balance. The population is living in an agricultural community where many infants are born and diseases are spread. The second stage is the developing or the early expanding phase of the demographic change. High birth rates and high death rates of the "high stationary" level are present, although the death rates fall more than in the first phase. Agricultural methods and food supply are improved, including crop rotation, selective breeding, and seed drill technology. In addition, public health is enhanced, reducing the mortality rate, especially in infancy. Moreover, industries such as machines, transport by road and rail have progressed. The third stage is distinguished by its urbanization and is the late expanding phase. Urbanization alters the traditional values for families; hence, the rising costs of having children and the higher female employment. The birth rates and death rates are now declining, yet the death rates are lower than the birth rates, bringing annual population growth. The fourth stage is the industrialized and low stationary phase in which there are low birth rates and low death rates. Lastly, the fifth stage is the post-industrialized and declining phase implying excess death rates over birth rates unless increasing immigration occurs. Especially Japan and numerous European countries are experiencing the last stage of the demographic transition (Blacker, 1947).

When Thompson (1929) specified the demographic transition theory, he also defined three types of industrialized countries in which the shift of population growth rates differed. The first country, called A, was experiencing a population decline due to a fast fertility decrease and a low mortality. For the second country, B, birth rates and death rates had dropped. However, the death rates declined earlier and faster than birth rates. This lead to a population growth until it was offset by falling birth rates and afterwards decline. In the third country, C, the birth rates or death rates change in an uncontrolled manner, hence, the population growth would fall. Thompson found that Japan among the other countries he analyzed would face a demographic change like in category C and it would take 30-40 years, i.e. around the 1970s, until it became a country within category B. Already when the demographic transition theory was stated, Thompson warned about the consequences arising due to the economic demographic transformation (Kirk, 1996).

2.2 Growth Theory

Solow's neoclassical growth theory describes how various factors of production such as capital and labor affect growth in total output and how the accumulation of production factors and increased productivity lead to a steady economic growth. To understand the new growth theory and the structure of the model used in this paper, one has to apprehend the growth model and the growth accounting that Solow introduced. Solow's growth model presents the steady-state equilibrium that will be eventually reached through variations in capital and labor. The steady-state equilibrium occurs when the economy is following a balanced growth path, implying that growth rates of output and capital are constant, and the economy stay in this state. The capital and labor adjust in order to keep the equilibrium when new technology enters the country. In other words, economic growth continues only when technology advances. At steady-state equilibrium the investment required to provide capital for new workers and substitute worn-out machines is equal to the saving of the economy. That is, the growth of the ratio of capital to population is dependent on savings after depreciation and supply of capital per worker to new workers entering the labor force, with the assumption of constant technological progress. The change in the ratio of capital to population has a positive effect on saving per capita and a negative effect on growth of labor per capita (Todaro & Smith, 2008). A high savings rate leads the economy to a balanced growth path with the property that there exist possible alternatives involving higher consumption at every period (Romer, 2006). If savings exceeds the investment requirement, output will increase as capital per capita increases. If the savings rate is less than the investment requirement output will fall. When capital per capita is less than the steady-state value of capital per capita, and income less than the steady-state value, capital accumulation will eventually move the economy to the steady-state values (Dornbusch, et al., 2008).

Solow's model is based on a general production function, Y = AF (K, L), which shows the relationship between output and input. Output (Y) rises as the capital stock (K) increases and also through increases in productivity (A) due to technology improvements and a higher labor force stock (L). Thus, the marginal product of labor (MPL) and the marginal product of capital (MPK) are positive. The production function can be used to derive the growth accounting equation. With the growth accounting equation, one can find how large extent capital and productivity attributes to economic growth, assuming diminishing returns to capital and labor.

$$\frac{\Delta Y}{Y} = \left[(1-\theta) * \frac{\Delta L}{L}\right] + \left(\theta * \frac{\Delta K}{K}\right) + \left(\frac{\Delta A}{A}\right) \qquad (1)$$

In Equation (1), $\Delta Y/Y$ is the growth rate of output, $(1-\theta)$ is the labor share, θ is the capital share, $\Delta L/L$ is the growth rate of labor, $\Delta K/K$ is the growth rate of capital, and $\Delta A/A$ is the technological progress (Dornbusch, et al., 2008). With the equation, we can obtain information of how much growth over a time period is due to increases in diverse factors of production and how much comes from other factors.

Growth models show that economic growth comes from one or more factors which are the following: growth in labor quantity and quality (through population growth and education), capital growth (through saving and investment); and technology improvements. Policy making is essential for economic growth as it can promote saving and investment among other factors. Also, by opening up a market of an economy will attract even more domestic and foreign investment, which increases the capital accumulation and economic growth. Population growth can either have a positive or negative effect on the economy. An increase in population growth rate, through for example immigration, can enhance output per capita as more workers are entering the workforce. This depends on how well the economic system incorporates and productively employs the additional workers, a skill connected to the rate of capital accumulation and the availability of associated factors, for instance managerial and administrative skills (Todaro & Smith, 2008).

