HUMAN CAPITAL AND ECONOMIC GROWTH IN JAPAN

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ABSTRACT

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In recent decades, Japan's growth rate gradually declined and now lags behind those of other advanced economies and other Asian nations. Japanese government's plan to revitalize the nation's economy stresses population decline and population aging as factors that undermine national growth and development, but also highlights the need to enhance the productivity of human capital through training, economic diversification and technology advancements. Given the closed nature of its island economy, declining birth rates and significant aging of the population, Japan's human capital-focused approach to economic revitalization requires strong understanding of the roles of human capital, as well as new insights on the opportunities to transform such roles to achieve improved economic development.

In this dissertation, I argue that understanding the pattern of productivity growth, the role of immigrants, the quality of human capital and the differentials between Japanese prefectures in development patterns are key to improving the performance of the Japanese economy. I therefore develop three related studies which culminate in three essays. In the first essay, I develop the theoretical framework for growth decomposition and estimate the relationship between economic growth and labor productivity at various scales and identify its determinants. I find that national and regional labor productivities grew over time but their growth rates decreased. I further found that labor productivity measures are positively correlated with physical capital, education and immigrants, but negatively correlated with population aging.

In the second essay, I develop the conceptual framework for deeper understanding of the

role of population aging in regional economic growth. I invoke the multiple generations model in estimating the impacts of various living Japanese generations on economic growth. I find that as generation Z (Gnz), the base generation, ages, economic output increases at a decreasing rate, peaking at age 36, which is younger than current Japanese median age. This reconfirms the notion that as the Japanese society ages, the average contribution of Japanese people to the economy decreases. However, this is conditional on the distributions of other generations and their ages. The older generations, generation X, the before baby boomer generation and the first baby boomer generation, have positive additional economic contribution. On the other hand, the Yutori generation's contribution is less than Gnz and the contribution of the second baby boomer generation and generation Y stops growing at their early 20s. These suggest that younger generations are not able to replace the older ones in terms of productivity.

In the third essay, I develop the conceptual framework for understanding the relative impact of both immigrants and the native population on regional economic growth. I find that the average impacts of international immigrants and natives are both positive, but that the impacts of natives are larger than those of immigrants. I further find that the impacts of immigrants are increasing over time, while natives struggle to contribute to the economy. Given the closed nature of Japanese economy and historical strictness of immigration rules, it appears that immigrants have the potential to help turn around the economic growth rate slowdown. Attempts by the Japanese government to enhance labor productivity by improving the technology environment, especially through information and communication technology seem justifiable.

The findings from my three-pronged essay research make important contributions to the literature on economic transformation and are useful in labor and immigration policy for the future of Japanese society.

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KEY TO ABBREVIATIONS

AI	Artificial Intelligence
GDP	Gross Domestic Product
GOJ	Government of Japan
IoT	Internet of Things
JPY	Japanese Yen
PAC	Prefectural Account Calculation
SNA	System of National Accounts
SSDS	System of Social and Demographic Statistics
USD	United States Dollar

CHAPTER 1. INTRODUCTION

1.1 Background

Japan's annual GDP growth rate declined gradually from over 10% in the 1960s to less than 2% in the 2010s. Japan's growth rate now lags behind those of most other Asian nations and many advanced economies. While Japan's GDP level is still ahead of other Asian economies, the recent decline in growth rate is worrisome, especially for a country which historically relied heavily on its exports for economic viability. In recent years, the Japanese government has made it a high priority to take actions to address the low growth status of Japan.

In 2019, under the leadership of Prime Minister Shinzo Abe, the Japanese government initiated a two-pronged approach to revitalizing the nation's economy (GOJ 2019). The first approach is based on the goal of "Achieving Sustainable Growth." This involved implementing comprehensive reforms to accelerate an economic virtuous cycle, which will help grow Japan's GDP to six hundred trillion JPY[1]. While the target year for this accomplishment is not specified, component strategies for achieving the goal include driving innovations in societal structures, promoting diversity, empowerment of people; advancing smart regulations and laws; exploring attractive international opportunities and creating a more competitive business climate. These strategies are designed to result in production growth, enhanced demand for goods and services, increased consumption and higher incomes. The government particularly stresses shrinking and the aging population of Japan as key factors undermining national growth and development. This

[1] The Japanese government and Japan's ruling party (Liberal Democratic Party) do not state whether the target is real or nominal GDP. Note that Japan's real (base year: 2011) and nominal GDP in 2018 are 534 trillion JPY and 548 trillion JPY, respectively (Cabinet Office 2019).

approach obviously seeks, in part, to leverage Japan's increasingly knowledge-based human capital in expanding the nation's future growth and development.

The second approach is based on the goal of realizing "Society 5.0". This approach is designed to address social problems by utilizing Japan's vast volume of real data in tandem with cutting-edge industrial technologies. This will harness technology to create a new social contract and economic model. According to government documents, robotics, AI, IoT and big data will be used to improve, not only business, but also daily life. As technology eases administrative burdens and knowledge selection, and enhances creativity, it is expected that the nation will discover new solutions to complex social issues such as declining birth rates, aging populations and changes in the environment. Obviously, this approach also seeks to harness Japan's increasingly knowledge-based human capital.

1.2 The Human Capital Focus of the Japanese Government

These initiatives of the Japanese government, often referred to as "Abenomics[2]", strongly recognize the role of human capital in the transformation of the Japanese economy. The government proposes that promoting innovation and developing human resources, especially focusing on women, seniors and immigrants; along with deregulation and economic partnership agreements; are at the root of Japan's economic transformation. Japan's largely human capital-focused approach to economic revitalization requires strong understanding of the historical and current roles of human capital in national development, as well as expanded knowledge of new opportunities to transform such roles to achieve improved economic development.

An important dimension of a nation's human capital is the age structure of the economy. Japan's population aging has been considered to be a cause of decline in economic growth

[2] Named from former Prime Minister of Japan Shinzo Abe, who served from 2006 to 2007 and from 2012 to 2020.

because it has changed the nation's human capital inputs. Due to advances in medicine, health care and quality of life, Japan has low fertility rates and high life expectancy. These make Japan almost the oldest society in the world. Japan has a median age that is the second highest in the world (48.6 years old), after Monaco (55.4) (CIA 2020). This may explain why the Japanese government considers the aging of society and the shrinking of the population as the most important structural issue facing Japan (GOJ 2019).

It is important to recognize that human capital is only one of various exogenous factor that can possibly explain a country's economic growth and development. For example, several factors have been identified in the literature as the causes of declining growth rate in Japan. Ohno (2006) identified the Japan's asset price bubble burst in the 1990s as a culprit. Hoshi and Kashyap (2004) pinpointed Japan's financial system problems as culprits as well. Clearly, the asset price bubble would ordinarily be considered to be an idiosyncratic shock to the Japanese economy. One cannot expect that the 1990s asset bubble would have had a persistent and long-lived declining effect on Japan's economic growth rate. Indeed, several countries that went through similar asset price bubbles recovered within a reasonable period of time. With respect to Japan's financial system, one might also expect its effects not to be long-lived. The implication is that in addition to human capital-related issues, other structural factors are responsible for Japan's declining economic growth performance. It is therefore important to explore their roles in the decline of Japan's growth rate.

1.3 Problem Statement

From an economic standpoint, it makes sense to explore the role of human capital in the context of other factors that may affect growth and productivity. The overall goal of my dissertation is to uncover valuable information that can aid the Japanese society in identifying its options for transforming the economy through human capital improvement. In this dissertation, I identify various limiting human capital factors and evaluate their impacts in the context of other deterrents to growth.

1.4 Dissertation Chapters

I propose to study three specific topics related to the role of human capital in the Japanese economic growth, covering various areas where existing research is inadequate but improved knowledge will increase the ability to develop beneficial policies. The first topic will focus on measuring Japanese labor productivity. In this study, I will estimate national, regional and sectoral labor productivity and test which determinants explain them, focusing on the roles of population aging, immigration and other critical factors. Such analysis will be used to preliminary explore opportunities related to human capital for improving Japanese growth and productivity. Evidence of the relevance of human capital variables in labor productivity will provide some rationale for deeper analysis of factors such as aging and immigration.

The second topic will focus on the impact of population aging on Japan's regional economic growth. This is designed to take the analysis from topic one to the next level. I will utilize a traditional aging variable along with the population and average age of multiple generations as proxies for the aging process. This will help to explain the impacts of generations based on their values and experiences. Deeper knowledge in this area will be useful in understanding the impacts of legacy demographics and the potential to add new demographics to the retinue of growth drivers.

The third topic is the impact of immigration on Japan's labor market and economic growth. I will investigate the impact of international immigration on regional growth in Japan, using Japanese prefectural panel data. By showing the relative economic power of immigrants, this proposed analysis is useful in the development of immigration-based policies for economic development.

To study these three topics, I develop a database comprising of (1) real GDP at the national level, (2) sub-sectoral (by industry) and regional GDP (by prefecture); (3) national, sub-sectoral and regional inputs; (4) other control and exogenous factors that will be identified through my review of the growth and productivity literature, especially human capital factors. I also develop innovative growth decomposition models that allow me to contribute to improved understanding of the human-capital-related drivers of growth in the Japanese economy. Relevant growth elasticities are then estimated and used to develop better understanding of the relative effects of alternative factors, stimuli and policies.

All analyses are conducted at three levels: national, regional (prefectural) and sectoral levels. Because the national analyses are based on data from a longer period, they provide more robust national-level insights. However, the regional analyses allow the observation of prefectural-level differences in the nature of growth and productivity. Finally, sectoral-level analyses allow the observation of differences across major sectors such as manufacturing, agriculture and services. The multi-level analyses in this dissertation could therefore contribute to the ability to set policies that are region- and sector-specific.

1.5 Contributions to the Literature

My dissertation makes several fundamental contributions to the understanding of the pattern of Japan’s growth structure and the decline in GDP growth rate. First, this is the first attempt to simultaneously explore the role of aging and immigration in growth and development in Japan. Second, my use of the current living generations model in growth decomposition for Japan is unique and innovative. Third, my thorough investigation of the relative contributions of immigrants and natives to growth and development at prefecture level is novel. Finally, this dissertation specifically links study finding to the current policy discourse about how to achieve growth and development in Japan.

1.6 Dissertation Outline

The outline for the rest of this dissertation is as follows. In section 2 through 4, I will present three specific topics that my dissertation will cover. Specifically, for each of these topics, I will discuss the motivation for the topic, review relevant literature, present a conceptual framework, discuss the empirical approach, explain required data and present the results. Finally, in section 5, I will cover policy implications of the dissertation research topics and present a summary and conclusions to the dissertation.

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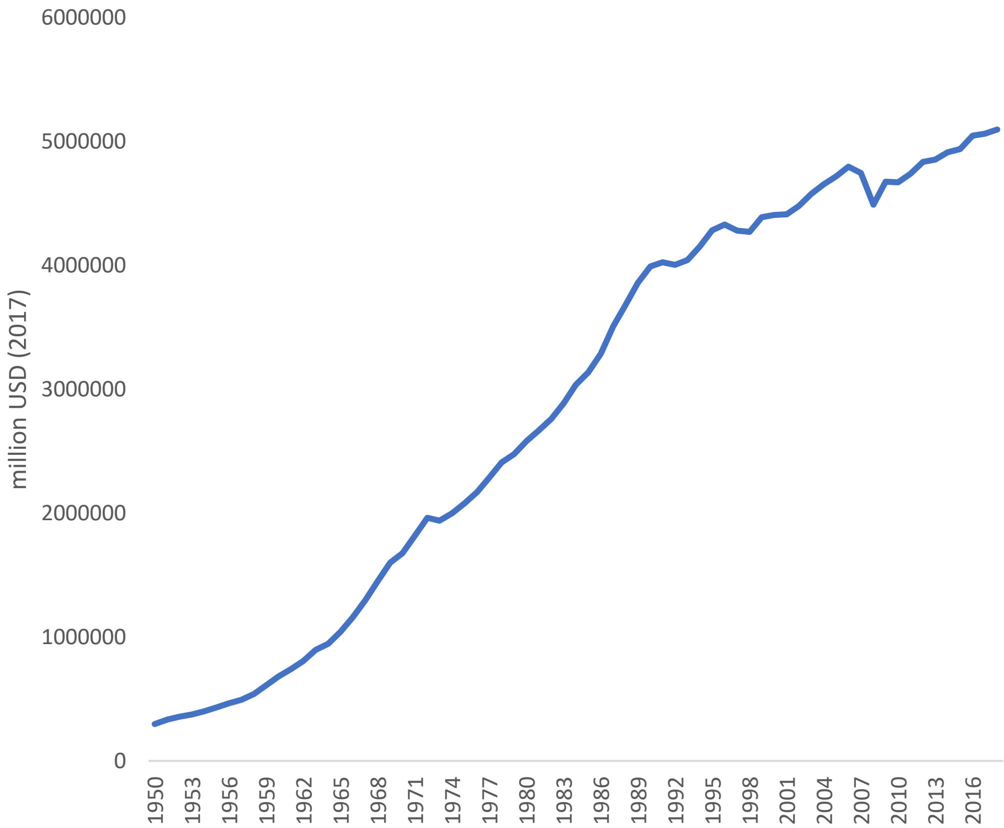
CHAPTER 2. ESSAY 1: LABOR PRODUCTIVITY CHANGE AND ITS DETERMINANTS IN JAPAN: IMPLICATIONS FOR NEW GROWTH OPPORTUNITIES

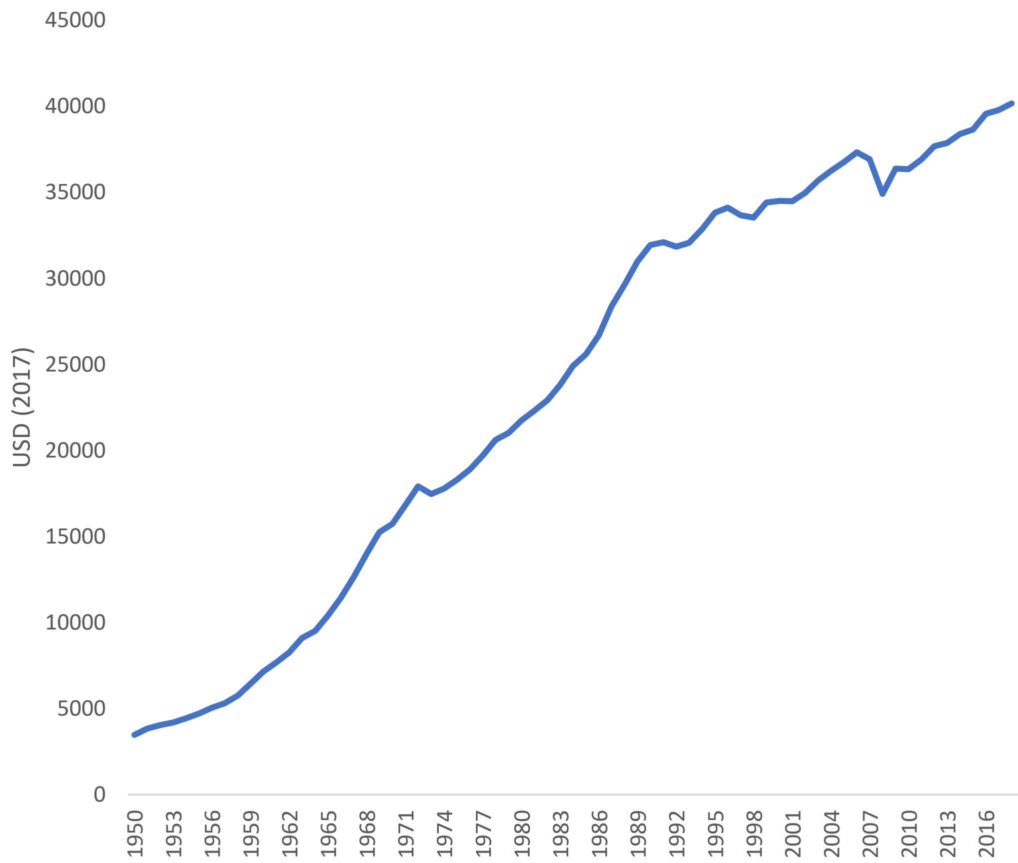
2.1 Introduction

Japan's economy recovered and grew rapidly after World War II. Japan's real GDP increased from 272 billion USD in 1950 to 5.1 trillion USD in 2019 (see Figure 1) while its GDP per capita increased from 3,235 USD in 1950 to 40,167 USD in 2019 (see Figure 2).



Source: Penn World Table

Figure 1: Real GDP in Japan from 1950 to 2019 (million USD in 2017)

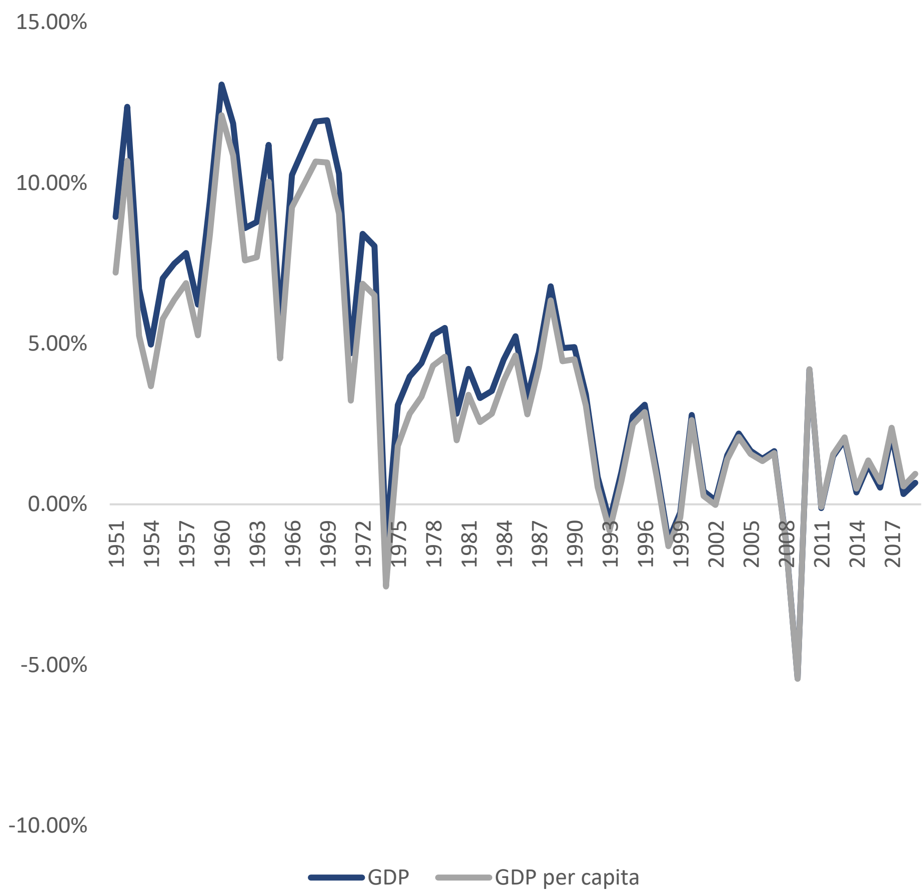


Note: Data compiled and calculated by author on basis of Penn World Table.

Figure 2: Real GDP per capita in Japan from 1950 to 2019 (USD in 2017)

Despite the growing GDP and GDP per capita, their growth rates decreased over time. Figure 3 presents the annual growth rates of GDP and GDP per capita for the period 1951 to 2019. Before the first global oil crisis of 1973, both GDP growth rates and GDP per capita growth rates were over 5% annually and sometimes over 10%. During that period, GDP growth rate was higher than GDP per capita growth rate, suggesting that population growth rates were positive but smaller than GDP growth rates in Japan.

From 1973 to the early 1990s, these growth rates were between 2% and 5%, reflecting a slow-down to the levels for other developed nations whose growth rates were lower than Japan's (growth convergence). The slowdown resulted from structural changes due to the oil crises, from floating exchange rates since 1973 and from trade frictions (Ohno 2006). After the asset bubble burst around 1990, however, both growth rates further declined to about 0-3%. In addition, GDP per capita growth rates was sometimes larger than GDP growth rates, suggesting recent negative population growth in Japan.



Note: Data compiled and calculated by author on basis of Penn World Table.

Figure 3: Real GDP and real GDP per capita growth rate in Japan from 1951 to 2019 (annual, %)

Subsequent Japanese governments have been concerned about the declining growth rates of the economy. Recently, however, the government unfolded new economic policies to revitalize Japan's economy. For example, in 2017, the "New Economic Policy Package" was approved by the Japanese cabinet (Cabinet Office 2017) to break through Japan's stagnant economy and achieve more sustainable growth. This was partly in recognition of the role of falling birthrates and an increasing aging population played in slowing down Japan's growth. The new policy focuses on supply system innovation (to facilitate to improve technology and process efficiency) and human resources development (to increase human productivity). The former was expected to push up productivity through the use of technologies such as AI, robots and the IoT. The latter, human capital development, focused on policies related to the child-rearing generation and children. Through policies such as free early childhood education, free higher education and improvement of compensation for long-term care workers, the government sought to establish a social security system that accommodates the need of all generations, including the elderly and the youth, and to eliminate the concerns of the working-age generation about child-rearing and nursing care.

Even more recently, due to the COVID-19 pandemic, the Japanese government introduced the Emergency Economic Measures on April 2020 (Cabinet Office 2020a) and the Comprehensive Economic Measures on December 2020 (Cabinet Office 2020b) to safeguard the economy and to spur economic recovery. While the Emergency Economic Measures focused on palliative to cushion the effect of the pandemic, the Comprehensive Economic Measures focused on promoting structural change and positive economic cycles for the Post-Corona era. The latter addressed how to realize digitalization, to foster green society, to facilitate structural changes and to promote innovation as a way of enhancing productivity in Post-Corona Japan.

As the Japanese government's strategy is to set economic revitalization policies to improve Japan's productivity (by focusing on human capital, structural change and innovation), it is important to better understand the dynamics of productivity growth in Japan. Specifically, studies focused on calculating Japan's productivity growth and investigating their sources are potentially helpful to Japan's national and regional governments in setting policy targets and improving economic policies. The multi-level analyses pursued in this chapter further allows better understanding of differences between sectors and prefectures. For example, knowledge of how productivity responds to factors such as education, capital accumulation, societal aging, immigration and other factors could be useful in projecting the economic outcomes from specific policy instruments designed to shape the economy thorough enhance productivity. Providing such relevant information is one of the motivations in this study.

There are several measures of productivity, including labor productivity, material productivity and total factor productivity, the latter being an aggregate productivity measure. This chapter focuses only on labor productivity for a number of reasons. First, it is the measure that is most relevant to the types of policies that the Japanese government has been recently implementing. Second, it directly relates to human capital capacity development, which seems to be Japan's focus in revitalizing its economy. Third, evidence from the literature suggests that the labor productivity growth rates are more likely to have been the cause of Japan's economic slowdown in recent decades. For example, the Japanese government regards falling birthrate and aging population as the biggest challenge (Cabinet Office 2017). Furthermore, as I explain in chapter 1, rather than focusing only on productivity analysis at the national level, I also examine regional and sectoral labor productivity growth. This allows deeper insights into regional and sectoral strategies. Improving labor productivity is needed to maintain or increase economic output in the society with population aging where the working-age population is decreasing and where older and more dependent people grow in population share. However, the effectiveness of policies is expected to vary by region and sector.