New growth theory, also known as endogenous growth theory, states that growth is determined by the system ruling the production process instead of forces outside that system. The theory assumes that investments in human capital lead to external economies of scale and productivity improvements. In contrast of the neoclassical assumption of diminishing marginal returns to capital investments, there exist increasing returns to scale in aggregate production. Endogenous growth models emphasize the importance of public policy in encouraging economic development by investments in human capital and promotion of investment in knowledge-intensive industries, for instance computer software and telecommunications (Todaro & Smith, 2008).

The Ramsey-Cass-Koopman's model and the Diamond model are similar to Solow's growth model in the sense that they take into account the growth rates of labor and technological progress which also refers to advances in knowledge. Nonetheless, they differ in the dynamics of economic aggregates since they are established by policies at the microeconomic level. The models derive the development of capital stock from the maximization of households and firms in competitive markets, leading to an endogenous savings rate. These models treat saving as endogenous and time-varying and they are constructed from individuals' behaviors. Since welfare depends on consumption (not output), the models can be used to discuss welfare issues (Romer, 2006).

The Ramsey-Cass-Koopman's model assumes that competitive firms rent capital, hire labor to produce and sell output. In addition to the existence of competitive firms, there is a fixed and infinite amount of households that supply labor, hold capital, consume and save. Firms maximize profits and are owned by households, meaning that any profit accumulates to the households. The economy depends on the behavior of households and firms. Firms employ stocks of capital and labor, pay marginal products and sell the output. Since firms are competitive, they earn their marginal product. Households want to maximize their life-time utility by dividing their incomes (from supplying labor and capital as well as the profit they earn from firms) between consumption and saving at each point in time. Households' utility also depends on the amount they work. This distinguishes the Ramsey-Cass-Koopman's model from Solow's model as saving is derived from the behavior of households while there exist no externalities, implying that saving is not constant along the transition to the steady-state equilibrium. There cannot be an equilibrium in which the economy follows a path and reaches a higher consumption level for every time period. Since households value current consumption more than future consumption, the advantage of the permanent increase in consumption is restricted. What influence households' preferences between current and future consumption is the interest rate. If the interest rate decreases, the savings rate increases. When analyzing the behavior of households, one has to first specify whether the decline in the interest rate was expected or unexpected. Households optimize their utility, dividing the output between consumption and investment, while they believe the interest rate will be unchanged. At some point, the households realize that the preferences have been altered and now lower the future rate of utility (Romer, 2006).

The Diamond Overlapping Generations Model is similar to the Ramsey-Cass-Koopman's model, but differs in the assumption of the population. According to the Diamond model, new households are continuously entering the economy. New individuals are frequently born while old individuals are dying. The individuals have different behavior in two time periods, as young-aged and old-aged. While the young supply one unit of labor dividing it into consumption and saving, the old consume savings and any interest they earn. If an individual's consumption is increasing or decreasing over time depends on whether the real rate of return is higher or lower than the real interest rate. A rise in the real rate of return implies that the second-period consumption is now more favorable which tends to increase saving, but an amount of saving that gives more second-period consumption decreases saving. As the assumptions in the Ramsey-Cass-Koopman's model, there are competitive firms with constant returns to scale and technology grows exogenously. In addition, the real interest rate is equal to the marginal product of capital, since capital earns its marginal product due to competitive markets. Since it is assumed that there is no depreciation, the wage per unit of effective labor is labor's marginal product multiplied by capital per unit of effective labor (Romer, 2006).

Growth models including human capital and Research & Development (R&D) assume endogenous growth of productivity since they highlight investment to knowledge or technological progress. The effectiveness of labor represents knowledge or technology which explains why more output can be produced today. Romer (1990), Grossman and Helpman (1991), Aghion and Howitt (1992) developed growth models including R&D. Their models contain two sectors, a goods-producing sector where output is produced and a R&D sector where the stock of knowledge grows. The general production function still contains the combination of labor, capital and technology (or knowledge) in order to improve technology, capturing the idea of devoting more resources to research will lead to more innovations. Knowledge is not assumed to have constant returns to scale to capital and labor, i.e. doubling inputs as output doubles, implying that the new inputs can do the same as if the old inputs were doubled. With constant returns to scale, the same innovations would be made twice; thereby there is a possibility of diminishing returns in R&D. On the other hand, cooperation between researchers, fixed setup costs etc. might be essential enough for R&D to double capital and labor more than doubling output. In that way there is a possibility of increasing returns in R&D. Population growth increases with growth of knowledge, as the population increases more innovations can be made. New innovations are not created exogenously, but by the population. That is, the long-run growth rate of output per capita is increasing with the rate of population growth. The growth of knowledge can be the source of a higher output and standards of living today than earlier time periods (Romer, 2006).