To investigate the sources of labor productivity changes, I build on the work of Maestas et al. (2016). In their study, Maestas et al. (2016) decompose GDP per capita growth into stock of technology growth, physical capital per capita growth, employment rate change and labor productivity growth. They then regress each component (including labor productivity) on old-age dependency ratio to estimate the impact of population aging on US state output per capita. In my application of this approach to Japanese economy, I go further in the second stage regression by expanding the explanatory variables to include immigration, physical capital and educational levels. I also go further by conducting the analysis at the national, regional (prefectural) and sectoral levels in order to observe the efficacy and robustness of my research findings.

The rationale for my expanded analysis is that the dependency ratio does not fully explain labor productivity. The possible determinants of changing Japan's labor productivity may include population aging and international immigration, as investigated in this chapter. As the Japanese government regards it as the biggest challenge (for example, Cabinet Office (2017)), and same as the US cases in Maestas et al. (2016), population aging may affect labor productivity by decreasing working-age population and increasing skilled, experienced and/or physically weakened labor. Although international immigrant stock is still low in Japan, it is increasing over time and may stimulate innovation, increase business opportunities and solve labor deficiency problems in Japan's labor market.

Here, I explain the methodology utilized in this dissertation in greater detail. To investigate the role of human capital in labor productivity in Japan, national, regional and sectoral labor productivity measures are first calculated to show when, where (place and sector) and how much Japanese labor productivity growth has declined. For example, one is able to identify the sectors or prefectures which contribute more or less to economic growth than average. Second, using the calculated labor productivity measures and data on other economic inputs, the determinants of the labor productivity change are investigated. Based on this and information from the literature review sections, population aging and migration seem to be the most important factors in recent Japanese labor market. Therefore, I estimate whether these two factors, along with other factors such as educational attainment, technology and physical capital, affect Japanese labor productivity.

The findings from this chapter are useful in understanding the importance of human capital to Japan's past, current and future economic growth. They are also useful in understanding which sector or region might be focused on to achieve optimal stimulation to the economy. The findings regarding determinants of labor productivity change are also useful and informative in the execution of subsequent essays or chapters of this dissertation.

The rest of this chapter is organized as follows. Sections 2.2 and 2.3, respectively, present the literature review and conceptual framework for the analysis. Section 2.4 and 2.5, respectively, present the empirical framework and data used in this analysis in this chapter. Section 2.6 presents the empirical result. Finally, section 2.7 presents the conclusion of this chapter.

2.2 Literature Review

The areas of growth decomposition and labor productivity analysis have been the subjects of numerous empirical studies in the literature (see, for example, Mankiw et al. 1992; Islam 1995 and Bassanini and Scarpetta 2001). To summarize this literature, I echo Mankiw et al. (1992) and Bassanini and Scarpetta (2001), who pointed out that the accumulation of physical capital as well as human capital are the main drivers of economic growth. Therefore, I begin the literature review of this chapter by focusing on these aspects of growth research.

Several empirical studies calculated these productivity measures, found their determinants and estimated their contributions. For example, Dua and Garg (2019) investigated the trends in labor productivity of the developing and developed countries of the Asia-Pacific region and examines their determinants. Samargandi (2018) scrutinized the role of various determinants such as human capital, oil rent and industrialization in labor productivity of the Middle East and North Africa (MENA) countries. These studies essentially suggest that labor productivity can be explained based on determinants including inflation, financial development, government size and share of agriculture in GDP.

Adelaja (1992a) expanded the literature by introducing the concept of material productivity. He calculated indices of material productivity for New Jersey's food-manufacturing sector and investigated the mechanism of material productivity growth. Subsequently, Adelaja (1992b) examined total and partial productivity growth in New Jersey's food-processing sector. Studies by Adelaja essentially recognize the notion that labor, capital and raw materials, the factors of production, provide pathways through which productivity growth could be explained.

Maestas et al. (2016) further showed the importance of previously unexplored sources of productivity growth, population aging. They estimated the economic impact of population aging on the US state output per capita, labor productivity, labor participation rate and wage rates. Evidence provided Maestas et al. (2016) suggests that aging reduces GDP per capita and two-thirds of the reduction is due to slower growth in the labor productivity. They also showed that one-third of the reduction arises from slower labor force growth.

Many studies that specifically explored productivity growth in Japan focused on the concept of convergence. They examined output growth, productivity growth and income convergence within regions of the Japanese economy. The convergence framework is important because it would allow the evaluation of how various growth determinants affect important growth outcome disparities between various demographics within the Japanese society.

Specifically, Barro and Sala-i-Martin (1992) found convergence across and within regions of Japan and the US. The finding that low status regions grow faster than higher status ones suggest the existence of an equilibrium relationship between regions and the national economy. However, Kawagoe (1999) showed that convergence does not hold for the Japanese economy with respect to regional data. Kakamu and Fukushige (2005) analyzed both regional and individual income inequality for different periods and found that interregional income inequality decreased in the 1990s, but individual income inequality increases over the same period. Fukushige and Ishikawa (2007) found that there is a small interregional differential in productivity and each degree of inequality gradually decreases over time. Seya et al. (2012) analyzed regional income disparities in Japan in the period after the bubble burst. Shibamoto et al. (2016) used panel cointegration approach to analyze both long-run equilibrium growth path and short-run dynamics across the regions. Another study on convergence aspect of the Japanese economy was conducted by Essletzbichler and Kadokawa (2010). They calculated labor productivity for the manufacturing sector in Japanese prefectures and found polarization of productivity levels during the period of fast productivity growth, while convergence was found during the period of slow growth.

The general conclusion that can be drawn from the literature of convergence is that output and labor productivity growth depend on the relationships between regions, between region and nation, and between nation and the rest of the world, on the differences across sectors and on whether the economy is growing (or not due to such as the financial crisis and large earthquake). These suggests that it is important to evaluate productivity growth from the national, regional and sectoral perspectives.

In terms of data sources, the literature suggests various sources of productivity measures or ingredients for calculating such measures. For example, labor productivity calculations for Japan are provided by the Japan Productivity Center (JPC). National labor productivity, prefectural labor productivity and sectoral labor productivity are available at their website. I use some of their data for the calculation of productivity measures used in my empirical analysis. However, JPC does not provide information on the factors that determine labor productivity. Therefore, by explaining the sources of labor productivity growth, this chapter provides more comprehensive rendering of productivity change in Japan. This should be of interest to Japan's policy makers. The analysis contained in this essay also fills a gap in the literature, specifically the role of human capital for changing labor productivity in Japan.

2.3 Conceptual Framework

Rather than using a traditional production function approach, which has been heavily criticized based on the notion that its independent variables are not purely exogenous (Aguirregabiria 2009), I utilize a productivity decomposition approach. Maestas et al. (2016) presents a framework for evaluating the impacts of population aging on measures of regional economic outputs such as GDP per capita and labor productivity of the US. I propose to use and expand on this methodology in investigating and calculating labor productivity and how human capital variables shape Japanese economy. The model is specified as follows.

Let Prod_{pst} be the labor productivity of prefecture *p*, for sector *s*, in year *t*. Since labor productivity is defined as output per unit of labor, it is specified as follows:

$$Prod_{pst} = \frac{Y_{pst}}{L_{pst}}, \qquad (1)$$

where Y_{pst} and L_{pst} are output and labor input of prefecture *p*, for sector *s*, in year *t*. The output is implicitly specified as follows:

$$Y_{pst} = F\left(K_{pst}, N_{pt}, H_{pst}, X_{pst}\right), \tag{2}$$

where K_{pst} is physical capital, N_{pt} is total population, H_{pst} is human capital, X_{pst} is a vector or other contributory factors, including technology and place characteristics in year t. Assume that the production function exhibits constant returns to scale. Dividing both sides of equation (2) by L_{pst}, one obtains,

$$Prod_{pst} = \frac{F\left(K_{pst}, N_{pt}, H_{pst}, X_{pst}\right)}{L_{pst}} = f\left(k_{pst}, n_{pst}, h_{pst}, x_{pst}\right), \tag{3}$$

where $k_{pst}, n_{pst}, h_{pst}$ and x_{pst} are physical capital, population, human capital and other contributory factors per unit of labor input in year t.

In reality, while labor is observable and often measurable, human capital is typically unobservable. However, human capital is often proxied by workers' educational attainment and age (working experience). In addition, I expect that migration status also affects human capital, positively (by stimulating innovation and increasing business opportunities) or negatively (by downgrading and assimilation) depending on whether new immigrants possess greater or lower human capital, skills, experience or know-how. That is,

$$h_{pst} = h\left(e_{pst}, age_{pst}, mig_{pst}\right), \tag{4}$$

where e_{pst}, age_{pst}, and mig_{pst} are the average educational attainment, median age and the share of migrants. Therefore, the equation (3) becomes

$$Prod_{pst} = f\left(k_{pst}, n_{pst}, h\left(e_{pst}, age_{pst}, mig_{pst}\right), x_{pst}\right). \tag{5}$$

Taking the total derivate of equation (5), the following is obtained:

$$\begin{aligned} dProd_{pst} = {} & \frac{\partial f}{\partial k} dk_{pst} + \frac{\partial f}{\partial n} dn_{pst} + \frac{\partial f}{\partial x} dx_{pst} \\ & + \frac{\partial f}{\partial h}\left(\frac{\partial h}{\partial e} de_{pst} + \frac{\partial h}{\partial age} dage_{pst} + \frac{\partial h}{\partial mig} dmig_{pst}\right). \end{aligned} \tag{6}$$

Equation (6) can further be expressed as

$$\frac{dProd_{pst}}{Prod_{pst}} = \frac{\partial f}{\partial k}\frac{k_{pst}}{Prod_{pst}}\frac{dk_{pst}}{k_{pst}} + \frac{\partial f}{\partial n}\frac{n_{pst}}{Prod_{pst}}\frac{dn_{pst}}{n_{pst}} + \frac{\partial f}{\partial x}\frac{x_{pst}}{Prod_{pst}}\frac{dx_{pst}}{x_{pst}}$$
$$+ \frac{\partial f}{\partial h}\frac{h_{pst}}{Prod_{pst}}\left(\frac{\partial h}{\partial e}\frac{e_{pst}}{h_{pst}}\frac{de_{pst}}{e_{pst}} + \frac{\partial h}{\partial age}\frac{age_{pst}}{h_{pst}}\frac{dage_{pst}}{age_{pst}} + \frac{\partial h}{\partial mig}\frac{mig_{pst}}{h_{pst}}\frac{dmig_{pst}}{mig_{pst}}\right). \quad (7)$$

Hence,

$$\ln Prod_{pst} = \alpha_k \ln k_{pst} + \alpha_n \ln n_{pst} + \alpha_x \ln x_{pst}$$
$$+\alpha_h\left(\beta_e \ln e_{pst} + \beta_{age} \ln age_{pst} + \beta_{mig} \ln mig_{pst}\right), \quad (8)$$

where α_j is the elasticity of labor productivity with respect of j^{th} input ($j \in \{k, n, x, h\}$) and β_l is the elasticity of average human capital with respect to l^{th} input ($l \in \{e, age, mig\}$). Equation (8) suggests that the log of labor productivity is a function of the log of per capita physical capital, average educational attainment, average age and migrant stock.

Equation (8) is the basis for evaluating the effects of determinants on labor productivity. The process involved calculating labor productivity and then specifying it as a function of physical capital, average educational attainment, average age and migrant stock.

2.4 Empirical Framework

Dua and Garg (2019) investigate the determinants of labor productivity by regressing the log of labor productivity on the log of human capital, physical capital, technological progress and several other variables that could affect labor productivity (e.g., inflation, financial development, quality of institutions, macroeconomic factors and share of agriculture in GDP). Their unit of analysis is countries. For the US, Maestas et al. (2016) investigate the economic impact of aging on various economic indicators such as output per capita, labor productivity and employment rate. I propose to combine Dua and Garg (2019) and Maestas et al. (2016) methodologies, but expand on them in investigating how population aging and immigrants contribute to labor productivity in Japan. I will estimate the following empirical model or a variant of it:

$$\ln Prod_{pst} = a_0 + a_1 \ln k_{pst} + a_2 \ln dep_{pst} + a_3 \ln e_{pst} + a_4 \ln mig_{pst} + a_5 \ln age_{pst} + x_p + x_s + x_t + \varepsilon_{pst}, \quad (9)$$

where ln dep_{pst} is the dependency ratio defined as the ratio of non-employer population to employer population, $x_p, x_s,$ and x_t are the prefectural, sectoral and time fixed-effects and ε_{pst} is the error term. Please note that equation (9) is a decomposition analysis and does not connote any causal relationship.

The estimated contributions of population aging are observed through a_2 and a_5. In addition to the median age, I use median age square as explanatory variable. As pointed out in Miyahara and Adelaja (2020), single indicators like dependency ratios, average age and median age are not enough to capture the impact of population aging on the economy. Further investigation on this challenge is addressed in the second essay (chapter 3). The ratio of international migrants to the population are used as the indicator of migration (ln mig_{pst}). The impact of international migration, its change and its comparison between the impact of native population is investigated in the third essay (chapter 4).

2.5 Data

First, to calculate labor productivity at the national level, real GDP and the number of persons engaged (total employment) are obtained from the Penn World Table 10.0 (PWT) (Feenstra et al. 2015). Labor productivity indices are calculated following Maestas et al. (2016) and they range from 1950 to 2019. To calculate the regional labor productivity measures, prefectural real GDPs are obtained from the PAC, which is available at the SSDS. The earlier part of the series runs from 1990 to 2003, but has the base year of 1995. The latter part of the series, which runs from 2001 to 2010, has the base year of 2005. So, I merged the two series by using the base year of 2001 in order to have a continuous dataset spanning 1990 to 2010. Data on employers are obtained from the PAC, which is also available at the SSDS.

Two sectoral labor productivity measures are used in this chapter. One is the sectoral labor productivity at national level (national-sectoral labor productivity) ranging from 1994 to 2018, obtained from the Japan Main Productivity-indicators database (JMPID) calculated by the JPC. The other is the sectoral labor productivity at prefectural level (regional-sectoral labor productivity) based on sectoral GDP (from the PAC) and employers (from the Economic Census for Business Frame, Establishment and Enterprise Census of Japan, which is also available at the SSDS) at prefectural level. Note that to follow the industry classification used in the JMPID, in calculating the regional-sectoral labor productivity, I use the GDP series running from 2006 to 2018, which is different from the GDP series used to calculate regional labor productivity. Table 1 shows the industry classification used in this chapter.

Table 1: Industry classification

Industry
Agriculture, forestry and fishing
Mining
Manufacturing
Electricity, gas and water supply, waste management service
Construction
Wholesale and retail trade
Transport and postal services
Accommodation and food service activities
Information and communications
Finance and insurance
Real estate
Professional, scientific and technical activities
Public administration
Education
Human health and social work activities
Other service activities

Source: JMPID, PAC

To investigate the role of population aging and international migration in labor productivity growth, data on total population, working-age population, median age and a population of registered foreign nationals are utilized. Total population and working-age population are obtained at the national level from the PWT and at the regional level from Population Census (PC) and Population Estimates (PE). At the national level, data on median age is obtained from the World Population Prospects 2019 (UN Population Division 2019). At the regional level, it is obtained from the PC. Note that the PC is carried out every five years. In generating approximations of the median age of each prefecture, I assume that the median age changes linearly. The population of registered foreign nationals are obtained from the Foreign Resident Statistics generated by the Ministry of Justice. This is available at the SSDS.

As control variables, physical capital and educational attainment are utilized. National capital stock is obtained from the PWT. Regional and sectoral capital stock is proxied by the consumption of fixed capital, which is obtained from the PAC. I use the percentages of people that have completed high school, junior college and university from the PC as proxies for human capital stock. Since the education data is collected every ten years (the available data is in 1980, 1990, 2000 and 2010), as oppose to other variables, I assume that the education variables change linearly over non-Census years.

2.6 Empirical Results

Empirical results for this chapter of the dissertation are presented in this subsection.

Labor Productivity Calculation

The estimated values of national labor productivity for Japan are presented in Figure 4. Note that for these values, the data range is from 1950 to 2019. The associated annual labor productivity growth rates appear in Figure 5 for 1951-2019. In general, similar to GDP and GDP per capita (see Figure 3), Japan's national labor productivity continued to grow, but its growth rate decreased over time. Due to this similarity, investigating the changes and differences in labor productivity seems to have significant role in the research on Japan's economic growth.

Before the first global oil crises in 1973, Japan's annual national labor productivity growth rate ranged between 4% and 10%. For the period between the first oil crisis and Japan's asset bubble burst in the 1990s, the annual labor productivity growth rate ranged from 2% to 4%. After the asset bubble burst, the annual labor productivity growth rate fell to between 0% and 2%, with exceptions such as the 2009 financial crisis and recovery from it in 2010 when the growth rates were negative. The continuous downward trend in the national labor productivity growth rate is particularly evident in Figure 5. Note the negative annual labor productivity growth rate in 1975, 1994 and 2009.

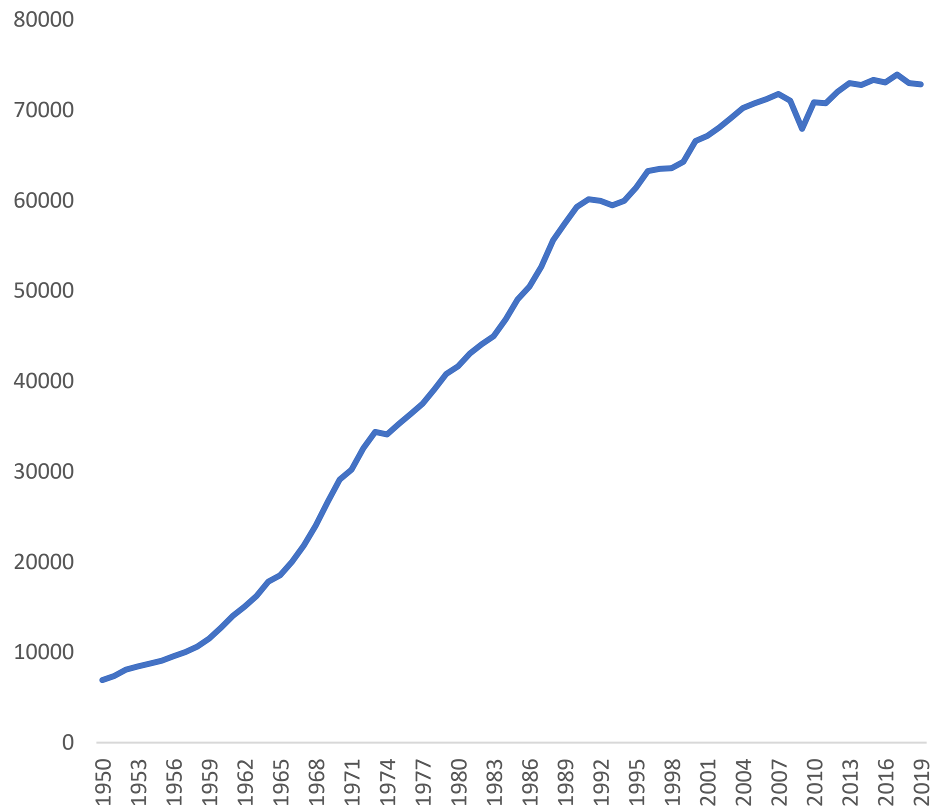


Figure 4: National labor productivity in Japan from 1950 to 2019 (2017 USD)

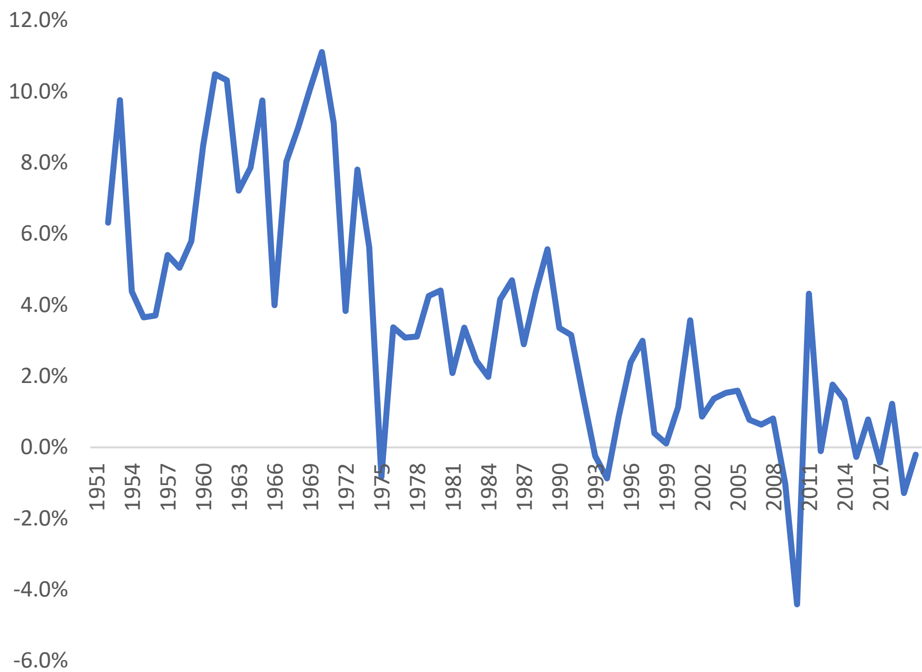


Figure 5: National labor productivity growth rate in Japan from 1951 to 2019 (annual, %)

Table 2 presents regional labor productivity measures in 1990 and 2014. Note that the data range of regional labor productivity is from 1990 to 2014. Note the similarity between Figure 5 (national labor productivity growth rate) and Figure 3 (GDP growth rate). This supports the argument that labor productivity growth rate is the dominant determinant of GDP growth rate. In Table 2, the regional-level labor productivity measures are ordered across prefectures on the basis of their 1990 labor productivity measures. Note the generally higher labor productivity measures for 2014, compared with 1990. Note also the discrepancy across prefectures in labor productivity rate. For example, Tokyo was consistently the most productive both in 1990 and 2014. Larger labor productivity is generally observed in other metropolitan areas such as Osaka and Aichi[3]. However, non-metropolitan and rural prefectures tended to feature or start with low labor productivity measures. It is noteworthy, however, that Mie, which featured low labor productivity in 1990, became the second most productive prefecture by 2014. High growth in

[3] Kanagawa, Chiba, Saitama and Ibaraki are in the Greater Tokyo area. Shiga and Hyogo are close to Osaka.

labor productivity generally tended to occur in non-metropolitan and regions that started with low levels of labor productivity. All prefectures experience labor productivity growth from 1990 to 2014 but there are large regional differences in growth rates. Higher levels of dependence on agriculture, faster population aging and decreasing population may explain the persistently low productivities in many rural prefectures (Table 3). Therefore, these factors appear to be correlated with low levels of labor productivity.

Table 2: Regional labor productivity in 1990 and 2014 (JPY)

	1990	2014		1990	2014
Tokyo	9,029,855	12,371,430	Hokkaido	6,551,285	8,454,122
Kanagawa	8,841,892	9,468,205	Wakayama	6,380,206	8,440,959
Shiga	8,700,362	10,995,917	Kagawa	6,329,116	8,662,831
Chiba	8,326,931	9,221,995	Oita	6,309,426	9,164,157
Osaka	8,141,352	9,759,063	Gifu	6,275,922	8,298,403
Hyogo	8,077,766	9,856,995	Niigata	6,242,138	8,335,146
Aichi	7,522,156	9,640,947	Okinawa	6,010,086	6,708,770
Saitama	7,392,924	8,434,883	Tottori	5,913,763	7,481,178
Ibaraki	7,317,038	9,799,942	Fukushima	5,866,414	9,924,366
Hiroshima	7,299,356	9,268,612	Nagano	5,850,135	9,013,561
Toyama	7,155,893	9,326,189	Kumamoto	5,834,883	7,800,508
Tochigi	7,145,056	9,507,507	Tokushima	5,757,292	9,936,522
Kyoto	7,137,269	9,078,586	Saga	5,624,271	7,866,678
Okayama	7,120,191	9,241,199	Nagasaki	5,589,438	7,199,243
Shizuoka	7,006,261	9,055,361	Yamagata	5,559,569	8,581,270
Nara	6,998,427	8,330,903	Ehime	5,525,350	8,077,919
Gunma	6,988,062	9,324,324	Miyazaki	5,451,183	7,626,124
Fukuoka	6,806,718	8,313,158	Akita	5,430,345	7,927,066
Mie	6,780,981	11,381,927	Kagoshima	5,423,958	7,706,127
Ishikawa	6,646,636	8,548,539	Aomori	5,277,426	7,715,599
Yamanashi	6,634,748	9,554,901	Shimane	5,255,326	7,700,607
Fukui	6,633,927	9,202,413	Kochi	5,084,576	7,396,814
Miyagi	6,579,219	9,627,169	Iwate	4,923,112	7,731,305
Yamaguchi	6,576,602	10,317,468			

Table 3: Comparison of population aging and dependence of agriculture between higher-labor productivity regions and lower-labor productivity regions

	Population growth	Median age	Old people share	Agriculture share
Tokyo	13.0%	42.3	22.5%	0.05%
Kanagawa	14.1%	42.6	23.2%	0.19%
Shiga	15.7%	42.5	23.4%	0.65%
Chiba	11.8%	44	25.3%	1.09%
Osaka	1.3%	43.7	25.7%	0.10%
Kagoshima	-7.6%	49	28.6%	3.70%
Aomori	-10.8%	49.1	29.0%	3.86%
Shimane	-10.5%	51	31.8%	1.55%
Kochi	-10.8%	50.9	32.2%	3.95%
Iwate	-9.0%	49.5	29.6%	3.08%

Note: "Population growth" is the total population growth from 1990 to 2014, calculated by the author. "Median age" is in 2010. "Old people share" is the share of people aged more than 64 years old to total population in 2014. "Agriculture share" is the GDP share of agriculture, forestry and fishery to total GDP in 2014, calculated by the author.
Source: SSDS

In relative terms, in 1990, Tokyo's labor productivity was the highest and it was 1.83 times higher than that of Iwate. However, this ratio had shrunk to 1.67 by 2014 (comparison between Tokyo's and Kochi's labor productivity). This suggests convergence in regional labor productivity between 1990 and 2014. This is consistent with the finding of Essletzbichler and Kadokawa (2010) that regional labor productivity of the Japanese manufacturing sector has converged since the early 1990s.

Figure 6 presents regional labor productivity measures for five prefectures in Japan. Three of these prefectures are at the center of Japan's three major metropolitan areas (Tokyo, Osaka and Aichi). The other two prefectures (Kochi and Iwate) had the lowest labor productivity levels among 47 Japanese prefectures in 1990 (Iwate prefecture) and in 2014 (Kochi prefecture).

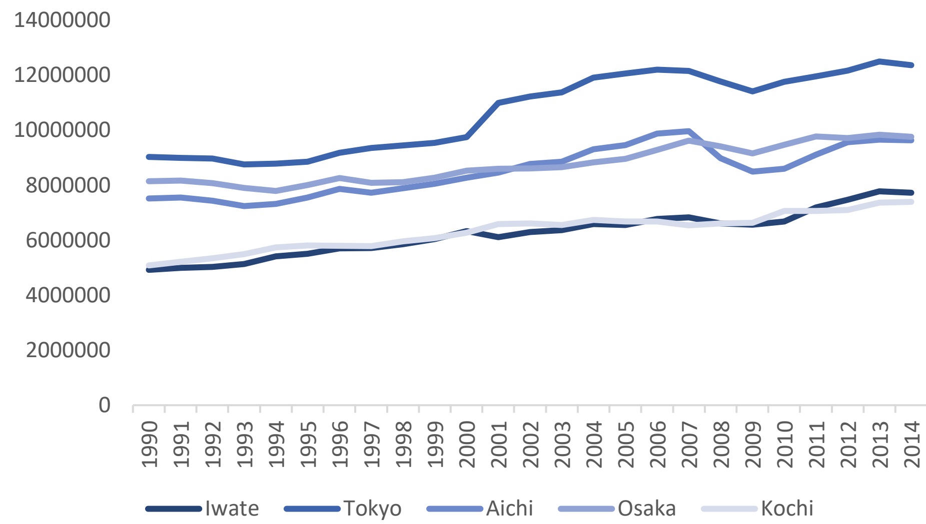


Figure 6: Regional labor productivity in selected five prefectures from 1990 to 2014 (2011 JPY)

The trend in national labor productivity observed in Figure 4 can also be observed in regional labor productivity. For example, regional labor productivity grew over time but in 2008 and 2009, it decreases, probably due to the global financial crisis. Tokyo and Aichi appear to have been more adversely affected by the financial crisis than other prefectures. This may be because of their dependence on international trade and global markets. Since Tokyo is the capital of Japan and Aichi depends on the automobile industry (Aichi is home to the Toyota Motor Corporation), their economies are more affected by global economic conditions.

Figure 7 and Figure *8* present the sectoral labor productivity measures. Note that for the sectoral analysis, the data range is from 1994 to 2018. Estimates of labor productivity for all industries, for the primary sector (agriculture, forestry and fishing), for the secondary sector (manufacturing) and for the tertiary sector (service) are presented in Figure 7. Agricultural labor productivity was very low and less than one-third of national labor productivity. This reflects the fact that agricultural commodities tend to be input into various manufacturing, wholesale, retail and service products where more value-added activities are occurred. In addition, it has been stable over time since 1994. Agricultural policies in Japan were introduced to ensure stable food supply, to fulfill the multifunctional role of agriculture and to achieve sustainable growth of agriculture and rural development (Food, Agriculture and Rural Areas Basic Act set in 1999). This may explain why sustainable growth of agriculture has not been achieved yet, at least in terms of labor productivity.

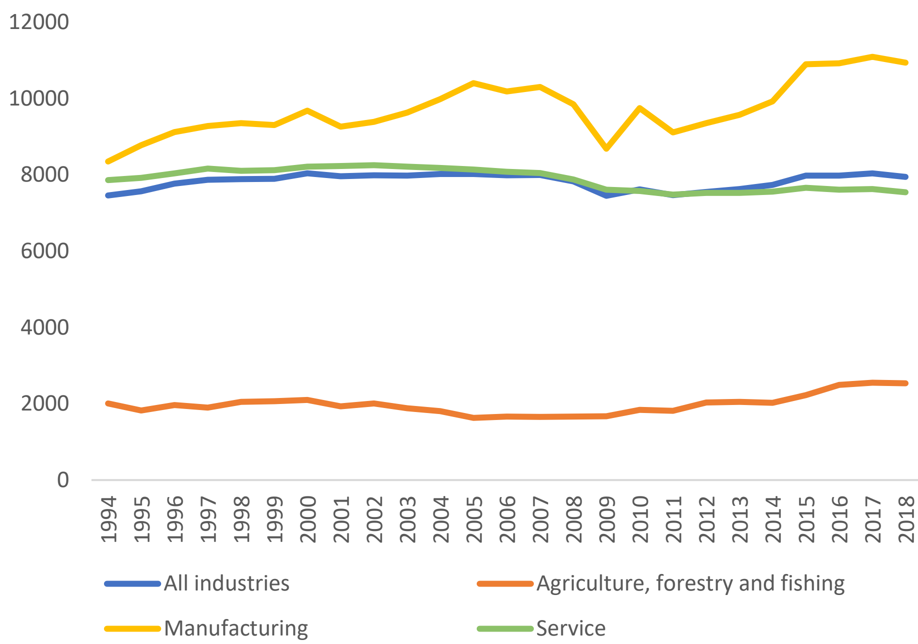


Figure 7: Labor productivities of Japan's primary, secondary and tertiary industries from 1994 to 2018 (2011 JPY)

Manufacturing labor productivity was consistently larger than national and other sectors' labor productivities. This makes sense, considering that Japan is known to be highly efficient in manufacturing, especially electronics and automobiles, which it is known globally for. Despite some temporal declines during the financial crisis of 2008 and the Great East Japan Earthquake of 2011, manufacturing labor productivity increased over time. However, labor productivity in the service sector was stable and close to national labor productivity from 1994 to 2018.

More detailed sectoral labor productivity measures are presented in Figure 8 for key subsectors. This figure breaks down labor productivity for segments of the service sector and compares these to other sectors such as manufacturing and agriculture. Actually, the real estate sector had the highest level of labor productivity, higher than manufacturing. The electricity, gas and water supply and waste management service sector come second, compared with real estate. These sectors are capital intensive and require substantial land, building, power supply and other infrastructure. Therefore, the high infrastructure inputs naturally lead to higher labor productivity.

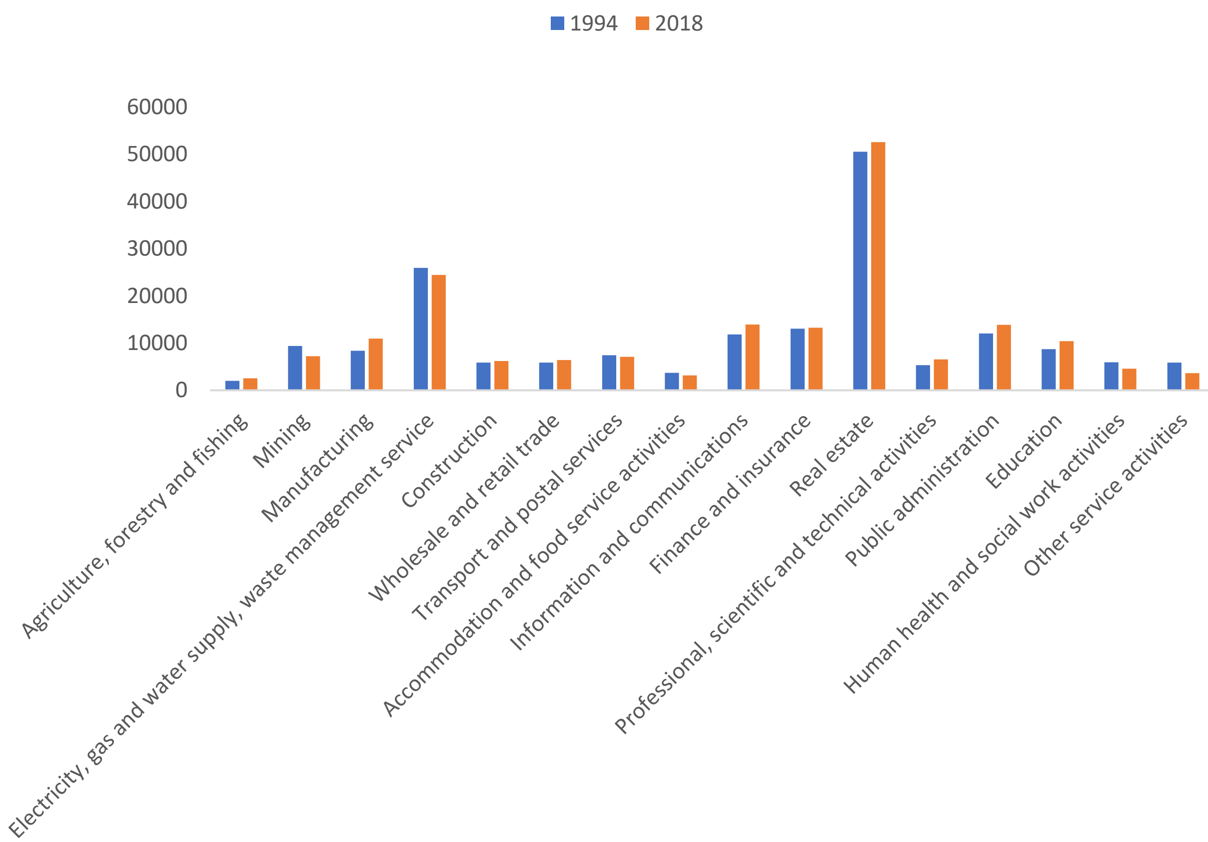


Figure 8: Sectoral labor productivities in 1994 and 2018

The finance and insurance sector had the third highest labor productivity measure in 1994, while the information and communications (ICT) sector had the third highest in 2018. The faster growth in labor productivity for the ICT sector is consistent with global trend. That is, economic growth and technology development in ICT may be a reason for its high labor productivity and subsequent growth. Since the Japanese government recently targeted the promotion of digitalization as a national strategy (for example, Cabinet Office (2020b)), labor productivity of the ICT sector would likely increase faster in the future if this new government policies are effective.

Similar to the findings from Figure 7, Figure 8 shows that the agriculture, forestry and fishing sector had the lowest labor productivity. The accommodation and food service activities (hospitality) sector had the second lowest labor productivity in both 1994 and 2018. While this sector is labor intensive, its labor productivity is generally lower than other sectors.

Overall, 10 sectors experienced labor productivity increases from 1994 to 2018 while 6 sectors experienced labor productivity decreases. The latter category includes shrinking industries (such as mining) and low wage industries (such as accommodation and food service activities and human health and social work activities[4]). Note that although it seems that low wage is correlated with low labor productivity, this does not imply that low wage results in decrease in labor productivity, and vice versa.

Investigating the Determinants of Labor Productivity Change

In the previous subsection, the heterogeneity of labor productivity measures across regions, sectors and over time are explained. In this subsection, the goal is to explain such differences on the basis of hypothesized explanatory factors. So, the hypotheses that labor productivity measures are affected by factors such as population aging, immigration, industrial structure, physical capital and education are tested. Specific hypotheses to be tested include: (a) population aging negatively affects labor productivity, (b) physical capital positively impacts on national, regional and sectoral labor productivity, and (c) industrial structure/composition

[4] In 2019, the average monthly wages of accommodation and food service activities sector and human health and social work activities sector were 125.1 thousand JPY and 298.9 thousand JPY, respectively (for establishments with at least five regular employees). These are smaller than the average wages of all sectors (322.6 thousand JPY) (MLHW 2021).

explains regional labor productivity differences. Equation (9) is estimated at the national, regional and sectoral levels.

Results from the National Labor Productivity Model

The parameter estimates for equation (9) are presented in Table 4, Table *5* and Table *7*. Table 4 reports the estimated result of national labor productivity model where the dependent variable is the log of national labor productivity and the independent variables are the log of physical capital per employer, median age and its square, dependency ratio and time trend. Note that this model is estimated using time series data. Table 5 reports that of the regional labor productivity model where the dependent variable is the log of prefectural labor productivity and the independent variables are the log of capital per employer, dependency ratio, median age and its square, immigrant share (immigrant population per 1,000 people), educational attainments and time trend. Note that this model is estimated using panel data (47 prefectures across time). Table 7 reports the results of the sectoral-regional labor productivity model where the dependent variable is the log of sectoral labor productivity at prefecture level and the independent variables are the same as those of the regional labor productivity model. The data used in this model is three-dimensional in the sense that each observation is for a specific sector in a given prefecture across time. Appropriate estimation techniques are used in estimating each of the models.

Possible independent variables in equation (9) are the dependency ratio, immigrant share, log of capital per employer, educational attainment, time trend, median age and its square. However, due to the limited available time series data for the education (1990-2010) and migration (1986, 1988, 1990, 1992, 1994 and 1996-2014) variables, to obtain the robust estimation results I exclude them in my national productivity model estimation[5]. The roles of immigration and education are estimated in the regional and sectoral productivity models. It is required that the dependent variable (log of national labor productivity) is stationary in order to avoid the problem of spurious regression. Therefore, the series is tested for unit root based on the Augmented Dickey–Fuller (ADF) test. The result of the ADF test suggests that the log of national labor productivity does not have a unit root (the test statistic is -8.50 and the null hypothesis that the variable has a unit root is rejected at the 1% level). Therefore, the first model was estimated via ordinary least squares (OLS). Preliminary results, however, suggests serial correlation in its disturbance term based on the Durbin-Watson tests (the test statistic is 0.199 and it is lower than the 5% significance points of lower bound, 1.464). Therefore, I use the Prais-Winsten estimation technique which is a feasible form of GLS (FGLS). The results reported in Table 4 are based on the FGLS estimation technique.

As shown in Table 4, the estimated coefficient of the log of capital per employer is 0.415 and it is statistically significant at the 1% level. This indicates that a 1% increase in capital is associated with an increase in labor productivity by 0.415%. The estimate from this study of 0.415 is close to the 0.433 value estimated by Stresing et al. (2008) as the output elasticity with respect to capital in Japan for the 1965 to 1992 period. However, the estimated coefficient of the dependency ratio (non-workers per worker) is -0.535. It too is statistically significant at the 1% level. This suggests that an increase in the number of non-workers (e.g., older people, children or unemployed people) is associated with a decrease in labor productivity.

[5] When including migration and education variables in the estimation, the data range decreases from 70 years to 20 years. In this case, only two of the estimated coefficients are significant and both of them are positive (immigrant share and high school graduates). This result suggests that international immigrant and high school education (compared with high school dropouts) positively contribute national labor productivity in Japan.

Table 4: National labor productivity model

VARIABLES	FGLS
Dependency ratio	-0.5346***
	(0.142)
Median age	0.0927*
	(0.047)
Median age sq.	-0.0023***
	(0.001)
Log of capital per employer	0.4154***
	(0.082)
Time trend	0.0402***
	(0.010)
Constant	4.2925***
	(0.641)
Observations	70
R-squared	0.998

Note: Prais-Winsten AR(1) estimation is used as a feasible GLS (FGLS). Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

To the best of my knowledge, there is no comparable estimate for Japan from previous studies. Since the population of younger people is decreasing and the unemployment rate has been stable over time in Japan[6], increased older people population appears to be the main source of increase dependency ratio in Japan. Therefore, this finding suggests that population aging (increase of dependency ratio) has an adverse relationship to labor productivity.

The estimated coefficient of the median age of the population is 0.0927 and it is statistically significant at the 10% level. However, the estimated coefficient of its square term is -0.0023 and this is statistically significant at the 1% level. These suggest that as the median age increases, national labor productivity increases at a decreasing rate, peaking at age 20.2[7]. Since

[6] Population of younger people (aged less than 15) decreased from 27.2 million in 1975 to 15.2 million in 2019. Its share to total population also decreased from 24.3% in 1975 to 12.1% in 2019 (SSDS). From 1975 to 2015, the highest unemployment rate in Japan was 6.4% in 2010 (SSDS).

[7] Note that the estimated peak median age of 20.2 is younger than past studies such as Miyahara and Adelaja (2020) (39 years old) and Liu and Westelius (2017) (40-49 years old) suggest. I admit that the omitted educational variables

the median age in Japan is now 48.6 years (CIA 2020), this finding suggests that population aging (increase of average age of the workers and total population) has a negative effect on labor productivity above the age of 20.2. This is consistent with the results of the impact of dependency ratio. The fact that Japan's population is expected to continue to age means that labor productivity will continue to decrease. This should be an issue of concern to policy makers. For Japan's labor productivity to rise, the government must rely on other factors to drive labor productivity growth since nothing can be done to stop the aging process except the import of younger people. The role of immigration is examined in chapter 4.

Finally, the estimated coefficient of the time trend is 0.0402 and it is significant at the 1% level. That is, if all other independent variables are held constant, national labor productivity has a positive trend. The estimated coefficient suggests approximately a 4% adjusted annual trend rate of growth. This accounts for the effects of technology development, structural reform and improving educational attainment[8] in Japan.

Results from the Regional Labor Productivity Model

In the regional labor productivity model, I estimate the roles of determinants of labor productivity. Although the estimated model is a decomposition rather than a causal model, I not only utilize a fixed-effect estimation method, but also utilize an instrument to address possible endogeneity from potential movement of people across prefectures. Because both results are very similar, I present the result for the instrumental variable (IV) approach in Table 5.

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and migration ratio may introduce possible bias in the national-level model. For this reason, I consider the results provided in essay 1 regarding the national level model to be somewhat unreliable. Therefore, in the rest of this chapter, I highlight the results from the regional- and sectoral-level productivity decomposition more than I do the national-level decomposition.

[8] Note that educational attainment variables are excluded in the national labor productivity model estimation.

Note that two instruments are used. First, I use the dependency ratio in 1990 (oldest data used in regional labor productivity model). Second, I calculate and use the expected ratio of international immigrants based on the past immigrant distribution across prefectures and current national immigrant and native stock. These IVs may satisfy the relevance condition and exclusion restriction because they are the past values or are calculated based on past values, which may be close to current endogenous variables but cannot be affected by the current situation. To further test the validity of the IVs, endogeneity and weak instrument are tested. Both the Durbin and Wu–Hausman tests reject the null hypothesis that the possible endogenous variables are exogenous at the 1% level. Also, the Stock and Yogo's test rejects the null hypothesis that the endogenous variables are weak at the 5% level. Although the regional labor productivity model uses panel data, since I cannot use fixed-effect and random-effect estimation techniques, I use the IV estimation technique with errors clustered at the prefectural level.

The estimated coefficient of the log of capital per worker is 0.412 and is statistically significant at the 1% level. This is close to the estimate of 0.415 obtained for the national labor productivity model. However, the coefficient of time trend is statistically insignificant. There are two possible reasons. First, since the data range of the regional labor productivity model is shorter (1990-2010) than national labor productivity model (1950-2019), the positive trend of economic expansion period from the end of World War II to the asset bubble burst in 1990s are not considered in the regional labor productivity model. Second, since immigrant share and educational attainments are included in the prefectural model but not in the national model, it can be concluded that the observed positive trend in national labor productivity is correlated with growing immigrant population and increase educational attainment in Japan.

Table 5: Regional labor productivity model

VARIABLES	IV
Dependency ratio	-0.0559*
	(0.032)
Median age	-0.0316
	(0.024)
Median age sq.	0.0003
	(0.000)
Immigrant	0.0063***
	(0.002)
Log of capital per employer	0.4122***
	(0.073)
High school	0.0049**
	(0.002)
Junior college	-0.0129
	(0.008)
University	0.0172***
	(0.004)
Time trend	-0.0022
	(0.003)
Constant	16.1408***
	(0.523)
Observations	846
R-squared	0.865

Note: Past dependency ratio and expected immigrant ratio are used as instruments to control the endogeneity of dependency ratio and immigrant variable. Clustered errors within prefectures are used. Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Now I focus on the role of education. The education variables are proxied by three variables: the percentage of people who completed high school education, the percentage of people who completed junior college, and the percentage of people who completed a university degree. Note that since I exclude the ratio of people who did not complete high school (dropouts) to avoid multicollinearity, the coefficients of these three variables show relative impacts of education beyond high school, vis-à-vis no secondary school education. The estimated coefficient of high school completion is 0.0049 and it is statistically significant at the 5% level. This suggests that the productivity of the typical high school graduates is higher than that of a typical high school dropout. The fact that secondary school education contributes to improved labor productivity is consistent with previous studies on Japan and other countries (Keller 2006).