The standard growth accounting function implies that the change in technological progress does not affect the balance of capital and labor. Mankiw, Romer, and Weil (1992) agreed with Solow that the long-run steady state, the level of output per capita should be positively correlated with the savings rate. They developed an augmented version of the Solow model by adding human capital as a third factor in the growth accounting function. The augmented Solow model provides a better description of cross-country data, according to MRW. Ever since this discovery, many authors have applied the MRW model to make research on the significance of additional growth variables. The MRW model has been very applicable as there have been many cases where the unexpected growth performance of countries are not explained by technological progress, but by factor accumulation (Aghion, et al., 2009). The main focus of the MRW model is on the accumulation of human capital (education), not the human capital stock. Human capital represents the amount of productive services supplied by workers, i.e. the contribution of different skill levels to production. The contribution contains of raw labor (skills that individuals are provided with) and human capital (obtained skills). Every worker's human capital depends on his or her time of education. The more education workers have the more human capital. In addition, as individuals obtain human capital, the ability of obtaining more human capital can improve. For example, individuals learn basic knowledge, such as reading and writing, during the first years of education which do not contribute to growth in output by themselves. However, they are important for attaining additional human capital (Romer, 2006).

The model of this paper is based on new growth theory that takes into account the endogenous savings rate altered by the behavior of different age-groups of a population as in the Diamond model. As the population growth rate is falling, the labor supply decreases while the effectiveness of labor decline as older workers increase. Since the declining young population invests in education, there will be less investment in human capital. Fewer people will graduate a higher education as the economy pressures the population to enter the job market as soon as possible. This also contributes to lower effective labor, which we can learn from the models including human capital and R&D. Technological progress has improved the standards of living which has extended the life expectancy of the population, raising the amount of the old-age population. As a consequence, household savings fall causing the economic growth to go in the same direction since the elderly spend their savings. In summary, the model of this paper focuses on the effect of the increasing second-period age-group (Hurd & Yashiro, 1996).

3 Data and Statistical Method

This section presents the regression model, a description of how the cross-sectional data was collected and has been computed to measure the impact of growth rates.

3.1 Data and Method

The data for the regression analysis and the definitions of the variables were taken from World Bank Development Indicators (World Bank, 2010). One of the demographic data: total dependency ratio, was taken from World Population Prospects (United Nations, 2009). Some data for a few countries were not available, which is the explanation why the test included 52 out of 60 observations. The number of 60 was chosen as sample size since it would give a general image of economic growth affected by demographic factors. The observations were chosen by taking the 60 richest countries judged on their GDP levels. The reason was to look upon countries that were most similar to Japan. The variables are given in growth rates during 10 years and per capita terms. Previous studies have done cross-country comparisons in per worker terms, focusing on the performance of companies on output per worker. This paper investigates the economy as a whole. When emphasizing the savings rate based on endogenous growth theory as this paper does, output per capita behaves similarly as output per worker (Romer, 2006). We are interested in the demographic effects on economic growth for all inhabitants of a country; thus the data is stated in per capita terms (Dornbusch, 2008). The method of forecasting the effect of the demographic change on the industrialized economy is to make a regression analysis on cross-country data using ordinary least squares and estimate the elasticity of each variable affecting GDP per capita. Adding two demographic variables, life expectancy and total dependency ratio into a growth accounting equation based on the neoclassical growth framework, the outcome of the demographic transition on economic growth is estimated. The demographic transition as a factor of economic growth has not been discussed much since numerous growth models include other common variables such as human capital and technological progress. Comparisons can be drawn to this paper with previous research made by Bloom and Finlay (2009), as they highlight the working-age share and include other demographic factors such as dependency ratio and life expectancy. They combine the two dependent age-categories, the young and the elderly into one variable: total dependency ratio. This paper focuses on the latter variables more since they provide the same outcome, i.e. the result of the changed age structure on economic growth.

3.2 Model specification

The following growth model was applied in the regression analysis and shows relationship between the natural log of GDP per capita as dependent variable and the log of capital per capita, labor per capita, total dependency ratio and life expectancy:

$$ln\left(\frac{\left(\frac{\text{GDP}}{\text{Cap}}\right)09}{\left(\frac{\text{GDP}}{\text{Cap}}\right)99}\right) = ln\left(\frac{\left(\frac{\text{Capital}}{\text{Cap}}\right)09}{\left(\frac{\text{Capital}}{\text{Cap}}\right)99}\right) + ln\left(\frac{(\text{Labor/Cap})09}{(\text{Labor/Cap})99}\right) + \left(\frac{(\text{Dependency ratio})09}{(\text{Dependency ratio})99}\right) + \text{Life expectancy}_{99}$$

The complete regression model becomes:

Δln(GDP/Cap) = β_0 + $\beta_1\Delta$ln(Capital/Cap) + $\beta_2\Delta$ln(Labor/Cap) + $\beta_3\Delta$(Dependency ratio) + β_4(Life expectancy) + ε

where Δ signifies the change in 10 years, from base year 1999 to current year 2009, and ε is the error term. GDP per capita, *ln(GDP/Cap)*, capital per capita *ln(Capital/Cap)* and labor per capita, *ln(Labor/Cap)*, were log differenced in order to make them as growth rates, since the rates of change of its natural log are equal to the growth rates of the variables. Only the difference in the total dependency ratio (*Dependency ratio*) was calculated. Life expectancy at birth (*Life expectancy*) was applied as a variable stating the number of years, based on year 1999. The summary containing definitions of the variables are explained in Table 3.1.