The estimated coefficient of junior college completion, however, is statistically insignificant. This suggests that the productivity of junior college graduates is comparable to high school dropouts. Please note that each education category is comprised of both males and females. Also note that the population of female junior college graduates was 7-14 times more than that of male junior college graduates from 1975 to 2007 (School Basic Survey 1975-2007, which is available at the SSDS). Female junior college graduates earned 22% lower wages and had 27% less experience than their male counterparts (see Table 6). Therefore, they contribute less to labor productivity, compared their male counterparts. This is the possible explanation for the similarity between the productivity of junior college graduates and high school dropouts.

Table 6: Average age, working experience and wage by sex and educational attainment in Japan

	Male			Female		
	Age (years old)	Working experience (year)	Wage (JPY)	Age (years old)	Working experience (year)	Wage (JPY)
High school dropout	52.2	18.1	280,200	53.3	13.6	174,400
High school	42.4	13.9	300,300	42.0	9.7	198,200
Junior college	36.8	11.0	310,500	35.5	8.0	239,800
University	40.3	12.7	406,500	32.9	6.3	276,400

Source: MLHW (2006)

The completion of university education is generally accepted as more critical than high school and junior college completion in labor productivity growth (Aghion et al. 2009). University graduates are typically educated in fields that are considered more appropriate for knowledge economy. Also, knowledge, talent and creativity are considered to be more impactful in economic development than pure labor. The estimated coefficient of university completion is positive and significant at the 1% level (Table 5). At 0.0172, it is also the largest of the education variables (3.5 times the value for high school completion). As shown in Table 6, the wage of university graduates is also the highest of all groups (e.g., 1.35 times the value for high school completion for male). Hence, university graduates can contribute more to economic growth than high school dropouts, high school graduates and junior college graduates. This suggests that the completion of university education is key to regional productivity growth. Imbalance in university completion may contribute to disparities in regional labor productivity. One implication of this finding is that to enhance labor productivity in Japan, public policy might seek to focus on university education, college completion and the development of a knowledge-based economy. Furthermore, such policies might also take into consideration gender differences in productivity across educational attainment levels. This is consistent with the strategies pursued by progressive governments across the globe.

Recall that the dependency ratio is indicative of population aging. The estimated coefficient of the dependency ratio in the prefectural model is negative (-0.0559) and statistically significant at the 10% level. As shown above, the same applies to the national case – population aging decreases regional labor productivity. However, the estimated coefficients of the median age and its square are both statistically insignificant. Recall that for the national model, the two coefficients were, respectively, positive and negative, resulting in a peak productivity age of 20.2. To further verify the efficacy of these results, I conducted a test of the joint hypotheses that both coefficients are jointly equal to zero. This joint hypothesis cannot be rejected (the p-value of the test statistic is 0.319). Therefore, the negative impact of median age on labor productivity at the national level could be explained based on the role of immigrants and the effect of educational attainments. Subsequent chapters will more deeply explore the roles of immigration and education in growth and development. It is noteworthy that the data used in modeling national labor productivity spans 70 years, while it is 18 years for regional labor productivity.

The estimated coefficient of the population share of immigrants is positive (0.0063) and significant at the 1% level. This suggests that international migrants contribute positively to labor productivity in Japan. Specifically, an increase in the percentage of immigrants by 1 percentage point is associated with a 0.0063% increase in labor productivity at the prefectural level. In 2015, the international migrant share of Japanese population was 1.6% (World Bank 2020). The doubling of this percentage to 3.2% will represent a 1.008 percentage points growth in national labor productivity. Similarly, the quadrupling of this population to 6.4% is equivalent to an increase in national labor productivity growth by 3.024 percentage points. Hence, the recent Japanese government policy of increasing the number of immigrants appears to be well founded. COVID-19, of course, has slowed down the realization of this policy[9]. Further investigation on the relationship between migration and economic growth is conducted in the fourth chapter.

Results from the Regional-Sectoral Labor Productivity Model

The results of the regional-sectoral model are presented in Table 7. Again, similar to the regional labor productivity model, I use the 2006 dependency ratio and the expected ratio of international immigrants as the instruments[10]. In addition, prefecture fixed-effect and sector-fixed effect are used as control variables. Since there are 18 sectors in the data (see Table 1), the sample size is much larger than previous models, though the data range is shortened to only 5 years, 2006-2010.

[9] In 2020, the number of foreigners newly entering Japan decreased by 87.4%. The number had been increasing over time since 2012, one year after the Great East Japan Earthquake (Immigration Services Agency of Japan 2021).
[10] Same as regional labor productivity model, endogeneity and weak instrument are tested. Both the Durbin and Wu–Hausman tests reject the null hypothesis that the possible endogenous variables are exogenous at the 1% level. Also, the Stock and Yogo's test rejects the null hypothesis that the endogenous variables are weak at the 5% level.

Table 7: Regional-sectoral labor productivity model

VARIABLES	IV
Dependency ratio	-0.0000
	(0.000)
Median age	0.6909***
	(0.150)
Median age sq.	-0.0050***
	(0.002)
Immigrant	0.1562***
	(0.020)
Log of capital per employer	0.6667***
	(0.011)
High school	0.0056
	(0.012)
Junior college	0.2516***
	(0.063)
University	0.3861***
	(0.070)
Time trend	-0.2789***
	(0.035)
Constant	-23.9831***
	(4.423)
Observations	3,760
R-squared	0.967

Note: Past dependency ratio and expected immigrant ratio are used as instruments to control the endogeneity of dependency ratio and immigrant variable. Prefecture fixed-effects and industry fixed-effects are included in the estimation. Estimated sector fixed-effects are presented in Table 8. Estimated prefecture fixed-effects are not presented. Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Again, the estimated coefficient of the log of capital per worker is positive at 0.667 and is statistically significant at the 1% level. In addition, it is higher than regional and national coefficients of the log of capital, possibly due to variations in capital intensity and structures of prefectural and sectoral economies. The time trend is negative (-0.279) and statistically significant at the 1% level, suggesting that after controlling for labor productivity differences in sectors, sectoral-regional labor productivity has a negative trend. This may reflect the economic slowdown from the financial crisis during the study period (2006-2010).

The estimated coefficient of high school graduation is statistically insignificant. In light of the results from the regional labor productivity model, this may suggest that the differences in labor productivity contribution observed in at the regional level between high school dropouts and high school graduates are associated with specific sectors in which workers are engaged. The estimated coefficient of junior college graduates is positive (0.252) and statistically significant at the 1% level. This result reinforces the notion that many junior college graduates are engaged in lower-productivity sectors and the difference between high school dropouts' contribution and junior college graduates are small in higher-productivity sectors.

The estimated coefficient of the university graduates is positive (0.386), statistically significant at the 1% level and much higher than that of the regional labor productivity model. This may reflect the sectoral differences in labor productivities and role of university education. For example, Aichi prefecture has a heavy concentration of high productivity workers, but is not necessary as populated as the Tokyo prefecture. That is, sectoral differences in labor productivity may decrease the elasticity of regional labor productivity with respect to higher education.

The estimated coefficient of the dependency ratio is statistically insignificant in the regional-sectoral model, whereas it was negative from the regional model. That is, an increase in the number of non-workers does not affect sectoral labor productivity. One will recall the huge differences in labor productivity across sectors, as depicted Figure 8. On the other hand, both of the estimated coefficients for median age and its square are statistically significant at the 1% level, again suggesting that in an aging society, sectoral labor productivity is increasing at a decreasing rate and peaks at 69 years old. This estimated peak is very high, compared with the estimate from the regional model. It may reflect the possibility peak age in some sectors is much higher than others and the fact that none of these models are weighted by population. Subsequent studies may wish to explore the possibility of utilizing a weighting technique so that the results of the national, sectoral and regional models can be better reconciled. Note that most people retire before they become 69 in Japan. By controlling for labor productivity differences in sectors, sectoral labor productivity improves as society ages. Combined with the negative correlation of population aging on national labor productivity, which is the weighted average of sectoral labor productivities, this result suggests that reforms may take into consideration the differences in industrial structure across regions in order to improve national labor productivity analysis in Japan.

Again, the estimated coefficient of the immigrant share of population is positive (0.156), statistically significant at the 1% level, and much higher than that of the regional labor productivity model. This, again, reflects the sectoral differences in labor productivity and the implications for its elasticity with respect to immigrants.

The estimated sector fixed-effects in the regional-sectoral labor productivity model are presented in Table 8. Sector fixed-effects represent the contribution of characteristics of each sector such as labor intensity, export-orientation and gender ratio of the workers in each sector. An agriculture, forestry and fishing dummy (fixed-effect) is excluded from the estimation to avoid multicollinearity. Therefore, these estimated fixed-effects reflect the differences between each sector and the primary sector.

All of the estimated sector fixed-effects are positive and statistically significant at the 1% level. Consistent with Figure 7 and Figure *8*, the primary sector has the lowest labor productivity in Japan.

Table 8: Estimated sector fixed-effects in the regional-sectoral labor productivity model

VARIABLES	IV
Mining	0.1043***
	(0.017)
Manufacturing	0.1070***
	(0.018)
Electricity, gas and water supply, waste management service	0.2842***
	(0.020)
Construction	0.7080***
	(0.031)
Wholesale and retail trade	0.5422***
	(0.034)
Transport and postal services	0.2204***
	(0.021)
Accommodation and food service activities	0.1820***
	(0.035)
Information and communications	0.4314***
	(0.015)
Finance and insurance	0.9432***
	(0.023)
Real estate	0.4737***
	(0.019)
Professional, scientific and technical activities	0.5396***
	(0.015)
Public administration	0.1042***
	(0.016)
Education	0.1898***
	(0.022)
Human health and social work activities	0.4174***
	(0.028)
Other service activities	0.0912***
	(0.026)

Note: Estimated sector fixed-effects in the regional-sectoral labor productivity model (Table 7). Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

However, after controlling for other factors such as physical capital, human capital, aging, migration and time trend, finance and insurance sector has the largest sector fixed-effect (0.943). Construction (0.708) and wholesale and retail trade (0.542) sectors have the second and third largest sector fixed-effects, respectively. Real estate (0.474) and electricity, gas and water supply, waste management service (0.284) sectors have the highest and second highest labor productivities (Figure 8**Error! Reference source not found.**) but do not have higher sector fixed-effects because these sectors are capital intensive and require large infrastructure, facility and physical capital. Such physical capital raises their sector productivities.

2.7 Conclusion

In Japan, growth rates of GDP and per capita GDP were decreasing over time and they are now less than 2%. To revitalize its economy, government policies focus on increasing productivity through structural reform, promoting higher education, increasing labor participation rate and supporting careworkers for the aged. In this chapter, since many policies are related to human capital and Japanese government considers population aging as one of the most serious problem in Japan's economy, I focus on explaining labor productivity in the context of hypothesized determinants.

Findings from the labor productivity calculations suggest that national labor productivity was increasing but its growth rate decreased over time. The same applies to GDP growth rate and GDP per capita growth rate. The national labor productivity growth rates fell under 2% in recent years. This is evidence that the Japanese economy is indeed slowing down and that declining labor productivity is one of the reasons. In subsequent chapters, I will examine in more detail how and why labor productivity is declining in Japan. I will particularly examine the roles of immigration policies and population aging, two important aspects of human capital and labor productivity growth in Japan.

There is a huge gap in regional labor productivities between metropolitan economies and non-metropolitan or rural economies. Metropolitan areas such as Tokyo, Osaka and Aichi have higher labor productivities but rural prefectures such as Iwate and Kochi have lower labor productivities. However, the gap shrank from 1.83 in 1990 to 1.67 in 2014, suggesting convergence in regional labor productivities. This regional difference may be explained on the basis of differentials in population growth, population aging and the industrial structure of each prefecture. There is also a huge gap in sectoral labor productivities. In 2018, the manufacturing sector's labor productivity was 4.3 times higher than agricultural sector's labor productivity, and 45% higher than the service sector's labor productivity.

Findings from the labor productivity decomposition models suggest that labor productivity changes are correlated with physical capital, educational attainment (especially higher education), sectors' characteristics (fixed-effects), population aging and immigrants. Population aging is negatively associated with Japan's national and regional labor productivities, while the share of immigrants is positively associated with regional and sectoral labor productivities in Japan. The roles of population aging and immigrants in Japan's regional economy are more closely investigated in Chapter 3 (population aging) and Chapter 4 (immigration). The estimated coefficient of time trend in the regional-sectoral labor productivity model suggests that Japan was still suffered from long-term depression and might experience little technology progress and structural reform in 2010s.

The findings from all models are consistent with Japanese government's assumptions that population aging is one of the most serious problem in Japan's economy. Since it is difficult to rapidly change Japan's societal aging, policies promoting higher education, physical capital investment, immigration, structural change focusing on productivity-growing sectors such as manufacturing and ICT sectors, and innovation would improve national and regional labor productivity, which also improves GDP and GDP per capita growth in Japan. More detailed policy implications are addressed in Chapter 5.

There are several limitations of the analysis reported in this chapter. First, due to the data limitation, the range of data is limited from time perspective. The data for the national labor productivity model span 70 years, while it spans only 18 years for the regional labor productivity model and only 5 years for the regional-sectoral labor productivity model. The 2020 Census data, which will be published in late 2021, will enable further investigation into the sources of more recent labor productivity changes. Second, the changes in contributions of each input (e.g., population aging and immigration) are not investigated in this chapter. Changes of the contribution of aging and migration to Japan's economy will be estimated in the following chapters. Third, although Table 6 suggests that there is a gender gap in wages and labor productivity, the gap is not estimated.

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CHAPTER 3. ESSAY 2: AGING AND ECONOMIC GROWTH: DIFFERENTIAL EFFECTS OF MULTIPLE GENERATIONS

3.1 Introduction

In Chapter 2 (essay 1), the role of human capital in labor productivity decline is explored. With the results pointing toward aging as a culprit, it is important to more closely explore the pathways through which aging is associated with declining economic growth rates. In this chapter, the role of population aging in regional economic growth is more thoroughly explored. I focus on regional level analysis because the result of chapter 2 suggests that there are regional nuances to the effect of aging on economic growth. For example, in a rural prefecture, the negative effect of aging on economic output may be less than in highly industrial prefecture where each person, especially the aged, has significant productivity.

Simply defined, the term "population aging" is a phenomenon where the percentage of older people increases over time in a country or economy. Every country eventually ages and countries experience different degrees of population aging (United Nations 2015). The rate of population aging depends on how rapidly life expectancy and fertility are changing over time (United Nations 2015). These two, in-turn, depend on several factors, including improvements in healthcare and nutrition, changing family structures and changing work-style patterns (Lee 2003). Countries experiencing rapid population aging tend to be the ones that have low fertility rates, rapidly growing life expectancy, rapid improvements in healthcare and high quality of life (United Nations 2015).

Population aging is an important topic in the area of economic development due to its possible effects on economic growth. Compared with younger workers, older workers tend to have more experience and skill-specific knowledge which might result in higher levels of economic activity. Conversely, as people age, they may experience reduced physical and mental abilities, as well as increased risk aversion, which can lead to reduced innovation and speed of growth. Also, there are additional effects that are related to specific abilities, preferences and other characteristics of particular generations, which may affect their productivity (Miyahara and Adelaja, 2020). The combination of all these effects determines the impact of aging on national economic growth.

Japan is an excellent example of a country that made huge socio-economic strides over many years but is now dealing with the adverse effects of population aging. As mentioned in the previous chapter, after Monaco (55.4 years), Japan's median age of 48.6 years is the second highest among advanced countries (CIA 2020). Its growth rate has declined from over 10 percent in the 1960s to less than 2 percent in the last decade. Concern about shrinking and aging population has led the Japanese government to explore novel approaches to economic development. For example, it recently amended its Immigration Control and Refugee Recognition Act to attract more immigrants to enhance economic performance - something that the Japanese would have rejected vehemently in the past. More recently, under the government of then Prime Minister Abe, the government also unfolded new human capital related policies to enhance the performance of working Japanese citizens and improve their economic contributions (Government of Japan 2019). These policies represent a major economic policy paradigm shift in response to population aging. Solutions to the problem of population aging can be few and far between. Therefore, it is important to better understand its nexus between aging and economic development, especially in the context of how various generations affect the economy.

Several studies have examined the effects of population aging on the economy. For example, Oliver (2015) regressed the populations of various age ranges (e.g., 40-44, 45-49 and

50-55) on regional outputs to measure the differential marginal effects of various groups on the economy. This is based on the notion that adding one more person from a given age bracket will add more to regional output than another bracket if people belonging to the former group are more productive. Others have used variables such as the number of older people (e.g., sixty years or over), the proportion of older people, the dependency ratios[11] and the mean or median age of the population as proxies for aging[12]. However, aging is a complicated process that involves the aging of different age brackets with different experiences, outlook toward life, interest in goods and services and expenditure patterns (Miyahara and Adelaja 2020). Between a numerical median age variable and economic outcomes lies several social, demographic, behavioral, taste and market factors that are embodied in each generation. With the exception of Miyahara and Adelaja (2020), which is the precursor to this chapter, models explaining population aging have not accounted for these aspects of the literature on demographics.

Given the importance of the relationship between aging and economic development, stronger empirical evidence is needed on the mechanisms through which population aging affects the economy. Previously used aging measures are too simple to effectively explain the economic impact of aging. One area where advancements can be made is the use of population aging proxies that actually more deeply reflect not only changing demographics, but also the impact on the economy through consumption patterns, lifestyles, market behavior and cultures. The multiple generations concept has been used to evaluate the impacts of age-related characteristics on the demand for products and services. For example, overlapping generations model assumes

[11] Three dependency ratios are defined in United Nations (2015). The child dependency ratio is the number of persons 0-19 years per one hundred persons aged 20-64 years. The old-age dependency ratio is the number of persons aged 65 years or over per one hundred persons aged 20-64 years. The total dependency ratio is the sum of these two dependency ratios (United Nations 2015, 111).
[12] In addition to these standard indicators, more refined indicators of population aging are proposed (for example, Spijker et al. (2014)).

that each person lives for a fixed number of periods and that a number of generations exist in each period. Marketing research considers each generation as having different preferences, attributes, collective experiences and similar ideals (Novak 2014). The multiple generation model can explain how the unique aspects of multiple generations impact on the economy as they grow older.

In my preliminary proof of concept work, which is now published in the Journal of Population Ageing (Miyahara and Adelaja 2020), the multiple generation model was introduced and estimates of the impacts of different Japanese generations on regional economic growth were estimated. Due to data limitation, that analysis was based on panel data which covered 14 years. That analysis was also hampered by a limited number of explanatory variables. That study can now be improved based on newly accessible data. In this chapter, I build upon my previous work by expanding temporal length of the panel database while bringing in new control variables such as high school graduation and junior college graduation. This is a recognition of the role of education and the need to better account for it. I still posit that disaggregate measures of aging allow added understanding of aging impacts. I propose to improve the literature by further leveraging information on multiple generations from the fields of finance and marketing because the impacts of sub-populations (economic generations) may vary due to the distinct behavior and characteristics, based on their tastes, common experiences and common history of each generation. Therefore, in this chapter, I investigate the impact of aging on the Japanese regional economic growth by using a traditional aging variable (median age) along with the median age of multiple generations as proxies for the aging process. Note that in this analysis, the dependent variable is the log of GDP, not the log of labor productivity. I account for general aging (aging of all cohorts) and generational aging (cohort effect, which is specific to a group of people born in a certain period) and the period effect of aging. I also address the regional difference in generational distribution by leveraging available prefectural panel data. I will also use structured tests to show the efficacy, efficiency and consistency of generational aging measures. In contrast to Miyahara and Adelaja (2020), the data for this chapter of the dissertation covers 21 years, rather than 14.

The multiple generations approach allows several things. First, it sheds light on the influence of economic generations, which enables us to predict future growth more precisely based on demographic changes and overall population aging. Second, it helps in identifying generations whose production and consumption impacts are more (or less) than average. This insight is beneficial in better focusing policies and strategies in support of generations by the Japanese government. Third, it helps to explain the impacts of generations based on their values and experiences.

The rest of this chapter is organized as follows. Sections 3.2 and 3.3, respectively, present the literature review and conceptual framework for the analysis. Sections 3.4 and 3.5, respectively, present the empirical framework and data used in the analysis. Section 3.6 presents the empirical result. Finally, section 3.7 presents the conclusion for this chapter.

3.2 Literature Review

In some countries, population aging increases the working age population and the number of experienced workers, with positive economic impacts (demographic bonus or population bonus) (Lee 2003). In others, it increases the number of retirees who are dependent on public welfare or their families. The increased cost of social welfare may hinder economic growth (population onus).

Studies have examined the effects of aging on various dimensions of the economy, not just GDP, gross national product (GNP) or their growth rates. For example, aging effects on labor supply was examined by the United Nations (2015), Bloom and Luca (2016) and Kaschützke and Maurer (2016). Aging effects on consumption was examined by Börsch-Supan et al. (2016). Börsch-Supan, et al. (2016) and Bloom and Luca (2016) also examined the impact of aging on savings while Kaschützke and Maurer (2016) further examined the impact on housing and medical expenditures. Lee (2011) examined the roles of public and private transfers in aging society. Two conclusions from these studies are that researchers recognize a variety of aging impacts and aging has an overall negative economic effect.

There are many reasons to expect aging to affect the growth of the economy. Nagarajan et al (2016), for example, pointed out three main causal mechanisms: public social expenditure, consumption and saving patterns and human capital. They argued that the demand for medical services and care services increases with age, thereby increasing public expenditures on social insurance programs. Novak (2014) also argued that American people in the GI generation (born in 1901-1926) avoid debt, while most members of generation X (born in 1965-1980) are deeply in credit-card debt. Workers' productivity and wages increase as they gain more work experience (see the Mincer equation, for example, Heckman et al. 2006). However, after some age, these are expected to decrease (Van Der Gaag and de Beer 2015). Also, the ratios of part-time and full-time workers in some age groups is larger than that in other age groups due to such things as mandatory retirement age and the existence of a recession. Therefore, using only one demographic indicator of aging is too simple to effectively explain the economic impact of aging. One indicator will also be limited in its capacity to explain how the unique aspects of multiple generations impact on the economy as they grow older.

Oliver (2015) linked a disaggregated aging indicator to economic outcomes in Japan. Using population composition and dependency ratios as proxies for demographic composition, she found that an increase in the 70-74 age group is negatively correlated with economic growth while an increase in the 75 and over population age group is positively correlated. Unfortunately, in exploring the roles that different age groups and their compositions play, Oliver (2015) did not consider the roles of multiple generations. The characteristics of people in their sixties in 2010 are essentially the same as for people in their fifties in 2000 because they are the same people. She ignored the possibility that habits associated with different cohorts may vary as they move through the aging process. By controlling for the distribution of generations, one may be able to clarify the economic impacts of aging to the economy more clearly.

Given the goals for this chapter, I briefly explain the multiple generations concept, which is the same as Miyahara and Adelaja (2020). In the US, the roles of the so-called six living generations of Americans have been well studied in the literature (see Novak 2014). Similar concept appears in Japan. For example, Matsuda (2006) identified thirteen Japanese generations and Takaoka (2016) identified eight generations. Although the definitions of each generation are different between these authors, three generations appear in all definitions: The first baby boomer ("Dankai-no-sedai"); the second baby boomer ("Dankai-junior-sedai"); and the Yutori generation ("Yutori-sedai").

The "first Japanese baby boomer" (Bb1) generation is defined as people born in 1947, 1948 or 1949. This definition is used by the Ministry of Health, Labor and Welfare (MHLW), GOJ. Note that the period of birth for the Japanese Bb1 generation is much shorter than the US Baby boomers, which is 1947-1964. I believe that this unique distinction is warranted based on the unique impact of World-War II (WWII) on Japan. The Bb1 generation is often mentioned as one of the most unique generations in Japan (e.g., Takao 2009). They organized student movements in late 1960s and entered the workforce during the economic miracle with ample job opportunities (Tashiro and Lo 2020). They left rural areas in the 1960s and early 1970s seeking a better life in urban areas. They spearheaded the effort to reinvent Japan in the wake of the 1973 oil crisis. Since many Japanese retire around the age of 60, most of the Bb1 generation retired before 2010 and are expected to have a long retirement. They are financially sound and have positive economic outlook.

The "second Japanese baby boomers" (Bb2) are people born in 1971, 1972, 1973 or 1974. This definition is also used by the MHLW. This generation is analogous to the US baby-boom-echo (generation Y or Millennials) population born between 1981 and 2000. Since most Bb2 generation are the children of the Bb1 generation, they grew up in an information and material-rich society and this has impacted their purchasing patterns. However, they had a hard time finding jobs since the Japanese asset bubble burst occurred around 1990 and the Japanese economy entered a long period of deflation and recession (Ohno 2006; Ohta et al. 2008). Like the US millennials, they are more cautious and have less consumption impact on the economy.

The "Yutori generation" (Ytr) is defined as people born during the 1987 to 2004 period. They received their compulsory education based on the curriculum guideline enforced during 2002 and 2011 ("Yutori" or "pressure-free" education). People in the Ytr generation are said to be highly conservative, less ambitious, more realistic and more practical than previous generations. For example, they spend less on luxury goods than previous generations.

The other four generations are the people born before, after or between the three generations described above. The "before baby boomer" (Bbb) generation comprises people born before 1947. They went through growth and depression and most are now retired. This generation worked hard for everything, experienced WWII, witnessed the resurgence of Japan, and are very cautious in their spending. People born between 1950 and 1970 are classified as the “generation X” (Gnx). The name comes from the US generation born just after baby boomers (Novak 2014). Their characteristics are a mixture of those of the Bb1 and Bb2 generations. They spend much of their formative years in Japanese rapid economic development and they are high spenders. They grew up being absorbed into Japan’s highly productive appliance, electronics and automobile industries and became key-executives during Japan’s most successful period in its history. However, they were more affected by the rise and fall of the bubble economy, though most of them got full-time job before the asset bubble burst in 1990s.

People born between 1975 and 1986 are in “generation Y” (Gny). The name also draws from the US generation Y. Their characteristics are similar to the Bb2 generations. The asset bubble burst when they were children or at the beginning of their adulthood. According to Hirayama and Ronald (2008), the Bb2 and part of the Gny generation (called “Lost generation”) suffered from a rapid decrease in stable employment and thus have noticeably delayed family formation and entry into the home ownership market. Finally, the youngest generation is comprised of the people born after 2004, named the “generation Z” (Gnz). They grew up in an information and material rich society. However, since they are aged less than ten in 2010, it is difficult to define their characteristics regarding consumption, preferences, and working profile. These group is similar to the American Generation Z.

3.3 Conceptual Framework

As a base, I intend to use the same framework in Miyahara and Adelaja (2020), which estimates the impacts of multiple generations on Japanese regional GDP growth rate. To estimate the contributions of generations to the Japanese economy, consider the case of an economy with *w* generations ($g = 1,2,\cdots,w$) and denote its output in year *t* as Y_t. Note that

$$Y_t = \sum_{g=1}^{w} Y_{gt} \tag{10}$$

where Y_t is national GDP and Y_{gt} is generational GDP for the g^{th} generation. Further, denote the growth rate of national GDP for a given year as $\dot{Y_t} = \partial Y_t / Y_t$. Note that

$$\dot{Y_t} = \sum_{g=1}^{w} s_{gt}\, \partial Y_{gt} / Y_{gt} = \sum_{g=1}^{w} s_{gt} \dot{Y_{gt}} \tag{11}$$

where $s_{gt} = Y_{gt}/Y_t$. Therefore, the growth rate of national GDP is the weighted average growth rate of generational contributions to national GDP. The weights (s_{gt}) are the generational GDP shares.

The conceptual challenge in this paper is to specify a growth model that accounts for the impacts of aging, including the effects of multiple generations and their impacts as they age. The output of generation *g* in year *t* is implicitly specified as follows:

$$Y_{gt} = F\left(K_t, G_{gt}, X_t, t\right), \tag{12}$$

where K_t is national capital input in year *t*, G_{gt} measures generational capacity in year *t* for generation *g*, X_t is a vector of other contributory factors including natural resources, national management capacity and other control variables in year *t*, and *t* is a trend variable which accounts for the independent period effect. Equation (12) can be specified to account for GDP growth at the prefectural level. Therefore, for the p^{th} prefecture,

$$Y_{pgt} = F\left(K_{pt}, G_{pgt}, X_{pt}, t\right), \tag{13}$$

where Y_{pgt}, K_{pt}, G_{pgt} and X_{pt} are prefecture level outputs, capital inputs, generational capacities and other contributory factors.

Assume that each generation's capacity (G_{pgt}) is defined as the product of the population (L_{pgt}) and the average characteristics (V_{pgt}) of each generation. The average characteristics is unobservable but is a function of some observable characteristics (Z_{pgt}) such as median age of the generation. That is,

$$G_{pgt} = L_{pgt} \cdot V_{pgt} = L_{pgt} \cdot \theta_{pgt}(Z_{pgt}). \tag{14}$$

The production function in equation (13) becomes

$$Y_{pgt} = F\left(K_{pt}, L_{pgt} \cdot \theta_{pgt}(Z_{pgt}), X_{pt}, t\right). \tag{15}$$

The outputs of prefecture *p* in year *t* are

$$Y_{pt} = \sum_{g=1}^{w} Y_{pgt} = \sum_{g=1}^{w} F\left(K_{pt}, L_{pgt} \cdot \theta_{pgt}(Z_{pgt}), X_{pt}, t\right). \tag{16}$$

Therefore, the total derivative of the production function in equation (16) is specified as follows:

$$\begin{aligned} dY_{pt} &= \sum_{g=1}^{w} \left\{ \frac{\partial F}{\partial K} dK_{pt} + \frac{\partial F}{\partial X} dX_{pt} + \frac{\partial F}{\partial t} dt + \frac{\partial F}{\partial G} \left(\frac{\partial G}{\partial \theta} \frac{\partial \theta}{\partial \mathrm{Z}} dZ_{pgt} + \frac{\partial G}{\partial L} dL_{pgt} \right) \right\} \\ &= w \left(\frac{\partial F}{\partial K} dK_{pt} + \frac{\partial F}{\partial X} dX_{pt} + \frac{\partial F}{\partial t} dt \right) \\ &\quad + \sum_{g=1}^{w} \frac{\partial F}{\partial G} \left(L_{pgt} \frac{\partial \theta}{\partial \mathrm{Z}} dZ_{pgt} + \theta_{pgt}(Z_{pgt}) dL_{pgt} \right). \end{aligned} \tag{17}$$

This can be expressed as

$$\begin{aligned} \frac{dY_{pt}}{Y_{pt}} &= w \left(\frac{\partial F}{\partial K} \frac{dK_{pt}}{K_{pt}} \frac{K_{pt}}{Y_{pt}} + \frac{\partial F}{\partial X} \frac{dX_{pt}}{X_{pt}} \frac{X_{pt}}{Y_{pt}} + \frac{\frac{\partial F}{Y_{pt}}}{\partial t} dt \right) \\ &\quad + \frac{\partial F}{\partial G} \frac{G_{pt}}{Y_{pt}} \sum_{g=1}^{w} \left(\frac{L_{pgt} \cdot \theta_{pgt}(Z_{pgt})}{G_{pt}} \frac{\partial \theta}{\partial \mathrm{Z}} \frac{Z_{pgt}}{\theta_{pgt}(Z_{pgt})} \frac{dZ_{pgt}}{Z_{pgt}} \right) \\ &\quad + \frac{\partial F}{\partial G} \frac{G_{pt}}{Y_{pt}} \sum_{g=1}^{w} \left(\frac{L_{pgt} \cdot \theta_{pgt}(Z_{pgt})}{G_{pt}} \frac{dL_{pgt}}{L_{pgt}} \right) \end{aligned} \tag{18}$$

and

$$\ln Y_{pt} = \alpha_K \ln K_{pt} + \alpha_X \ln X_{pt} + \alpha_t dt + \alpha_G \sum_{g=1}^{w} \gamma_{gt} \delta_Z \ln Z_{pgt} + \alpha_G \sum_{g=1}^{w} \gamma_{gt} \ln L_{pgt} \tag{19}$$

where α_j is the elasticity of output with respect to the *j^th^* input $(j \in \{K, X, G\})$, $\alpha_t = \partial \ln Y_{pt} / \partial t$ is the productivity growth, $G_{pt} = \sum_{g=1}^{w} G_{pgt}$ is the total capacities of prefecture *p* in year *t*, $\gamma_{gt} = \theta_{pgt} L_{pgt} / G_{pt}$ is the share of generational capacity for generation g and δ_Z is the elasticity of average characteristics of generation g with respect to *Z*.

The last term in equation (19) suggests that the impact of the population of each generation is affected by their characteristics. For example, when a younger generation enters the labor market, an older generation retires and generations in the middle get more working experience, their contributions to the economy change. I make no assumptions regarding economies of scale in equation (19). Equation (19) shows the impacts of various factors. Of particular interest is the impact of the characteristics (Z_{pgt}) on regional economic growth rate. From equation (19), α_X shows the effects of overall population aging where X_{pt} represents the median age for all population, $\alpha_G \gamma_{gt}$ shows the effect of the population of generation g and $\alpha_G \gamma_{gt} \delta_Z$ shows the effect of generational characteristics such as generational aging of each generation.

3.4 Empirical Framework

To estimate the impacts of changes in generational distribution and their characteristics on regional economic growth in Japan, the following empirical model is estimated. The unit of analysis is 47 Japanese prefectures.

$$\ln GDP_{pt} = \beta_0 + \sum_g \left(\beta_{1g} \ln GenPop_{pgt} + \beta_{2g} \ln GenPop_{pgt} \times \ln Z_{pgt} \right) + \beta_3 \ln K_{pt} + \beta_4 \ln X_{pt} + \beta_t + \varepsilon_{pt}. \quad (20)$$

Note that $\ln GDP_{pt}$ is the log of real regional GDP in prefecture p at time *t*. $GenPop_{pgt}$ is the vector of the population of generation g. No restrictions are imposed on the parameters of the equation (20) to reflect constant, increasing or decreasing returns to scale. Since it is assumed that the impacts of a generation may change with the generations' characteristics, interaction terms with time trend or median age of each generation (Z_{pgt}) are included.

In the specification in equation (20), the coefficients have important meanings. β_{1g} is the marginal impacts of the log of the population of each generation on GDP in percentage terms. The different measures of β_{1g} essentially show the differential elasticities of output with respect to the population Japanese generations. β_{2g} is the coefficients of cross terms between the log of generation's population and median age of each generation. It is intended the increasing or diminishing effects of specific generations' aging. Again, it measures the elasticity of output with respect to the population of each generation, adjusted for an aging. The K_{pt} variable represents capital input. The X_{pt} variables include human capital variables (educational attainment), technology level, as well as the median age of the population[13, 14]. Since one expects that increasing working age population positively affects economic growth but increasing the number of retired people will negatively affect growth (Van Der Gaag and de Beer 2015), the impact of median age may be nonlinear. Therefore, a square term for median age is also included as a control variable to capture the possibility of quadratic relationship. β_t represents time effects and ε_{it} represents the error term, which is assumed to be normally distributed.

Given the facts that previous studies on multiple generations present conflicting definitions, I had to decide which generational boundaries provide the generational distinction. To correct for these inconsistences and harmonize several confusing definitions, in this paper,

[13] Miyahara and Adelaja (2020) tried both average age and median age in their empirical analysis. The results were practically the same and they reported on only the results using average age. However, this study, which uses longer period data than Miyahara and Adelaja (2020), choose median age due to its availability.

[14] As chapters 2 and 4 suggest, excluding migration variables may cause omitted variable bias. Therefore, I also estimate equation (20) with the percentage of international immigrants as a control variable. The estimated results are almost the same as those without the migration variable presented in the next section. Since including migration variable reduces sample size, I exclude it from control variables in this chapter. Further investigation for migrants' impact on Japanese economy will be conducted in the next chapter.

seven living generations of Japanese are defined. Note that the three generations common to previous literature are retained: (1) “First baby boomer” (Bb1), (2) “second baby boomer” (Bb2) and (3) the “Yutori generation” (Ytr). I also retain the “before baby boomer” (Bbb) generation, “generation X” (Gnx), “generation Y” (Gny) and “generation Z” (Gnz).

Because our defined Japanese generations vary in length, I depart from the standard definition of Japanese generation by combining the Bb2 and Gny generation to generate the Bb2Y generation. The characteristics of the combined categories are not majorly different. As previous research such as Hirayama and Ronald (2008) and Takao (2009) did, I retain the Bb1 generation though it has the smallest population share. Generation Z is excluded from the specification and used as numeraire to reduce multicollinearity in our estimation since not some of them were not already born during our study period and their population seems correlated with time. Table 9 defines the six generations I use in this chapter.

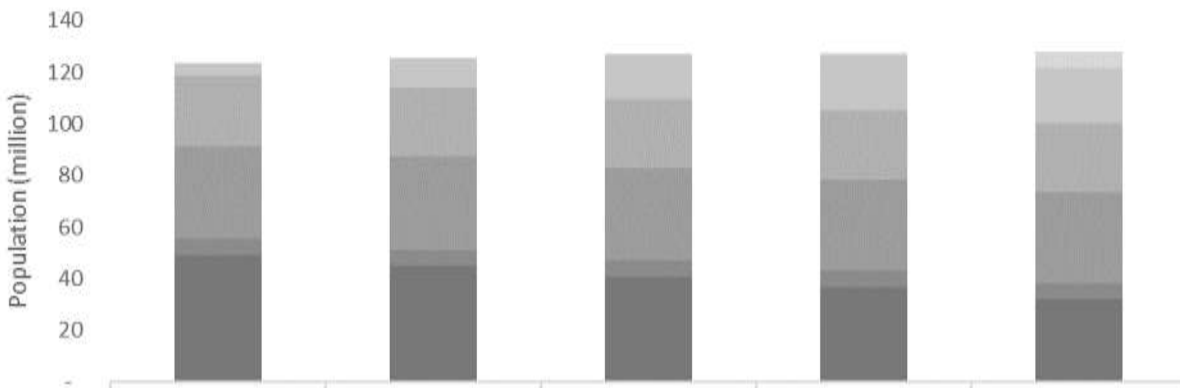
Table 9: Describing the seven living generations of Japan

Generation	Acronym	Born between	Number of years
Before baby boomer	Bbb	-1946	
Baby boomer I	Bb1	1947-1949	3
Generation X	Gnx	1950-1970	21
Baby boomer II + Genearation Y	Bb2Y	1971-1986	16
Yutori generation	Ytr	1987-2004	18
Generation Z	Gnz	2005-	

Generation	Age in 1990	Age in 2010	Share in 2010
Before baby boomer	44-	64-	25.2%
Baby boomer I	41-43	61-63	4.7%
Generation X	20-40	40-60	27.4%
Baby boomer II + Genearation Y	4-19	24-39	20.9%
Yutori generation	0-3	6-23	16.9%
Generation Z	-	0-5	5.0%

Source: SSDS

The contributions of different generations to Japan's total population are summarized in Figure 9. Bbb's population rapidly declined since 1990 due to aging and dying. Bb1's population also declined since 1990, but more slowly over time. The populations of Gnx and Bb2Y have been generally stable. Since most of them were born after 1990, Ytr's populations grew rapidly over time until 2004 but it has been stable since 2005. For similar reasons, Gnz's population is rapidly growing from 2005.



	1990	1995	2000	2005	2010
Gnz	-	-	-	1,115,617	6,413,880
Ytr	5,194,318	11,227,791	17,163,177	21,660,321	21,594,067
Bb2y	27,299,008	27,238,898	27,009,256	26,699,180	26,706,834
Gnx	35,793,956	35,866,564	35,696,100	35,389,768	35,090,664
Bb1	6,394,974	6,371,020	6,265,194	6,153,099	6,022,350
Bbb	48,928,910	44,865,975	40,792,116	36,750,008	32,229,558

Year

Source: SSDS

Figure 9: Six living generations in Japan: population changes

Since I have a prefectural panel data, I first estimate equation (20) with and without prefecture fixed effects (FE). Using F-test, I compare these two estimations. When FE model is chosen, I compare it to the random effect (RE) model by Hausman test. When without FE model is chosen, I estimate the model without FE but with errors clustered within prefectures. Prefecture's effect (FE or RE) will control prefecture characteristics which affects GDP growth but cannot be captured by available data.

There are several differences in the empirical framework between this study and Miyahara and Adelaja (2020), which is the base of this chapter. First, this study uses the log of population of each generation and log of capital as the independent variables (log-log model), while Miyahara and Adelaja (2020) estimated log-linear model. I can estimate the elasticity of output with respect to population of each generation in this chapter, while Miyahara and Adelaja (2020) estimated the impact of marginal increase of the population of each generation. Second, this study compares ordinary least square (OLS), FE and RE estimation and presents only the best estimation result, while Miyahara and Adelaja (2020) presented both OLS and FE estimation results. This change avoids redundancy in the estimation result section. Third, I use time trends as time variables instead of time fixed effects which are used in Miyahara and Adelaja (2020). By this change, I can estimate the long-term trend in the growth of each prefectural output including technology growth.

3.5 Data

To estimate the impacts of multiple generations on regional GDP growth, data from multiple sources are used. The data spanned the period 1990 to 2010 (21 years). Data on the real prefectural GDP and consumption of fixed capital (used as a proxy of physical capital stock) are obtained from the PAC, which is available at the SSDS. The earlier part of the series runs from 1990 to 2003, but has the base year of 1995. The latter part of the series, which runs from 2001 to 2010, has the base year of 2005. So, I merge the two series by using the base year of 2001 in order to have a continuous dataset spanning 1990 to 2010.

The number of people in each generation is calculated from the Population Census (PC) and Population Estimates (PE), which are available at the SSDS. It only provides information on the number of people in 5-year age brackets. In the absence of yearly details, in calculating the populations of each generation and their median ages, I assume uniform population distribution within each 5-year age bracket. I admit that this assumption may not be reasonable for estimating the median age of the oldest generation (Bbb) as the number of people aged one hundred is smaller than the number aged seventy. Hence, I use the youngest age of Bbb as a proxy for the median age of Bbb[15].

The median age of a prefecture's population is estimated from the PC, which is carried out every five years. In generating approximations of the median age of each prefecture, I assume that the median age changes linearly. I use the percentage of people that have completed high school, junior college and university from the PC as a proxy for human capital stock. Since the education data is collected every ten years (the available data is in 1980, 1990, 2000 and 2010), as oppose to other variables, I assume that the education variables change linearly over non-Census years.

There are three major changes from Miyahara and Adelaja (2020) in the data used at this study. First, the data range in this study is from 1990 to 2010, while the data range in Miyahara and Adelaja (2020) is from 2001 to 2014. I exclude the data from 2011 to 2014 because the educational variables during the period, which were used in Miyahara and Adelaja (2020), were out-of-sample forecasts[16]. Second, the educational variables used in this study are more detailed than in Miyahara and Adelaja (2020). That is, I use for this study the percentage of high school completion, junior college completion and university completion, while those used in Miyahara and Adelaja (2020) were the percentage of university completion only. Therefore, the estimated parameter in this study represents are the relative contributions between high school dropouts

[15] Please note that rather than use the log of populations of each generation as exogenous variables, I could have used the shares of each generation. I used the former because it has more direct policy implications as it allows the estimation of differential effects across generations of adding 1% more person.

[16] Miyahara and Adelaja (2020) used the out-of-sample forecasts to make their data range longer.

and each education level. Third, I exclude the urban prefecture dummy variable from this study since its estimated coefficient was not significant in Miyahara and Adelaja (2020) and my preliminary estimation. Although the new data excluded information from more recent years, the longer time frame for the data and its richness represents improvements in the quality of the data.

3.6 Empirical Results

The parameter estimates for equation (20) are presented in Table 10 and Table *11*. Table 10 reports only the estimated coefficients of the control variables, while Table 11 reports only the estimated coefficients of generations on regional output.

The first column in Table 10 and Table *11* presents the estimated result from the model without cross terms between the log of populations and the median age of each generation. The second column presents the estimated result from the model with the cross terms. The third column presents the estimated result with the cross terms and cross terms between log of populations and median age square of each generation. Based on the F-test and Hausman test, the prefectural FE estimation is preferred to OLS and RE for all three specifications. This suggests that prefectural time-invariant characteristics (e.g., geography, climate, place personality and character of residents) are important to account for in modeling the relationships between generations and output growth. This may indicate that place effects are critical determinants of regional economic growth. Since I assume that the contribution of each generation changes based on their characteristics, I present results of the second specification (column (2) in Table 10 and Table 11) as my main result and then compare them to the results of other two specifications.

The estimated coefficients of the control variables are consistent with the results in Miyahara and Adelaja (2020).