In this paper, GDP per capita is simply the growth rate of the economy. Capital per capita needed to be calculated since there are no available data of that kind. By taking the sum of gross capital formation in constant local currency unit (LCU) for 30 years, one can achieve an approximate measure of the capital stock. The gross capital formation (constant LCU) is adjusted for inflation. For capital in 2009, gross capital formation was summed from time period 1979-2009, and for capital in 1999, the sum derived from period 1969-1999. Dividing these capital values with the population rate, capital per capita was obtained for both 1999 and 2009. Labor per capita was calculated by taking the total labor force divided by the population rate. The variable of labor per capita represents the people who are economically active, aged 15 years and above. This includes the employed and the unemployed. The size of labor force depends partly on the amount of females who prioritize the career before families. Capital per capita together with labor per capita out of the growth model influence GDP per capita the most, and show the factors of production per head in a country (Dornbusch, et al., 2008).

To attain the change in the total dependency ratio (*Dependency ratio*), the difference between the value for 1999 and the value for 2009 was taken since the ratio is already in a percentage. The variable signifies the amount of the population aged 14 and below as well as the population aged 65 and above divided by the working-age population. In other words, the share stands for the amount of people being dependent on the work force. Total dependency ratio was chosen since it takes into account the (low) fertility rates as well as the (increased) aging population. Bloom and Finlay (2009) assumed homogeneity in the two dependent age-groups when they ran their regression analysis while this paper includes these groups as one variable. These age-groups do not contribute to growth in output as the old-aged retire and the young-aged are learning basic knowledge that does not add to human capital. However, the basic education is important for obtaining additional human capital (Romer, 2006).

Life expectancy at birth (*Life expectancy*) was handled as a level variable in base year 1999, i.e. the number of years in life expectancy. The definition is the average number of years an infant is expected to live if the current trends of mortality at that year of its birth were constant during its existence. Bloom and Finlay (2009) used life expectancy as level variable since the measurement in number of years would be appropriate in the regression analysis. The choice of the two demographic variables, dependency ratio and life expectancy, was based on the research made by Hurd and Yashiro (1996). They stated that these factors together foster population aging, which affects the labor force. That is, dependency ratio or life expectancy does not raise the population aging alone.

The growth rates of labor per capita and capital per capita are expected to have a positive correlation with the growth rate of GDP per capita in the regression analysis. In contrast, the growth rate of the dependency ratio and the average level of life expectancy are expected to have a negative relationship with the growth rate of GDP per capita.

Table 3.1 Definition of the Variables.

Variable	**Definition**	**Relation to the dependent variable**
lngdp_per_cap Δln(GDP/Cap)	Log of growth in GDP per capita, % Annual change in GDP per person during 10 years	
lnk_per_cap Δln(Capital/Cap)	Log of growth in capital per capita, % Annual change in capital stock to a country's population during 10 years	Positive
lnl_per_cap Δln(Labor/Cap)	Log of growth in labor per capita, % Annual change in labor force to a country's population during 10 years	Positive
Dep Δ (Dependency ratio)	Growth in total dependency ratio, % Annual change in the rate of dependents on the working-age population during 10 years	Negative
life_exp Δ (Life expectancy)	Life expectancy at birth, years Expected life time for newborn if the mortality pattern was constant at its birth year	Negative

4 Empirical Results and Analysis

This section gives an overview of the regression results as well as an interpretation of the values from the regression test.

4.1 Regression Results

The exogenous variables for capital per capita, total dependency ratio and life expectancy are all significant in the model. Their p-values are below the significance level of 5 % which is shown in Table 4.1. Capital per capita has a positive impact on economic growth while the demographic variables have negative effects as expected. The variable for labor per capita is insignificant; thus, this variable is not discussed in this section.

Table 4.1 Regresson results. Dependent variable: Ln(GDP per capita)

Variable	Regression coefficient	T-statistic	P-value
Δln(Cap/Cap)	0.133299*	2.288735	0.0266
Δln(Labor/Cap)	-0.710825	-1.61492	0.113
Δ(Dependency ratio)	-1.161887*	-3.01841	0.0041
(Life expectancy)	-0.011302*	-3.8185	0.0004

R-squared: 0.536025., Adjusted R-squared: 0.496538., # of observations: 60
* Significant at the 5% level

The coefficient of capital per capita shows that if the growth rate increases, GDP per capita will increase. If growth in dependency ratio or the level of life expectancy rises, GDP per capita will decrease. The complete regression results and correlation matrix are shown in Table 6.2 and Table 6.3 in Appendix 2.