Table 10: FE estimation (control variables)

	(1)	(2)	(3)
Log of capital	0.3485***	0.3490***	0.3401***
	(0.020)	(0.020)	(0.019)
High school	0.0040***	0.0025**	0.0031***
	(0.001)	(0.001)	(0.001)
Junior college	-0.0332***	-0.0422***	-0.0327***
	(0.004)	(0.004)	(0.004)
University	0.0195***	0.0185***	0.0145***
	(0.004)	(0.005)	(0.004)
Time trend	0.0097**	0.0369***	0.0203**
	(0.004)	(0.008)	(0.009)
Median age	0.0177	0.0657*	0.1721***
	(0.013)	(0.035)	(0.040)
Median age sq.	-0.0003**	-0.0009**	-0.0021***
	(0.000)	(0.000)	(0.000)
Constant	2.7778	0.6233	-2.9538
	(1.704)	(1.953)	(2.016)
Observations	987	987	987
R-squared	0.869	0.880	0.897
Number of id	47	47	47

Note: Only the log of populations of each generation is used as the generational variable in (1). The log of populations and the cross term between median age of each generation are included in (2). The log of populations and the cross terms between median age of each generation and its square term are further included in (3). All three models are estimated with prefecture fixed effect (FE). The estimated parameters of generations are presented in Table 11. Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

In the FE model with cross terms (column (2) in Table 10), the estimated coefficient of the log of capital is 0.349, which is statistically significant at the 1% level. Therefore, a 1% increase in capital is associated with an increase in prefectural GDP by 0.35%. This output elasticity with respect to capital is close to the 1/3 value which is usually expected for an economy when constant returns to scale is assumed. However, estimates of 0.544, 0.522 and 0.433 have been shown for the US during 1990-1999 (Bental and Demougin 2008), for Germany during 1960-1989 and for Japan during 1965-1992 (Stresing et al. 2008), respectively. This suggests that the returns to capital in current Japan is somewhat lower than in other advanced countries and historical values of Japan. One implication of this is that while opportunities exist for economic development through physical capital accumulation, such opportunities may be limited, vis-à-vis other countries. Another implication is that human capital and technology opportunities for economic development are more relevant to Japan's economic growth. The Japanese government set an annual real GDP growth rate target of 2%. If this target is achieved through only physical capital investment, a 5.71% annual rate of capital growth will be needed in Japan. Japan's history shows rapid capital accumulation rates before 1980. However, these rates have fallen below 5.71% in recent years, making excessive reliance on capital for economic growth somewhat unrealistic.

Education was proxied by three variables: the percentage of people who have completed high school education, the percentage of people who have completed junior college, and the percentage of people who have completed university degree. Note that since I exclude the ratio of people who did not complete high school (dropouts) to reduce the likelihood of multicollinearity, the coefficients of these three variables show the relative impacts of education beyond secondary school, vis-à-vis no secondary school education.

The estimated coefficient for the completion of high school is positive (0.0025) and statistically significant at the 5% level, suggesting that one percentage point increase in the high school completion rate is associated with an increase in the growth rate by about 0.25%. In other words, to achieve a 1% increase in growth rate will require 4 percentage points increase in the high school completion rate. Such an achievement will obviously require significant effort and investment by the Japanese government. This result also suggests that when population aging is controlled, regional economic contribution of high school graduates is larger than that of high school dropouts. Upper secondary education can contribute to regional economic growth, though its impact is smaller than that of post-secondary education (compared with the estimated coefficient of university).

The estimated coefficient of junior college completion was statistically insignificant in the regional labor productivity model (essay 1). However, the coefficient of junior college completion in the regional output model is negative (-0.0422) and statistically significant at the 1% level. The results of the labor productivity model basically suggests that junior college achievement does not add to productivity growth rate but the results of the output decomposition model suggest that it detracts from output. These two results are not inconsistent. The findings from this chapter suggest that the contribution of junior college graduate may be actually less than those of high school dropouts. As explained in chapter 2, this seems to reflect the fact that women who earn low wages dominate the ranks of junior college graduates.

As augured in chapter 2, the completion of university education is generally accepted as more critical to the economy and to development than high school and junior college completion. The estimated positive (0.0185) and statistically significant (at the 1% level) coefficient of university completion is consistent with expectations and suggests that university graduates contribute more to economic growth than others. The estimated coefficient is virtually the same as the estimated coefficient in Miyahara and Adelaja (2020). Holding other things constant, it would require a 1.08-point increase in the percentage of the university graduates to achieve the 2-point increase in GDP growth, which the government has set as a target. This suggests that improving graduate completion rate use almost the seven-fold the impact on growth vis-à-vis high school completion. This suggests that the Japanese government appropriately recognizes the effectiveness of policies to enhance university completion. For example, the Japanese government started a new learning support system for higher education in 2020. The program provides financial support to university or junior college students whose household incomes are low (Ministry of Education, Culture, Sports. Science and Technology 2020).

The coefficient of the time trend variable is positive (0.0369) and statistically significant at the 1% level. This result suggests that holding Japan’s population aging and other control variables constant, her economic growth rate has grown over time. This is encouraging and may reflect achievement in technology accumulation, economic integration, structure reform and increasing diversity in Japan’s labor market.

The sign and significance of the estimated coefficients in the other specifications (column (1) and (3) in Table 10) are essentially the same, suggesting that the estimated coefficients presented in column (2) are robust.

Contributions of Societal Aging

Now, examine the coefficients of overall aging variable. The median age variable and its square term capture the effects of overall societal aging on regional GDP, but not generational aging (“Median age” and “Median age sq.” in Table 10). The coefficient of median age is 0.0657 and statistically significant at the 10% level. The coefficient of its square term is -0.0009 and statistically significant at the 5% level. These coefficients suggest that overall societal aging has a positive contribution to growth which increases at a diminishing rate, eventually maxing out at age 36. This is similar to the peak age of 39 years obtained by Miyahara and Adelaja (2020) using average age as the independent variable. Liu and Westelius (2017) estimated the peak age for total factor productivity to be 40-49 years old using various age ranges. This study’s estimate of 36 years for peak age is a bit below Liu and Westelius (2017) lower range and close to Miyahara and Adelaja (2020). Note that this study uses median age as the relevant independent variable while Miyahara and Adelaja (2020) used average age. The coefficients of the median ages of various generations would have to be added to or subtracted from 36, depending on the signs of the coefficient, with the exception of the Gnz generation (numeraire). Japan's median age was 48.6 in 2020 (CIA 2020) and continues to increase. In general, population aging begins to suppress economic growth after at age 36 and people start to become a drain on the economy at the age of 73 (Figure 10). These findings say nothing about the differential impacts of various generations.

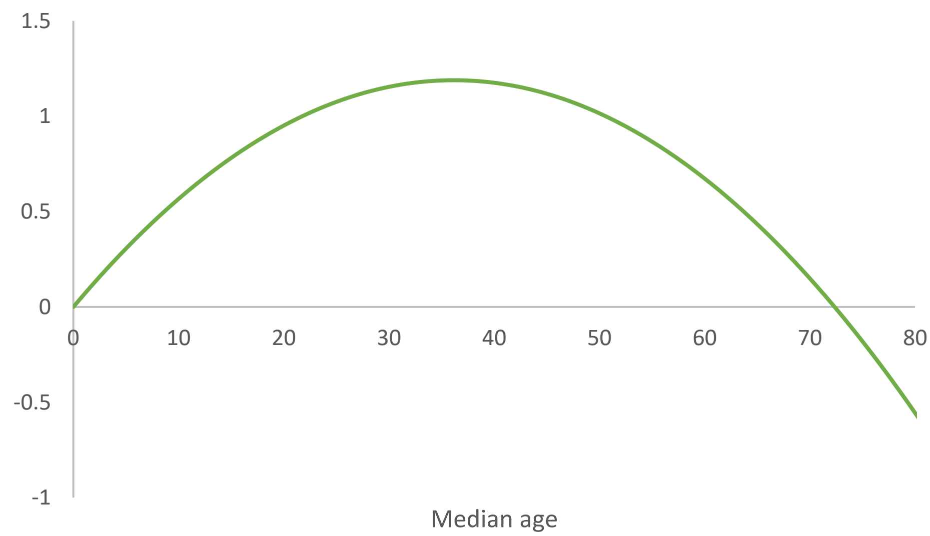


Figure 10: Estimated contribution of median age on Japanese economy

Contributions of the Populations of Each Generation

Now examine the impacts of generational population on prefectural GDP (Table 11). In the first column, the coefficients show the elasticity of output with respect to the population of each generation, without controlling aging of each generation. The generational population impact for Bb1 and Gnx are positive and statistically significant at the 1% level, suggesting a positive contribution of an additional person in the Bb1 and Gnx generations. Their ages during the study period, the fact that they are high spenders, the experience that they had as being young during the period of Japan's rapid economic growth, their higher income induced by their age and the fact that Japan maintains a seniority-oriented pay system are possible explanation for this result.

The contribution of the Bbb variable is not statistically different from the Gnz. The youngest person in the Bbb generation was 43 in 1990 and 63 in 2010. Therefore, most of the Bbb generation are well past their peak productivity age during the analysis period. The contribution of the Bb2Y variable is also not statistically different from the Gnz. The youngest person of the Bb2Y generation was 4 in 1990 and 24 in 2010. Hence, for most of the analysis period, this generation was probably too young to contribute meaningfully to the economy. When they started to contribute to the economy, the Japanese asset bubble burst, creating unemployment and limited opportunity to contribute meaningfully. Ono (2010) found that in the 1990s, new graduates were significantly less likely to be hired as standard workers than in previous periods, which caused increased nonstandard employment and job mobility. Genda et al. (2010) found that this generation met recession at their career entry points, and faced lower employment and earnings. This result suggests that they experienced difficulty in increasing their skills due to the challenged economy.

The contribution of Ytr is negative and statistically significant at the 5% level, suggesting a negative correlation of an additional person in the Ytr generations. This can be explained based on their ages. Before 2005, most of the Ytr generation did not work yet because they were younger than 18. Due to the possible negative impact from 1990 to 2005, the estimated average contribution during 1990-2010 is also negative.

Table 11: FE Estimation (Impacts of Generations)

	(1)	(2)	(3)
lnBbb	0.0735	0.0155	-5.4892***
	(0.094)	(0.257)	(0.814)
lnBb1	0.1202***	-0.1746	2.4505***
	(0.019)	(0.135)	(0.731)
lnGnx	0.6229***	0.5372***	6.0148***
	(0.071)	(0.200)	(0.793)
lnBb2Y	0.0312	0.3044***	-0.2941
	(0.043)	(0.112)	(0.203)
lnYtr	-0.0210**	-0.1119***	-0.0129
	(0.010)	(0.031)	(0.044)
Cross term with median age			
lnBbb		0.0016	0.1943***
		(0.005)	(0.030)
lnBb1		0.0055**	-0.0970***
		(0.003)	(0.028)
lnGnx		0.0062	-0.2888***
		(0.005)	(0.040)
lnBb2Y		-0.0130***	0.0870***
		(0.005)	(0.018)
lnYtr		-0.0021***	0.0054***
		(0.000)	(0.001)
Cross term with median age sq.			
lnBbb			-0.0017***
			(0.000)
lnBb1			0.0010***
			(0.000)
lnGnx			0.0038***
			(0.000)
lnBb2Y			-0.0028***
			(0.000)
lnYtr			-0.0003***
			(0.000)

Note: The estimated models in this table are the same as those of Table 10. The estimated parameters of control variables are in Table 10. Standard errors in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Added Contributions of Generational Aging

When introducing the cross terms between the logs of the populations of each generation and their median ages, the estimated coefficients of the cross terms are essentially additional shift factors in the relationship between generational aging and regional GDP growth (column (2) in Table 11). The generational population impact for Bb2Y is statistically significant at the 1% level. The first term is positive (0.3044) and the cross term is negative (-0.0130), suggesting a positive but diminishing marginal contribution of an additional person in the Bb2Y generation. The result is consistent with that in Miyahara and Adelaja (2020). These generations are highly educated and grew up in an information and material-rich society. This may have contributed positively to their past productivity. However, as mentioned previous subsection, they experienced difficulty in increasing their skills due to the challenged economy which started from 1990s. The Bb2Y generation had growing marginal impacts in their teens and early 20s but have stable contribution in their prime age range. These may explain the declining marginal contribution of the Bb2Y generation. The age range of members of the Bb2Y generation in 2010 was between 24 and 39. Their declining contribution in their prime age range is worrisome for current and future Japanese economic growth.

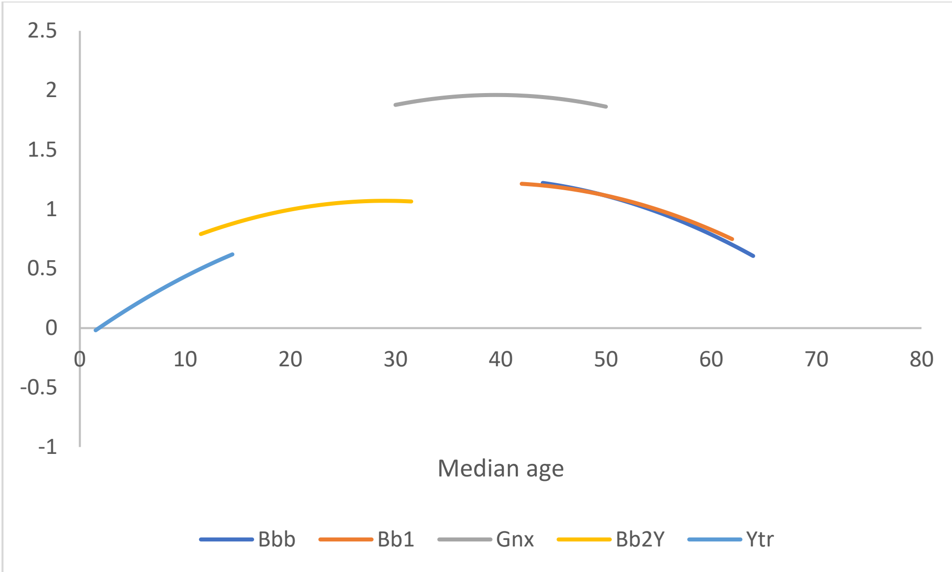
When the interaction terms are added, the contribution of the Ytr generation is statistically significant at the 1% level. In fact, both the linear term (-0.1119) and interaction term (-0.0021) are negative. This suggests that their contribution is smaller than that of Gnz and the gap is increasing as they age. As explained above, the age of Ytr may cause Ytr's smaller contribution. However, since the age range of members of the Ytr generation in 2010 was 6 and 23, same as the Bb2Y generation, their declining contribution is worrisome. Their conservativeness, education[17] and Japan’s challenged economy[18] may explain their lower contribution[19].

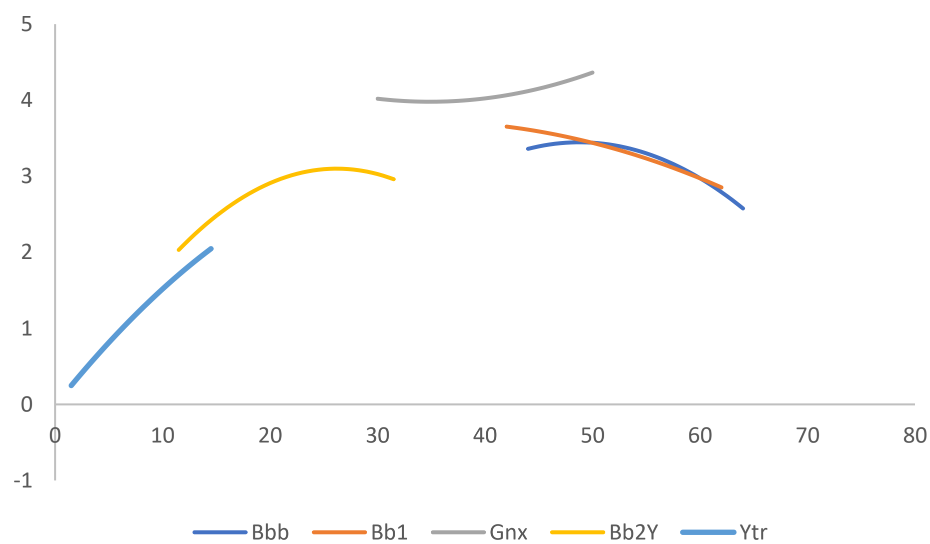
The coefficient of the Gnx generation is positive, large (0.5372) and statistically significant at the 1% level, though its cross term is statistically insignificant. This suggests that their positive contribution observed in the previous specification is robust and stable over time. On the other hand, the coefficient of the Bb1 generation is statistically insignificant, while its cross term is positive (0.0055) and statistically significant at the 5% level. They were between 40 and 42 in 1990 and between 60 and 62 in 2010. Their reputation as high spender, their high and increasing income, and the attainment of retirement amongst their rank suggests that their contribution to Japan’s economy may increase over time. The coefficients of the Bbb generation and its cross term are both statistically insignificant, suggesting that their impact is not different from Gnz. This result is consistent with previous subsection and with the result in Miyahara and Adelaja (2020).

The upper graph of the Figure 11 represents the estimated contribution of generational aging based on the second specification (column (2) in Table 11). The curves represent estimated generational contributions. Note that Figure 11 suggests the existence of the peak age. Note also that the contribution of Gnx seems rather high, compared with other generations. Members of Gnx were between 20-40 in age at the beginning of the analysis period (1990) and between 40-60 at the tail end of the analysis period (2010). It can be augured that this generation were the technical people behind the early development of advanced information and communication

[17] “Yutori education, intended to relieve academic pressure on students and improve their creativity, has been criticized by many for falls in students' academic abilities.” (“Japan Makes Break” 2016)
[18] The asset bubble burst, long deflation and recession in Japan also affected Ytr’s careers, albeit less severely than the Bb2Y generation (Ohta et al. 2008).
[19] In Miyahara and Adelaja (2020), which used 2001-2014 data, the impact for the Ytr generation is slightly increasing over time. Therefore, as the Ytr generation ages, their productivity may improve.

technology (ICT). While the predecessors made major contributions to Japan's ranking as manufacturing powerhouse, one can argue that it was this generation that helped to raise the bar with respect to the infusion of ICT into traditional manufacturing sectors. Cellphones, personal computers, advanced technology features in automobiles a smarter televisions and other home appliances became relatively well-accepted during the study period. This may explain why this generation is estimated to be more productive than other generations. It is also possible that the generation contributions curve is bell-shaped, peaking at 36 rather than a simple inverted U-shaped curve (such as Figure 10). It is hoped that when the Bb2Y and the Ytr generations become fully mature and integrated into the economy, their contributions will at least be comparable to or surpass the contributions of the Gnx. Enabling the Bb2Y and the Ytr generations to step up their roles as effective successors to Gnx should be a major policy issue for the Japanese government to consider.





Note: Upper (lower) graph are based on the estimated result presented in the second (third) column of Table 11.

Figure 11: Estimated contribution each generation on Japanese economy

Exploring Nonlinearity

Since there seems to be nonlinear relationships between overall median age and its impact on economic growth, it can also be expected that the relationships between the median age of each generation and its population impact is nonlinear. To explore such a relationship, I estimate a model which includes an interaction term between the square of median age and the log of population of each generation. Results are reported at the third column of Table 10 and Table *11*, and the lower graph in Figure 11 graphically presents the implied relationships between marginal contribution of population and median age for each generation. Similar to the previous results, the contributions of older generations (Bbb, Bb1 and Gnx) are larger and the contribution of Bb2Y seems stable during the period when they were at their prime productive age.

Endogeneity of the Population of Each Generation

The population of each generation may be affected by the degree of growth within each prefecture. For example, a prefecture with high economic growth rate may demand greater talent and better educated labor, thereby increasing the inflow of working-age population from other prefectures. If such a reverse causality problem exists, this would make my estimate spurious. To ensure that there is no reverse causality or endogeneity problem, I estimate the panel vector autoregression models using the log of generational population and the log of GDP for each generation and conduct Granger causality tests. Their results show that none of the logs of generational populations are Granger caused by the log of prefectural GDP when using the first two-year lags (for Bbb and Ytr) or four-year lags (for Bb1, Gnx and Bb2Y). This implies that prefectures that are experiencing growth do not necessarily face in-migration of people. Therefore, although some reverse causality may exist, I conclude that it is not a serious problem.

3.7 Conclusion

Previous studies on the impact of population aging on the economy of Japan treated the aging variable as a mean or median measure derived from the age distribution of the population. However, population aging has several nuances and affects the economy in different ways. Miyahara and Adelaja (2020) explained the growth patterns in Japan during the short 2001-2014 period by estimating the heterogeneous impacts of multiple generations on prefecture GDP. In this study, I re-estimate a similar model using different specification (log-log model), control variables (e.g., median age instead of average age, adding high school completion and eliminating urban dummy) and data range (1990-2010). I found that in addition to overall population aging, the distribution of generations also contribute to economic growth.

As the median age of the base generation (Gnz) increases, I found that the Japanese growth rate increases, but at decreasing rate. It peaks at age of 36 years. This peak, however, does not account for the effect of specific generations. Each generation adds an extra boost to economic growth due to its characteristics. The generation with the most extra boost is the Gnx, at least for the period of this study, followed by the Bb1 generation and then the Bbb generation. The population impacts of the Bbb and Bb1 generations are declining over time. On the other hand, the impact of the Ytr generations is increasing. The impact of the Bb2Y generation stops growing at their early 20s.

One of the challenges facing the Japanese government is how to ensure that the Bb2Y and the Ytr generations are as productive if not more productive than Gnx. The currently low estimate of the impact of the Bb2Y and the Ytr generation is due largely to their ages during the period of my analysis. These two generations are key to future Japanese growth because their productivity would determine how fast the national economy grows. If their contributions per capita do not surpass or exceed that of Gnx, I predict that Japan's economy will continue to be challenged and the turnaround of the economic growth rates will be difficult to achieve. It is also important to note that the enhancement of the completion rate for college education may be one of the better opportunities to increase or enhance the performance of the Bb2Y and Ytr generations.

Considering the growing life expectancy and low fertility rates in Japan, the results suggest that population aging will cause future economic declines, especially if not accompanied by significant increases in the productivity of younger generations. Eggleston and Fuchs (2012) suggested that to respond to this demographic challenge, public policy should encourage higher labor force participation among the elderly, improve productivity, with an emphasis on human capital, increase savings, investment and capital formation. This study also found positive contribution of human capital (especially post-secondary education) and physical capital. I further add enhancing the productivity of the younger generations through, for example, workforce development policies, could enhance future growth. Policies supporting childcare, education, and nursing can also help the growth contributions of working-age people by improving their labor force participation and productivity. More detailed policy implications are addressed in chapter 5.

I wish to highlight several limitations of the current study which can be improved on in subsequent studies. First, although the study period (21 years) is longer than that of Miyahara and Adelaja (2020) (14 years), it is still not sufficient for full understanding of the role of generations in economic growth. One clear indicator of this is the fact that the study period did not allow full rendering of the contributions of the Bb2Y and Ytr generations. The 2020 Census data, which will be published in late 2021, would be useful in future research on growth decomposition to explain the roles of multiple generations. Second, the fact that the age ranges of each generation vary in terms of the number of years pauses a problem. That is, since the model I used is a log-log model and a 1% increase in an explanatory variable (e.g., population of Ytr) may be not comparable to a 1% increase in another (e.g., Gnx), there is a need for future studies to consider how best to ensure that the impacts of each generation are easily interpreted.

Third, each generation possesses characteristics, including wants, needs, personality, purchasing habits, tastes, preferences, family structures and levels of education, future analyses might consider how to specify models that can help isolate the effects of these unique characteristics. Fourth, the sources of the generational difference such as selectivity of sectors and prefectures, and adoption of new technologies are not evaluated in this study. Future studies may need to pay more attention to these.