4.2 Analysis

The result of the regression analysis has affirmed that the current demographic change slows down economic growth. The coefficients of the demographic variables evidently show the negative impact that life expectancy and total dependency ratio have on growth in GDP per capita. Analyzing the scatter plots, Figures 7.1 in Appendix 3, one can observe the linkages of demographic factors and growth. In addition, it is shown that the high income countries share similar problem since many plots are close to each other. Japan, denoted by the colored plots, has the highest life expectancy and total dependency ratios contributing to a much lower labor force. The increased aging of the population has created increased costs in health care, retirement incomes and social security programs which explain the slowdown of the growth rate in capital per capita. The growth rate of capital per capita for Japan is not impressive, but is similar to the other countries'. One can discover that the demographic transition has hit Japan the hardest, but the other countries are not far away. These results are supported by previous studies made by Bloom and Finlay (2009).

The regression results show that labor per capita has an insignificant relationship to economic growth. Also, the regression results demonstrate the negative relationship between labor per capita and the dependency ratio, i.e. an increase in the population growth leads to a lower economic growth. This outcome is probably due to multicollinearity between labor per capita and the dependency ratio. In line with the neoclassical growth theory, a decreasing population growth rate, hence the decline in labor force, gives a negative effect on economic growth. However, the labor force is less essential than the skills and talents of workers, i.e. the effective labor, which can be explained by the growth theory. Investment in human capital, such as education and on-the-job training, is important since it increases the stock of skills, in the same way physical investment leads to physical capital. In other terms, labor productivity is more important than the size of the labor force (Dornbusch, et al., 2008). Thus, economic growth can still be sustained although a declining population. In addition, as the labor force has declined since the fertility rate has fallen, the aging population has increased and the life expectancy has extended, thanks to improved technological progress in medical services. The negative relationship between higher life expectancy and economic growth was proven in the regression analysis (see Table 6.2 in Appendix 2). One should keep in mind that Japan together with several other countries are in the last stage, the declining phase, and lies in category B of the demographic transition model, i.e. falling birth rates as well as death rates leading to a population decline. The low birth rate is due to the fact of having children implies higher opportunity costs for women entering the labor force. What distinguishes Japan from the other countries in the same stage is the women's strict choice of working or not working. In Japan, the women have to choose between being a full-time housewife and making a career. If the Japanese government minimized these opportunity costs by promoting child-care services or jobs for women with children, it could neutralize the country's low birth rate (Yashiro, 1998).

However, the amount of workers is decreasing tremendously even though there are more females participating in the labor force. The decline of the labor force has lowered GDP per capita, according to statistical data from World Bank. The growth rate of the Japanese labor is the second lowest rate of the 60 richest countries (see Figures 6.1 in Appendix 3). The decline of population does not only decrease the labor supply, but also the level of labor productivity. This affects economic growth negatively because of the lower average quality of labor force due to the increasing amount of older workers (Hurd & Yashiro, 1996).

The large population of Japan has been a main contributor to its qualified labor force and for the economic growth of the country. On the other hand, there are rich countries with a small population for example the Scandinavian countries. The demographic issues are not based on the population sizes, but the course of the diminishing population rate. Japan has been accustomed to its great population size for a long time; thus dramatic changes in demography, from low to high dependency ratio, will shock the economy. The raised economic insecurity due to the financial crisis has elevated the pressure on the workers in terms of more labor hours. As the aged population rises, the working-age population is already pressured in the hectic working conditions such as more overtime work. Both the government and families will have a challenge in supporting the aged population. The working-age population will face lower income, higher taxes and social security contributions in the near future (Yashiro, 1998).

In order to dampen the negative effect on economic growth, the governments of the high income nations have to endorse immigration. The Japanese government must specifically encourage saving in addition to increasing the working-age population through immigration. Raising the normal retirement age might increase the labor force from the 65+ population, but is not the best long run option for the countries. Further implications for policy makers arise when trying to increase the fertility rates. The consequence of increasing the fertility rates will be a lower female labor force participation which could also hinder the economic growth. Promoting immigration seems like the only option to avoid a demographic economic crisis in the future (Bloom, et al., 2009).

Keeping in mind the new growth models, the demographic change has huge impacts on the economy. The demographic transition is responsible for the decline of labor per capita as the population rate decreases; the decrease in capital per capita due to the excess of elderly bringing costs for the countries; and the fall in savings per capita for a long period as the dependency ratio and life expectancy increase. Economic growth will be affected by the change in economic behavior of the population as the rapidly increasing elderly save less than the working-age population. The decreasing savings rate brings a decline in GDP per capita until a new steady-state is reached. How long the process of attaining the equilibrium is up to the governments when making policies that support the economy.

5 Summary and Concluding Remarks

This paper has highlighted the issues of demography affecting economic growth. The regression results have proven that the demographic transition has negative impacts on GDP per capita. As Thompson predicted with the demographic transition model, the higher income a country earns, the less new infants are born. This statement is supported by the conclusion that Japan as well as other high income countries are in the declining and post-industrialized phase. Additionally, as technological progress impacts the standard of living and health care, the higher life expectancies generate more old-aged people. With the new growth models, one can find that the demographic transition affects the growth rates of capital per capita and labor per capita negatively. This is due to the decreasing population rate and the rising costs of the increasing elderly that spend their saving. Consequently, the working-age population must deal with a higher pressure at work, lower income, higher taxes and social security contributions to support the elderly.

Yashiro (1998) stated that Japan is in a situation in which elderly labor force participation rates are higher and more discouraged workers are entered into the job market. Even though, more people are entering the labor force, it has already begun to fall, holding the labor force participation rates constant. There is an increased rate of female participating in the labor force; among those are unmotivated workers who feel they cannot work as well as those who put their career before making a family. This will lead to a lower quality of the labor productivity. A possible solution to stabilize the birth rate is to reduce the opportunity costs for females, for example by raising child-care services or providing work for the women who are over the age of bringing up a child.

The future of high income countries looks critical since the demographic changes are unavoidable. If some governments do not involve in demographic issues, the arising consequences for the economies will be severe. The Japanese government needs to consider increasing in-migrating population immediately. If not, the Japanese population rate is predicted to fall by around 75 % in 2050. This would be a disaster for the economy, as the amount of workers increases or decreases, so does GDP per capita. There is no other choice than to raise innovative policies in order to increase the labor force contributing to economic growth.

6 Appendices

Appendix I

Table 6.1; Descriptive Statistics for the 60 richest countries.

Variable	LNGDP_PER_CAP	LNK_PER_CAP	LNL_PER_CAP	DEP	LIFE_EXP
Mean	0.26647	0.36477	0.058305	-0.053151	72.09644
Median	0.228955	0.237404	0.051518	-0.054936	72.86341
Maximum	0.916231	1.400571	0.181712	0.089747	80.50146
Minimum	-0.006063	-0.286055	-0.064307	-0.184071	43.10071
Std. Dev.	0.182275	0.338615	0.048243	0.061196	6.916645
Observations	52	52	52	52	52

Appendix 2

Table 6.2; Regression results for the 60 richest countries.

Dependent Variable: LNGDP_PER_CAP
Method: Least Squares
Date: 05/06/11 Time: 13:39
Sample: 1 60
Included observations: 52

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.012343	0.221444	4.571555	0.0000
LNK_PER_CAP	0.133299	0.058241	2.288735	0.0266
LNL_PER_CAP	-0.710825	0.440162	-1.614917	0.1130
DEP	-1.161887	0.384933	-3.018409	0.0041
LIFE_EXP	-0.011302	0.002960	-3.818502	0.0004

R-squared	0.536025	Mean dependent var	0.266470
Adjusted R-squared	0.496538	S.D. dependent var	0.182275
S.E. of regression	0.129333	Akaike info criterion	-1.161638
Sum squared resid	0.786173	Schwarz criterion	-0.974018
Log likelihood	35.20258	Hannan-Quinn criter.	-1.089709
F-statistic	13.57464	Durbin-Watson stat	2.198067
Prob(F-statistic)	0.000000		