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CHAPTER 4. ESSAY 3: ROLE OF IMMIGRATION IN REGIONAL ECONOMIC GROWTH OF JAPAN

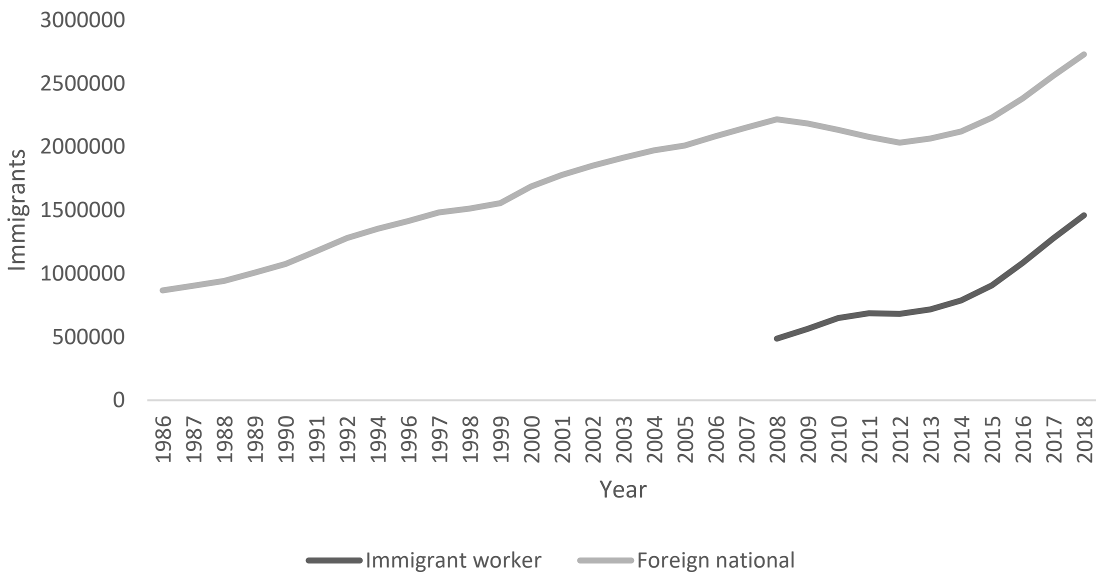
4.1 Introduction

The Japanese government maintained a restrictive stance toward immigration through the high-growth period of the 1980s because it wanted to maintain Japanese ethnic homogeneity and feared that large numbers of racially and culturally different immigrants could provoke social unrest (Hollifield et al. 2014). Therefore, Japan's international migrant population remains low, compared with other high-income or Asian countries (Table 12), though it is increasing over time (Figure 12). However, to accelerate economic growth, the Japanese government recently implemented a more liberal immigration policy to make up for what is perceived as a serious domestic workforce shortage (Yamawaki 2019).

Table 12: International migrant share of population (%) in selected OECD and Asia Pacific countries

Country	2000	2005	2010	2015	Change (2000-2015)
United Arab Emirates	80.2	73.2	87.8	88.4	+8.2
Singapore	34.5	38.1	42.6	45.4	+10.9
Luxembourg	32.0	32.9	32.1	44.0	+12.0
Australia	23.0	24.1	26.5	28.2	+5.2
Canada	18.0	18.8	20.5	21.8	+3.8
Germany	11.0	12.7	14.4	14.9	+3.9
United States	12.3	13.3	14.3	14.5	+2.2
United Kingdom	8.0	9.8	12.1	13.2	+5.2
France	10.6	11.0	11.4	12.1	+1.5
Italy	3.7	6.7	9.7	9.7	+6.0
Malaysia	5.5	6.7	8.6	8.3	+2.8
Korea, Rep.	0.5	1.0	1.9	2.6	+2.1
Japan	1.3	1.6	1.7	1.6	+0.3
China	0.0	0.1	0.1	0.1	+0.1

Note: "International migrant" in this table is the people born in a country other than that in which they live. "Change" is the percentage point change in international migrant share from 2000 to 2015.
Source: World Bank (2020)



Note: Immigrant worker data is obtained from Summary of Employment Situation of Foreigners.
Foreign national data is obtained from the Foreign Resident Statistics.

Figure 12: Immigrant stock in Japan since 1986

The policy change in Japan represents a major shift in the nation's perspective of the role of immigrants. On one hand, immigrants can contribute to output and productivity growth in the short and medium term by allowing for more dynamic labor market adjustments, by increasing the quantity (working-age population) and quality (human capital and diverse skill sets) of labor, by enhancing cultural diversity, by promoting capital investments and by stimulating innovation (Basso et al 2019; Freeman 2006; Kerr et al. 2016; Bove and Elia 2017; Peri 2012; IMF 2020). In this case, the effects of in-migration on the economy can be positive. Increasing or maintaining the working age population is important for economic growth in an aging society such as Japan. In addition, due to the currently low migrant population stock, there is significant expectation that immigrants can enhance diversity and stimulate innovation.

On the other hand, however, immigrant workers can compete with native workers who have similar characteristics (such as educational attainment and working experience). Due to such competition, some natives may face lower wages, lose or change their jobs or move to other places. Note that because most of the immigrants may have sufficiently different human capital quality from natives (Piras 2013; Dustmann et al. 2016), such negative effects may be reduced or may become insignificant. If so, immigrants are complements to nominally similar native-born workers (Freeman 2006). For example, native workers in jobs involving manual tasks respond to immigrants (Basten and Siegenthaler 2019) by shifting their job foci toward non-manual or communication and interaction-intensive tasks (Peri 2016).

The two paragraphs above illustrate the dilemma facing Japan and other countries with similar characteristics. Whether and how much increased immigrant population contribute to economic growth depends on its net effects, which regular citizens are not always clear about and research is very scarce, especially in the case of Japan. Although empirical studies conducted in other countries suggest that immigrants contribute to the host economy, as is the case with other countries (for example, Brockway and Doherty (2019)), there are some concerns about increasing the number of immigrants in Japan due to the lack of clarity about the net effect. For example, according to a Nikkei (Japanese financial newspaper) survey conducted in 2020, 26% of respondents indicated that an increase in the number of foreign people in Japan is "not good" while 50% of respondents indicated that they do not like to actively accept foreign workers, but it cannot be helped ("Nearly 70% of Japanese say more foreigners are 'good'" 2020).

The objective of this particular essay is to investigate the impact of immigrants on the Japanese economy. Using data on Japan's regional economy, native population and immigrant population, I estimate and compare the impacts of immigrants and natives on regional output growth. I also estimate the changes over time in the composition of the population by immigration status and identify the causes and dynamics of such changes.

Since the Japanese government is planning to increase the number of immigrants in order to revitalize its economy, evidence on the impact of immigrants on the economy is useful to Japan’s national and municipal governments, as well as natives. In addition, this study will be useful to other countries whose situations are close to Japan’s (for example, a country with few but increasing immigrant stock, and a country which would like to increase immigrants to incentivize its economy or to overcome labor deficiency).

The rest of this chapter is organized as follows. Sections 4.2 and 4.3, respectively, present the literature review and conceptual framework for the analysis. Section 4.4 and 4.5, respectively, present the empirical framework and data used in this analysis in this chapter. Section 4.6 presents the empirical results. Finally, section 4.7 presents the conclusion of this chapter.

4.2 Literature Review

A significant body of literature has examined the effects of immigrants on the economy, especially on labor markets. Examples include studies on the effects on wages and labor force participation rates. For example, Foged and Peri (2015) tracked Denmark's labor market outcomes for low-skilled natives in response to an exogenous inflow of low-skilled immigrants. They found that since native workers pursue less-manual intensive occupations in response to the supply of immigrants, immigration had positive effects on native unskilled wages, employment and occupational mobility.

On the other hand, the simulation result of the Edo and Toubal (2017) study using a French dataset showed that an increase in the relative number of female immigrants decreases the relative wage of female native workers. Mäkelä (2017) estimates the impacts of a large immigrant influx on labor productivity, wages and unemployment in Portugal using the synthetic control analysis. In contrast to previous research on Portugal, Mäkelä (2017) found that an increase in the number of immigrant workers lowered average labor productivity and wages. With little or no existing analysis based on data on immigrants from Japan, these studies suggest the need for a close examination of the impact of immigration in Japan.

De Arce and Mahía (2014) described a technical procedure for a complete evaluation of the economic impact of immigrant workers on GDP and employment in Spain. They divided immigrants' impact into two categories: overall effect derived from the migrant work in the production system and chain effects induced demand effects derived from consumption and saving behavior. They found that migrants' economic contribution was around 8.6%, which is lower than the share of migrant workers (around 14%). However, according to them, absolute contributions matter less than relative contribution to growth.

As Rodriguez-Planas et al. (2014) pointed out, however, that most of past research are based on economies with more experience as host countries, with higher labor mobility and higher unemployment rate. They found that the achievement of wage convergence and occupational assimilation take some time for both low- and high-skilled immigrants in Spain. Since Japan is a low labor mobility country[20], better knowledge of the impact of immigration on the Japanese labor market will contribute to both Japan and other countries which experience low labor mobility.

There are several existing migration studies on Japan. However, most of them focused only on internal migration. In addition to the literature which examine regional labor market adjustment to internal immigrants in Japan, Kondo and Okubo (2015) pointed out that there is

[20] Lifetime employment is a traditional feature of Japanese employment system. Although it is less common these days, Japan's labor market flexibility score (Hays Global Skills Index 2019), which is high when there are barriers in place restricting the local labor market, is the 9th highest among 34 countries (2nd highest among developed nations).

another stream of the literature related to regional disparities and labor migration. This stream focuses on regional convergence in growth and interregional migration within country. For example, Barro and Sala-i-Martin (1992) tested the role of migration on the speed of regional growth convergence in Japan and the US. They identified the determinants of net in-migration. For Japan, the levels of income, amenity (extreme temperature), population density and neighbor's density are the determinants. They found that domestic migration has little effect on regional growth convergence in both Japan and the US. Shioji (2001) also studied the roles of internal migration in regional income convergence in Japan, focusing on the effect of migration through changing educational attainment (human capital) and demographic structure. By using more recent data and focusing on international migration, the analysis contained in this essay can help fill a gap in the literature, specifically the role of immigrants in Japan.

4.3 Conceptual Framework

Barro and Sala-i-Martin (1992) presents a framework for exploring the impacts of immigrants on the regional economic convergence in Japan and the US. Shioji (2001) and Piras (2013) utilized a similar methodology in investigating the impacts of immigration on Japanese and Italian economies, respectively. I propose to use and expand on this methodology in investigating how immigrants contribute economic growth in the Japanese economy. The model is specified as follows.

Define the output for the p^{th} prefecture in year t as Y_{pt}. Note that

$$Y_{pt} = F\left(K_{pt}, H_{pt}, L_{pt}, X_{pt}\right) \tag{21}$$

where K_{pt} is physical capital, H_{pt} is human capital, L_{pt} is labor input and X_{pt} is other contributory factors, including technology and place characteristics for the p^{th} prefecture in year

t. Note that physical capital is immobile, while human capital and labor input are mobile. Let M_{pt} and N_{pt} be the immigrant and native population (therefore, $L_{pt} = M_{pt} + N_{pt}$). Then,

$$H_{pt} = M_{pt}Hm_{pt} + N_{pt}Hn_{pt} \tag{22}$$

where Hm_{pt} and Hn_{pt} are average human capital of immigrants and natives, respectively.

The total derivative of the production function in equation (21) is specified as follows:

$$dY_{pt} = \frac{\partial F}{\partial K}dK_{pt} + \frac{\partial F}{\partial H}dH_{pt} + \frac{\partial F}{\partial M}dM_{pt} + \frac{\partial F}{\partial N}dN_{pt} + \frac{\partial F}{\partial X}dX_{pt}. \tag{23}$$

This can be expressed as

$$\frac{dY_{pt}}{Y_{pt}} = \frac{\partial F}{\partial K}\frac{K_{pt}}{Y_{pt}}\frac{dK_{pt}}{K_{pt}} + \frac{\partial F}{\partial H}\frac{H_{pt}}{Y_{pt}}\frac{dH_{pt}}{H_{pt}} + \frac{\partial F}{\partial M}\frac{M_{pt}}{Y_{pt}}\frac{dM_{pt}}{M_{pt}} + \frac{\partial F}{\partial N}\frac{N_{pt}}{Y_{pt}}\frac{dN_{pt}}{N_{pt}} + \frac{\partial F}{\partial X}\frac{X_{pt}}{Y_{pt}}\frac{dX_{pt}}{X_{pt}} \tag{24}$$

and

$$\ln Y_{pt} = \alpha_K \ln K_{pt} + \alpha_H \ln H_{pt} + \alpha_M \ln M_{pt} + \alpha_N \ln N_{pt} + \alpha_X \ln X_{pt,} \tag{25}$$

where α_j is the elasticity of output with respect to the j^{th} input ($j \in \{K, H, M, N, X\}$).

Equations (22) and (25) suggest that output growth rate is a function of physical capital, average human capital of migrants and natives, the migrant and native population, and other contributory factors. Note that consistent with economic theory, $\alpha_M > 0$ and $\alpha_N > 0$. That is, I expect the marginal product of both immigrants and natives to be positive in the regional economic growth model. However, the critical issue is whether $\alpha_M < \alpha_N$ or vice versa. Note that if the contributions of migrant workers and native workers are equivalent after controlling for human capital differences, $\alpha_M = \alpha_N$, which is my null hypothesis. My alternative hypothesis is $\alpha_M < \alpha_N$, for a number of reasons. First, natives may have greater experience and enjoy more favorable policies that enhance their productivity, vis-à-vis migrants. Second, existing networks and connections may be more favorable to natives, vis-à-vis migrants. Third, there might exist some discriminatory policies and/or practices which hamper the productivity of immigrants, vis-à-vis natives. On the other hand, however, it is possible that immigrants are better educated and performing better in regional labor market, vis-à-vis natives, as have been shown in some regions (Akbari 2011). In this case, $\alpha_M > \alpha_N$. The basic empirical question in this paper therefore whether immigrants contribute more to the national economy of Japan vis-à-vis natives.

Another possible hypothesis would consider the trajectory of the productivities of both native workers and immigrants. That hypothesis involves whether α_M or α_N are increasing or decreasing. For example, it is possible that the productivity of native workers is higher than the productivities of immigrants, but that α_M is increasing while α_N is decreasing. Possible reasons for low initial levels of productivity for immigrants include limited early assimilation, cultural integration, discriminative practices, lack of support networks and selectivity bias in the provision of support services or capacity building support to immigrants. This alternative hypothesis will also be examined in this chapter.

The basic framework above can be used to account for the contributions of the immigrant population, as well as the native population. Of particular interest are such issues as the relative differences between the contributions of immigrants and existing population, the unique ways by which immigrants contribute to the economy and their unique regional contributions. These results are potentially useful to policy makers in assessing the impacts of immigrants and how they accrue.

4.4 Empirical Framework

Several studies investigate the impact of migrants on economies by regressing difference in economic outcomes (e.g., employment rate, unemployment rate, wage and occupational complexity) on the migrant share of workers (Basten and Siegenthaler 2019; Dustmann et al. 2016; Foged and Peri 2015). This methodology is used and expanded on in estimating the impacts of immigrants on regional economic growth in Japan. The basic model is specified as follows (note that the unit of analysis is Japanese prefectures and dependent variable is GDP):

$$\ln Y_{pt} = \alpha_0 + \alpha_1 \ln K_{pt} + \alpha_2 \ln H_{pt} + \alpha_3 \ln M_{pt} + \alpha_4 \ln N_{pt} + \alpha_5 \ln X_{pt} + \varepsilon_{pt}. \qquad (26)$$

Note that basic model can be adjusted so that each population-related determinant (M_{pt} and N_{pt}) is further crossed with time trend variable. In equation (26), note that H_{pt} is the average human capital in prefecture *p* in time *t*, a time trend variable is included among the variables in $\ln X_{pt}$ (technology change), and ε_{pt} is the error term. The coefficients of the log of human capital (α_2) represent the impact of human capital (quality effect of labor) and the coefficients of the log of immigrant population (α_3) and native population (α_4) represent the quantity effect of immigrant and native labor. No restrictions are imposed on the parameters of the equation (26) to reflect constant, increasing or decreasing returns to scale. While there is no a priori expectation that α_3 and α_4 are related in time and space, if the basic model suggests otherwise, this aspect will also be investigated.

One of the most important problems in estimating the impact of migration is the possible endogeneity of the migration stock (M_{pt}) variable because international immigrants tend to be more mobile and tend to move to places that they consider to be "better" (for example, economic opportunity, amenity, diaspora and natives' attitudes toward immigrants)[21]. Statistical techniques such as synthetic control analysis (Mäkelä 2017), difference-in-differences, natural experiments and instrumental variables (IV) can be used to control endogeneity. Therefore, due to the data limitation, I calculate the expected immigrant population based on the past immigrant distribution among prefectures and current national immigrant stock, which is used in many

[21] Such place characteristics pose push and pull factors. 'Push factors act as disincentives to live in the present location, whereas pull factors make the attributes of the location seem appealing." (Choi and Lim 2015: 16132)

previous studies (for example, Foged and Peri (2016)). I use it as an IV for the immigrant population. This IV may satisfy the relevance condition[22] and exclusion restriction because it is calculated based on past values, which may be close to the current endogenous variable but cannot be affected by the current situation. To further test the validity of the IV, I test for endogeneity and weak instruments in each estimation. Since I use a prefectural panel database, I first estimate equation (26) using IV without prefecture fixed effect (FE) and with FE. Using F-test, I compare these two estimations. When FE model is chosen, I compare it to the random effect (RE) model by Hausman test. When without FE model is chosen, I estimate the model without FE but with errors clustered within prefectures. Prefecture's effect (FE or RE) will control prefecture characteristics which affects GDP growth but cannot be captured by available data. Note that due to the data limitation, I cannot estimate some of these models. When this happens, I choose the available estimation model as my main result.

Physical capital (K_{pt}) is proxied by the consumption of fixed capital. Average human capital (H_{pt}) is proxied by average educational attainment. The time trend variable is used as a proxy for technological progress.

4.5 Data

The data used in this section comes from multiple sources. Data on the real prefectural GDP and consumption of fixed capital (used as a proxy of physical capital stock) are obtained from the PAC, which is available at the SSDS. The earlier part of the series runs from 1990 to 2003, but has the base year of 1995. The latter part of the series, which runs from 2001 to 2014,

[22] If the IV is not relevant, the IV estimation is biased. For example, if special economic zone where immigrant restriction is relaxed is introduced during study period, the past immigrant distribution cannot estimate current immigrant stock. Note that no such deregulation or economic zone was introduced in Japan during study period.

has the base year of 2005. Therefore, I merge the two series by using the base year of 2001 to have a continuous dataset spanning 1990 to 2014 (25 years).

Data on the native population are obtained from the Population Census (PC) and Population Estimates (PE), which are available at the SSDS. The human capital stock is proxied by the percentages of people that have completed high school, junior college and university, based on data from the PC. Since data on the education variable is collected every ten years (the available data is for 1980, 1990, 2000 and 2010), as opposed to other variables, I assume that the education variables change linearly over non-Census years. Japan's national data of the education variables, which is annual and obtained from OECD, suggests that there are no drastic short-term shifts in education attainments (OECD 2020).

Migration-related variables are obtained from two data sources. The first variable, the international immigrant workers population, is obtained from the Summary of Employment Situation of Foreigners (SESF) by the Ministry of Health, Labor and Welfare, GOJ (MHLW). The data runs from 2008 to 2018. The second variable, the number of registered foreign nationals, is available for 1986, 1988, 1990, 1992, 1994 and 1996-2011, while the number of foreign residents is available from 2012 to 2017. These are obtained from the Foreign Resident Statistics (FRS) generated by the Ministry of Justice, GOJ. This is available at the SSDS[23].

4.6 Empirical Results on the Role of Immigrants

The parameter estimates for equation (26) are presented in the Table 13 of this section. Because I use two different immigrant variables, the data range for each model is different. The "IM Worker" or immigrant worker model (column (1)) is based on annual cross-sectional prefectural data from 2008 to 2010. Because this is a short time period (3 years), I see the need to

[23] In 2012, the Japanese name for the FRS and some variables changed. Therefore, the "registered foreign nationals" and "foreign residents" are equivalent.

consider other data sources. The “FN” or foreign national model (column (2)) is based on data for 1990, 1992, 1994 and 1996-2010. This database covers a total of 18 years. Note that one additional difference between the IM Worker model and the FN model is that the first is data only on immigrant workers while the second is data on all foreign nationals. It is possible that foreign nationals exist in a prefecture who are not working or can be considered as immigrant workers. An example would be a foreign spouse of a Japanese citizen who is not engaged in any employment.

Another important issue is the choice of appropriate estimation technique. Recall that the IV method is considered more appropriate in modeling the effect of immigration on economic growth because of possible endogeneity problems[24]. For example, it is possible that certain immigrants are attracted to specific places, perhaps because of inherent job opportunity, quality of life features, and the degree to which the places are welcoming. For the model where the log of the IM worker population is used as a proxy for immigrants, based on an F-test comparing the IV without FE and the IV with FE estimation methods, I choose and present the result of the IV estimation methods without FE, but using clustered errors. For the model where the log of the FN as a proxy for immigrants, based on the F-test and Hausman test, the result of IV with FE estimation method is chosen and presented, rather than the IV without FE and the IV with RE. This suggests that prefecture fixed effects are important to account for in modeling immigrant in modeling immigrant in general but not important in modeling immigrant workers. This may indicate that place effects are critical determinants of regional economic growth in the longer

[24] Same as chapter 2, endogeneity and weak instrument are tested. For the model where the log of the IM worker population is used as a proxy for immigrants, neither the Durbin and Wu–Hausman tests can reject the null hypothesis that the possible endogenous variable (log of the IM worker population) is exogenous even at the 10% level. However, the Stock and Yogo’s test rejects the null hypothesis that the possible endogenous variable is weak at the 5% level. For the model where the log of the FN as a proxy for immigrants, Both the Durbin and Wu–Hausman tests reject the null hypothesis that the possible endogenous variable is exogenous at the 1% level. Also, the Stock and Yogo’s test rejects the null hypothesis that the endogenous variable is weak at the 5% level.

term. Since the FN model estimation involves a longer-period data than the IM worker model estimation, I present results based on a FN model parameter estimates and then compare them to the results based on the IM worker model.

Table 13: IV Estimation with human capital variables

	(1)	(2)
	IM Worker	FN
VARIABLES	CL	FE
Log of immigrants	0.0478**	0.0716**
	(0.019)	(0.034)
Log of natives	0.1818**	0.2575**
	(0.087)	(0.122)
Log of capital	0.7875***	0.3518***
	(0.092)	(0.030)
Time trend	-0.0025	-0.0026*
	(0.003)	(0.001)
High school	-0.0015	-0.0013
	(0.003)	(0.002)
Junior college	-0.0076	-0.0100***
	(0.008)	(0.003)
University	0.0044	0.0069**
	(0.005)	(0.003)
Constant	2.7493***	9.5970***
	(0.611)	(1.913)
Equal impact	Yes	Yes
Observations	141	846
R-squared	0.994	

Note: "Equal impact" is "Yes" if the null hypothesis that the coefficient of the log of immigrants is equal to that of the log of natives cannot be rejected. "IM Worker" is the immigrant worker obtained from the SESF. "FN" is the foreign nationals obtained from the FRS. "CL" is the estimation without prefecture effects but using clustered error. "FE" is the fixed effect estimation. Standard errors in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

As expected, the impact of capital is positive and statistically significant at the 1% level. This suggests that capital accumulation enhances prefectural GDP growth. Specifically, a 1% increase in capital is associated with an increase in prefectural GDP by 0.35%. This output elasticity with respect to capital is close to the 1/3 value which is usually expected for an economy when constant returns to scale is assumed. However, estimates of 0.544, 0.522 and 0.433 have been shown for the US during 1990-1999 (Bental and Demougin 2008), for Germany during 1960-1989 and for Japan during 1965-1992 (Stresing et al. 2008), respectively. Hence, returns to capital in current Japan appear to be lower than in these other countries and the historical values for Japan. One implication of this is that while opportunities exist for economic development through capital accumulation, such opportunities may be limited. Another implication is that human capital and technology opportunities for economic development are more relevant to Japan's economic growth than physical capital. The Japanese government set an annual real GDP growth rate target of 2%. If this target is achieved through only capital investment, a 5.71% annual rate of capital growth will be needed in Japan. Japan's history shows rapid capital accumulation rate are before 1980. However, recent rates have fallen below 5.71%.