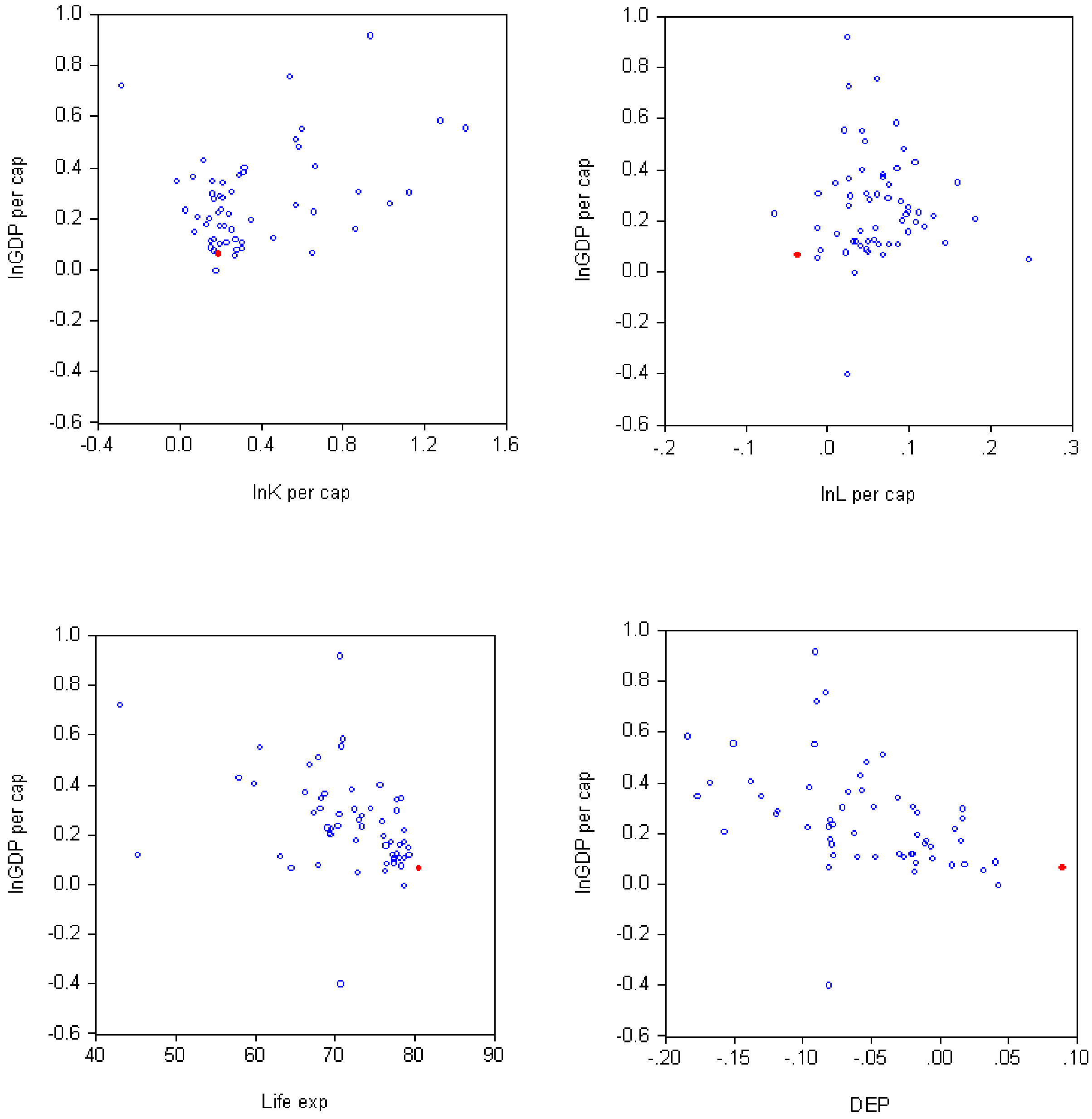
Table 6.3; Correlations between the variables.

Correlations

		lny	lnk	lnl	dep	life
Pearson Correlation	lny	**1.000**	**.351**	**.026**	**-.542**	**-.557**
	lnk	**.351**	**1.000**	**-.188**	**-.194**	**.030**
	lnl	**.026**	**-.188**	**1.000**	**-.444**	**-.209**
	dep	**-.542**	**-.194**	**-.444**	**1.000**	**.445**
	life	**-.557**	**.030**	**-.209**	**.445**	**1.000**
Sig. (1-tailed)	lny	**.**	**.005**	**.428**	**.000**	**.000**
	lnk	**.005**	**.**	**.091**	**.084**	**.416**
	lnl	**.428**	**.091**	**.**	**.000**	**.068**
	dep	**.000**	**.084**	**.000**	**.**	**.000**
	life	**.000**	**.416**	**.068**	**.000**	**.**

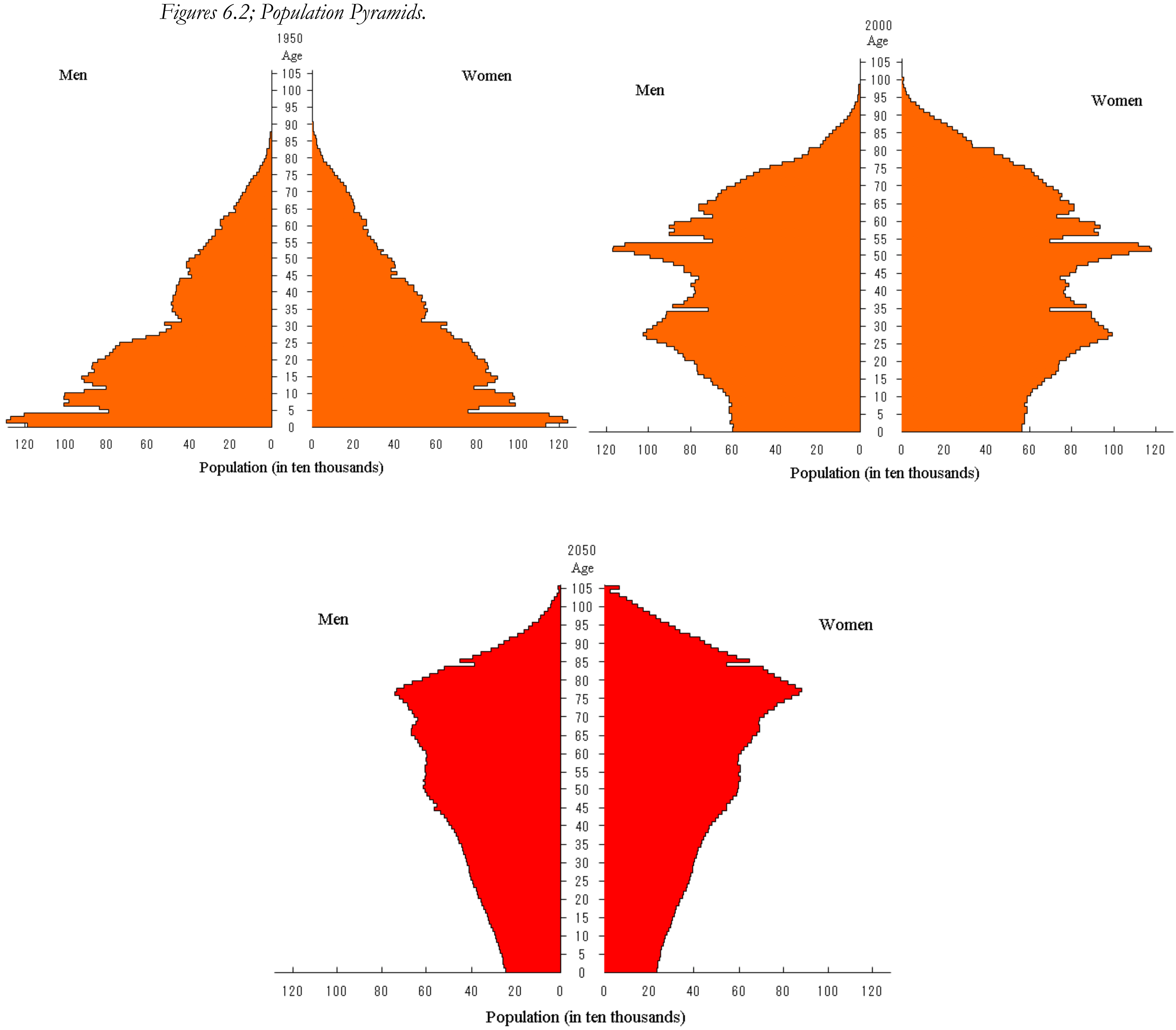
Appendix 3

Figures 6.1; Scatter Plots.



Appendix 4

Figures 6.2; Population Pyramids.



Source: National Institute of Population and Social Security Research, 2010

References

Aghion, P. & Howitt, P. (2009) *Economics of Growth* (p 288-292). Cambridge: MIT Press

Blacker, C. P. (1947). Stages in population growth. *A Survey of Eugenics, 39* (3), p.88-101

Bloom, D.E., Canning D. & Sevilla J. (2001). *Economic Growth and The Demographic Transition* (p. 14-24, 74). Massachusetts: National Bureau of Economic Research

Bloom, D. & Finlay, J. (2009). Demographic Change and Economic Growth in Asia. *Asian Economic Policy Review, 4* (1), p.45-64

Dornbusch, R., Fischer, S. & Startz, R. (10th ed.). (2008). *Macroeconomics*. Singapore: McGraw-Hill/Irwin

Gujarati, D. N. & Porter D. C. (5th ed.). (2009). *Basic Econometrics*. Singapore: McGraw-Hill/Irwin

Hagemann, R. P. & Nicoletti, G. (1989). Population Ageing: Economic Effects and Some Policy Implications for Financing Public Pensions. *OECD Economic Studies, 12* , p.52-84

Horlacher, D., Ermolieva, T., MacKellar, L. & Mayhew, L. (2003). *Economic Impacts of Population Aging in Japan* (p. 45-63). Laxenburg: International Institute for Applied Systems Analysis

Hurd, D. M. & Yashiro, N. (1996). *The Economic Effects of Aging in the United States and Japan* (p. 15-72). Chicago: University of Chicago Press

Kirk, D. (1996). Demographic Transition Theory. *Population Studies: A Journal of Demography, 50* (3), p.361 – 387

Romer, D. (3th ed.). (2006). *Advanced Macroeconomics*. New York: McGraw-Hill/Irwin

Pollack, M. E. (2005). Intelligent Technology for an Aging Population: The Use of AI to Assist Elders with Cognitive Impairment. *AI Magazine,* p. 9-24

Todaro, P. & Smith, C. (10th ed.). (2008). *Economic Development.* Prentice Hall

Yashiro, N. (1998). The Economic Factors for the Declining Birthrate. *Review of Population and Social Policy,7*, p. 129–144

Internet sources

World Bank. *World Bank Development Indicators*. Retrieved 2011, from http://data.worldbank.org/indicator

United Nations. *World Population Prospects*. Retrieved 2011, from http://data.un.org

Population pyramid. *National Institute of Population and Social Security Research.* Retrieved 2011, from http://www.ipss.go.jp/index-e.asp