The coefficient of the time trend variable is negative and statistically significant at the 10% level in the FN model. The FN model covers a long enough period to allow the effects of Japanese asset bubble burst, which took place in 1990s, to be detected. These results suggest that over time, Japan's economic growth rate has declined when other factors are held constant. This temporal decline in Japanese GDP is what current Japanese policies are seeking to reverse.

Education was proxied by three variables: the percentage of people who have completed high school education, the percentage of people who have completed junior college, and the percentage of people who have completed university degree. Note that since I exclude the ratio of people who did not complete high school (dropouts) to avoid multicollinearity, the coefficients of these three variables reflect the relative impact of education beyond secondary school, vis-à-vis no secondary school education. The estimated coefficient for the completion of high school education is statistically insignificant, suggesting that there is no difference between high school dropouts and high school graduates in regional economic contributions. This may be explained on the basis of their ages, working experiences and wage ranges. For example, one would expect that high school graduates, compared to junior college and university graduates, are generally low wage workers who essentially compete for the same types of jobs. While high school degree recipients may be paid higher, the evidence of this study does not suggest that they contribute more effectively to economic development.

It is important to note that the ratio of junior high school graduates going to further education is over 90% since 1975 and over 95% since 1991 (School Basic Survey, obtained from the SSDS). Therefore, the average age and working experience of high school dropouts are much higher than that of high school graduates. Due to these differences, the average wage of high school dropout and high school graduates are actually close, especially for men (see Table 6).

The estimated coefficient of junior college completion is negative and statistically significant at the 1% level. This suggests that their contribution may be actually less than those of high school dropouts, which is consistent with the findings in chapter 3. As explained in chapter 2 and 3, this may reflect gender differences across regions and sectors. The positive and statistically significant coefficient at the 5% level coefficient of university completion is consistent with expectations and suggests that university graduates contribute more to economic growth than high school dropouts. If wages are reflection of the productivity, then one should observe a significant wage gap between university graduates and others. As shown in Table 6, this is the case with Japan. Holding other things constant, a 2.9-point increase in the percentage of the university graduates is associated with a 2% increase in real GDP growth. This is consistent with the findings from chapter 3. In chapter 3, I use this positive relationship to explain the human capital focus of the Japanese government.

Now examine the empirical results related to immigrants. The coefficients of the log of immigrants and the log of natives are both positive and statistically significant at the 5% level, suggesting that both contribute to the economy at the margin. A 1% increase in both immigrant and native populations is associated with an increase in prefectural GDP by 0.072% and 0.26%, respectively. This suggests that the average contributions of an immigrant and a Japanese native to regional growth are both positive, but immigrants' contributions are smaller than those of natives[25]. This is the essence of the first hypothesis above. As stated above, the difference in the impacts of immigrants versus natives may reflect differences in working experience, culture, assimilation and language barriers. Specifically, a 1% increase in the population of natives is much larger in head count than a 1% increase in the population of immigrants. Since the international migrant ratio is less than 2% in Japan (Table 12), 1% increase in native population is about 50 times larger than that of immigrants in head count. On converting the impacts of these population variables per person, one observes that immigrant productivity per person is actually higher than natives[26].

The signs of the estimated parameter of the IM worker model (column (1)) are basically the same as the FN model, suggesting the robustness of the FN model. However, since the sample size of the IM worker model is smaller than the FN model, some of the IM worker model's coefficients are insignificant.

[25] However, I conducted a test of the hypothesis that the coefficients of log of immigrants and the log of natives are equal and this hypothesis cannot be rejected even at the 10% level (p-value is 0.2211). This suggests that the difference between the contributions of immigrants and natives may be trivial.

[26] I estimate the same models using million immigrants and natives instead of log them to test this issue. This enables us to intuitively compare the impact of immigrants and natives on regional economic growth in nominal terms. Only the estimated coefficient of the immigrant in FN model is positive and statistically significant.

Alternative Specification: Interaction Terms

Interaction terms between the time trend variable and the population variables are included in alternative specifications in order to capture the more dynamic aspects of the impacts of both immigrant and natives. Same as before, the clustered error without prefecture effect is chosen for the IM worker model and the FE estimation is chosen for the FN model.

Findings suggest that the contributions of immigrants increase over time while the contributions of natives decrease over time (see Table 14)[27]. This is based on the estimated coefficients of the cross terms between the logs of both the migrant and native populations and the time trend variable. Note that although each of the coefficient of immigrants, natives and their cross terms are not statistically significant individually, the joint hypothesis that the coefficient of the log of immigrant (native) population and its cross term with time trend are simultaneously equal to zero is rejected at the 10% (1%) level. This further suggests differentials in the productivity path for natives and immigrants over time.

In the FN model (column (2)), the estimated coefficients of the log of capital, high school and junior college are the similar to the findings from model in chapter 3. Note that the coefficient of the time trend variable in the model with interaction terms is now positive and statistically significant at the 10% level, rather than the negative coefficient observed before. This suggests that the temporal decline in Japanese growth can be attributed directly to the dynamics of immigrants and native Japanese populations. Native population's contribution is declining, immigrant population's contribution is growing, but the net effect is negative.

[27] I also conducted a test of the joint hypothesis that the coefficients of log of immigrants and the log of natives are equal, and that the coefficients of two cross terms are equal. This joint hypothesis is rejected at the 1% level.

Table 14: IV estimation with cross terms between time trend

VARIABLES	(1) IM Worker CL	(2) FN FE
Log of immigrants	-0.1424	-0.1662
	(0.169)	(0.162)
Log of immigrants	0.0035	0.0083
* Time trend	(0.003)	(0.007)
Log of natives	0.5106*	0.3242
	(0.262)	(0.241)
Log of natives	-0.0060	-0.0111
* Time trend	(0.004)	(0.007)
Log of capital	0.7873***	0.2618***
	(0.091)	(0.090)
Time trend	0.0543	0.0827*
	(0.046)	(0.047)
High school	-0.0015	-0.0006
	(0.003)	(0.002)
Junior college	-0.0075	-0.0083**
	(0.008)	(0.004)
University	0.0043	-0.0242
	(0.005)	(0.023)
Constant	-0.3743	12.7252*
	(2.564)	(6.548)
Equal impact	Yes	No
Zero immigrant impact	No	No
Zero native impact	No	No
Observations	141	846
R-squared	0.994	

Note: “Equal impact” is “Yes” if both of the null hypotheses that the coefficient of the log of immigrants is equal to that of the log of natives, and that the coefficient of its cross term is equal to that of the cross term between log of natives and time trend, cannot be rejected. “Zero immigrant (native) impact” is “Yes” if the null hypothesis that the coefficients of the log of immigrants (natives) and its cross term are simultaneously equal to zero cannot be rejected. “IM Worker” is the immigrant worker obtained from the SESF. “FN” is the foreign nationals obtained from the FRS. “CL” is the estimation without prefecture effects but using clustered error. “FE” is the fixed effect estimation. Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Figure 13 further illustrates how the interaction terms work by graphically depicting the contributions of immigrant and native populations. The contribution of immigrants, which was negative, became positive since 1975 as a result of the positive coefficient of the cross term between the log of the migrant population and the time trend variable. The contribution of natives, which was positive, became negative since 1984 as a result of the negative coefficient of the cross term between the log of the native population and the time trend variable. The two series in Figure 13 suggest that the impacts of both natives and immigrants were equal between 1979 and 1980. This is explained further below.

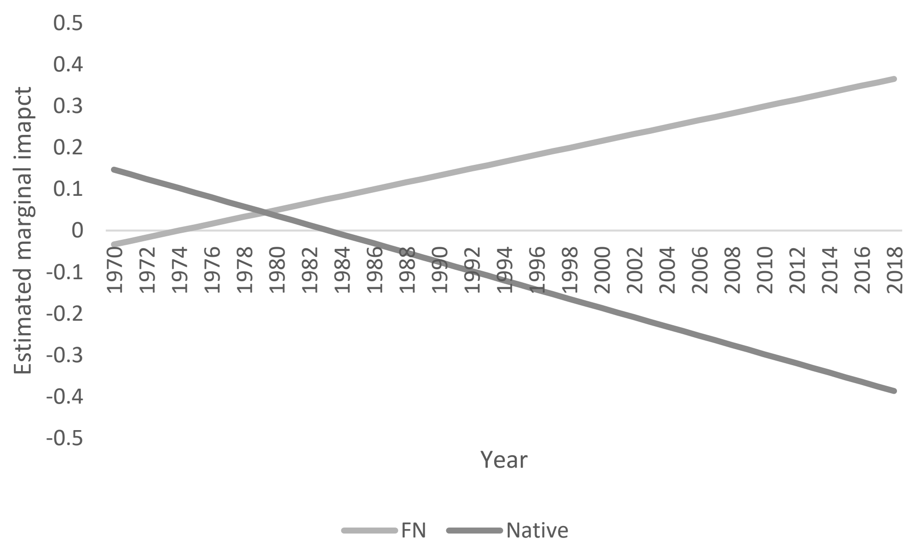
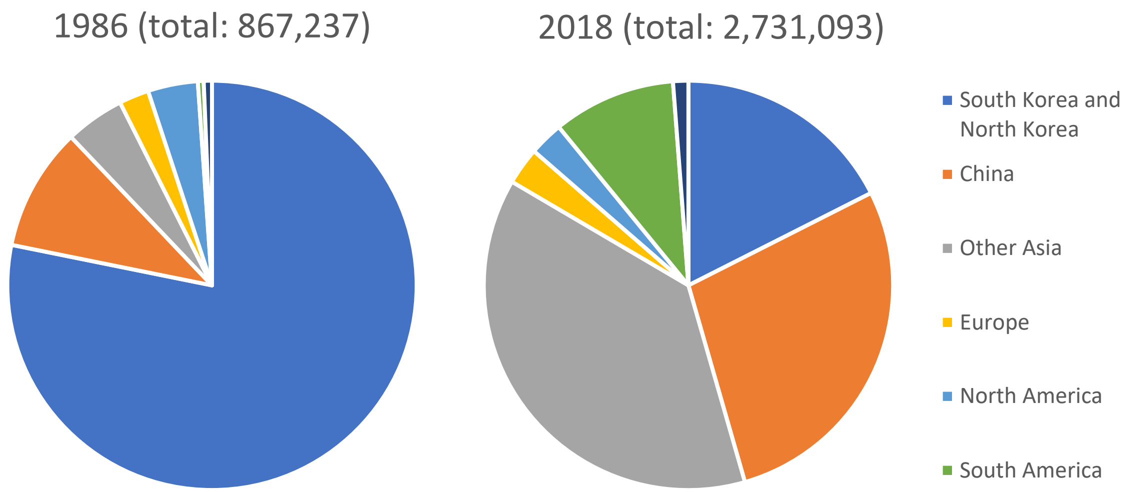


Figure 13: Estimated marginal contribution of log of immigrants and natives during 1970-2018

There are several possible explanations for the increasing contributions of immigrants. First, the immigrant population is increasing. For example, according to the FRS, the population of foreign nationals (FN) increased from 0.9 million in 1986 to 2.7 million in 2018 (SSDS 2020). Second, the composition of immigrants is changing. That is, their source countries, skills and industries they are involved in have been changing. Most of the immigrants in Japan were from South Korea and North Korea (78.2% in 1986). However, the percentage of Korean immigrants decreased to 17.5% in 2018. At the same time, the share of China, other Asian nations and South America rapidly increased (Figure 14). This diversity can stimulate innovation and increase business opportunities.



Source: SSDS

Figure 14: Share of the source countries of immigrants in Japan in 1986 and 2018

Also important is the policy environment for immigration and immigrants in Japan. The Japanese government recently implemented several policies to attract immigrants with specific skills. For example, the Technical Intern Training Program started in 1993 to encourage people from developing countries to work and learn skills, technologies or knowledges in Japan. Although this program was not meant for adjusting labor supply and demand in Japan, it is widely seen as supplying cheap foreign labor to Japanese sectors facing labor shortages ("Address issues in the technical intern program" 2018). Based on the Economic Partnership Agreements (EPAs) with Southeast Asian countries, nurses and certified careworkers from Indonesia (from 2008), Philippine (from 2009) and Vietnam (farom 2014) can work in Japan. A Points-based System for Highly-Skilled Foreign Professionals was started in 2012 to promote entry of highly-skilled foreign professionals. In 2019, the Japanese government established a new visa status, Specified Skilled Worker, to address serious labor shortages in specific fields and specific industries.

The declining contribution of natives suggests that without increasing their productivity, the GDP will decrease over time. This may be explained by the decrease of the share of working-age population (population aging) and natives' struggle to adapt to the new economy. Policies to improve native workers' productivity such as higher education, vocational training and support for childcare and nursing care can contribute economic growth in Japan.

4.7 Conclusion

The new policies of the Japanese government accentuate the important role of immigrants in economic development. Japan plans to further relax its immigration policies to increase the number of immigrants based on the presumption that immigrants can contribute to economic growth and help reduce the decline in Japan's economic growth rates. However, specific evidence that immigrants are relatively more productive or contribute more to the economy than natives is basically lacking. Previous studies from other countries suggest that the impact of immigrants depend on the characteristics of the immigrants themselves and of natives, as well as the characteristics of their source and host countries. Immigrants are also typically shown to have positive impacts on the economies of their host countries. However, what is more important is the relative impact of both immigrants and natives. For increased immigrant population to improve the economic wellbeing of a country, it must be the case that they add value at the margin. However, for increasing immigrant population to increase a growth rate, it must be that immigrants are more productive than natives at the margin. In this study, I estimate the relative economic contribution of immigrants and natives in Japan. I demonstrate that the growing marginal contributions of immigrants can potentially help mitigate the declining productivity of native Japanese. As far as I know, this is the first empirical analysis of the relative contributions of immigrants and natives in Japan. The result of this study, since to land some support recent Japanese policies to attract foreign immigrants to solve labor deficiency problems and stimulate Japan's economy. My findings also suggest that adding immigrants will not only contribute to GDP, but will contribute to average well-being and national productivity by replacing an aging Japanese population to highly productive immigrants. Specifically, policies supporting immigrants such as attracting international students and high-skilled immigrants, supporting immigrants to live in Japan and reducing language barriers may be promising in helping the growth contributions of immigrants both in quantity (increase their population) and quality (increase their average contributions). Similarly, policies to reduce gender wage gap, transition to the new economy and promote higher education among the native Japanese may also help Japanese economic growth by increasing the economic contribution of natives. More detailed policy implications are discussed in Chapter 5.

There are some noteworthy possible limitations of this study. First, again, since the study period is shorter than desired, the release of the 2020 Census data could help improve the quality of analysis. Second, given currently available data, which does not provide deeper insights into immigrants' characteristics (e.g., their educational attainment, age, wages and sectors they are engaged in), this study did not decompose the contributions of immigrants into finer components such as the quality of immigrants' human capital. A future study which evaluates the sources of the changes in immigrants' contributions will be of significant value.

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CHAPTER 5. SUMMARY, POLICY IMPLICATIONS AND CONCLUSION

5.1 Summary

Japan was known to be a very efficient in global leader in key sectors such as automobiles, robotics, appliances and electronics. However, due to its tight immigration policies and the fact that its population is rapidly aging, the economic growth rate in Japan has slowed down and remained low for more than 20 years. Today, Japan is one of the slowest growing advanced economies in the world. It is apparent that without major policy interventions, Japan's economy will continue to slow down.

To reposition the economy, a major goal of the Japanese government is to enhance human capital. The policies and strategies that have been enacted to achieve this goal include more progressive immigration policies, the encouragement of greater digitalization, improved education and the promotion of new innovations. Empirical justification for these policies and strategies have largely been limited, although it may seem obvious that these policies make sense for an island economy that is not growing its population, that is experiencing significant population aging and that has had strict immigration policies which historically prevented foreign workers from contributing to the economy. To better understand how this new policy direction can contribute to the resurgence of the Japanese economy, it is important to understand how Japanese growth has been affected by human capital. In this dissertation, I investigate the role of human capital in Japanese economic development. I specifically explore labor productivity growth and the historical roles of immigration and population aging in the evolution of the Japanese economy.

Previous studies shed some light on these issues, but gaps remain in the literature. For example, while one or two studies on migration to Japan exist, they are dated and do not provide the type of analysis contained in this dissertation. Similarly, while a few studies on the impact of aging on productivity and national growth exist, they do not account for inter-generational heterogeneity and how different generations may impact on productivity and economic growth as they grow older. Filling these gaps can enhance the quality of policies and strategies to improve the growth performance of Japan through improved human capital.

In chapter 1, I provide preliminary justification for a human capital approach to the analysis of Japan's economy and reviewed recent policy directions of the Japanese government. In chapter 2 (essay 1), to preliminarily explore the importance of labor productivity and explain its key drivers, I evaluate labor productivity growth at the sectoral, prefectural and national levels. In that chapter, I demonstrated the fact that the pattern of declining growth rate can largely be explained on the basis of declining labor productivity. Calculated labor productivity indices at the national, sectoral and prefectural levels reveal huge disparities between urban and rural prefectures, as well as manufacturing- and service-related versus agricultural-oriented prefectures. While confirming inter-prefectural convergence, I show that declining labor productivity growth can largely be explained on the basis of immigration and the aging of Japanese population. Specifically, as the Japanese population aged, national and regional labor productivity growth rates declined. This is not great news for society that is expected to continue to age. Also, immigration is found to positively contribute to regional and sectoral labor productivity growth. This suggests that a closed-door policy may not be optimal for Japan. The results of chapter 2 (essay 1) essentially suggest a deeper dive into the roles of aging and immigration by evaluating their impacts on economic performance through GDP.

In chapter 3 (essay 2), I more deeply explore how population aging affects Japan's economic performance. In that essay, rather than use labor productivity as a dependent variable, I use GDP. Specifically, I estimate the impact of aging on GDP by disaggregating the Japanese population into seven distinct generations, each of which is unique in its attitudes, preferences, purchasing power and other consumer demographics and characteristics. That essay revealed that different generations contribute differently to economic growth. Specifically, while Japan's older generations made significant contributions in the past, their contributions have been waning. Japan's Gnx population has been able to contribute more to the economy in recent years than older generations who are now in or entering their retirements. However, Japan's future economic performance will largely depend on the ability of younger generations such as the Bb2Y and Ytr to match or exceed the performance or contributions of the Gnx. Hence, how the Japanese government targets policies toward multiple generations can affect the effectiveness of its human capital-oriented growth enhancement policies.

In chapter 4 (essay 3), I more deeply explore how immigration affects Japan's economic performance. In that essay, again, rather than using labor productivity as a dependent variable, I use GDP. However, I expanded the list of independent variables to include key variables depicting population distribution between natives and immigrants in order to compare their contributions. Specifically, I estimate the contributions of the populations of immigrants and natives to GDP. The model is also specified to allow the estimation of the contributions of both natives and immigrants over time. I generally find that while native Japanese people were very productive in the past, their productivity is waning due to aging. I also find that immigrants are increasingly contributing to the Japanese economy, in contrast to native born people. This finding provides empirical evidence that justifies Japan's recent policies to liberalize its immigration stance.

5.2 Policy Implications

By evaluating three important aspects of human resources and growth policies in Japan, this study brings forth some important policy-relevant findings. First, the Japanese government appears to have appropriately targeted human capital development as the framework for its national and regional economic development. The current Japanese policy framework emphasizes achieving sustainable growth by driving innovations in societal structures, promoting diversity, empowering people, advancing smart regulations and laws, attractive international opportunities and creating more competitive business climates (GOJ 2019). These policies are essentially aimed at creating more enabling environments for improved human capacity. Findings from this dissertation suggest that sustainable growth has not yet been achieved, and that population aging hampers (and will hamper) its attainment, but efforts to improve the environment for human capital development will certainly ease some of the pressure. The fact that the Japanese government has correctly recognized that population aging is one of the most serious problems in Japan's economy is a big plus. Findings from this dissertation also suggest that investing in human capital, especially younger generations, immigrants and postsecondary education, part of which have been already implemented, could help Japan to achieve more sustainable economic growth.

5.3 Conclusions

The findings from my three-pronged essay research make important contributions to the literature on economic transformation and are useful in labor and immigration policy for the future of Japanese society, where the people are aging, the population is declining, and the government is planning to solve labor deficiency by supporting current workers, future workers (through improved education) and increasing international immigration. Human capital is important in economic growth, especially in Japan. However, countries all over are increasingly targeting talented workers and innovative technologies in their bid to enhance their competitiveness in the global market. Countries are also enacting policies that are more specific to key demographics that drive growth and development. In the case of Japan, this obviously includes immigrants, on the one hand, and key generations that can potentially offer huge returns in terms of economic growth. In light of the growing competition for human capital, it is important to understand the roles of these specific elements of human capital in growth and development.

In a nutshell, Japan's challenges relate to: (1) how to enhance the performance of the native Japanese population, and (2) how to build a more skilled future workforce through immigration. With respect to the native population, tailoring policies to specific generations to leverage their characteristics is possible when the roles of each generation are better understood. This dissertation provides new insights on such roles. For example, promoting postsecondary education can enhance productivities of younger generations, who currently appear to be less productive than older generations but need to match or exceed their performance for sustainable growth in Japan. Creating a more enabling environment for that generation may also lead to business innovation that can contribute to building a future new economy. Digitalization, ICT and robotics have the potential to enhance the readiness of that generation for value-added contributions to the economy. I also reveal in this paper the potential for more liberal immigration policy to contribute to economic growth and labor productivity. However, it is noteworthy that simply opening up access to immigrants may not be sufficient as, historically, the productivity of immigrants lagged behind those of native-born Japanese. Efforts may be needed to reduce the barriers to the productive engagement of immigrants in the Japanese economy. Perhaps, targeting specific immigrants so as to achieve the type of growth needed may be possible someday.

It is expected that Japan's society will continue to age, that its population will continues to decrease, and that the old-age dependency ratio will continue to increase[28]. This paints a gloomy picture. However, findings from this study suggest that immigration- and generation-related strategies and policies could alleviate Japan's population onus.

As I mentioned in each essay above, in conducting the research contained in this dissertation, there were several data-related limitations. First, data is not always available on a continuous basis at all levels of analyses. In particular, data on educational attainment is collected every ten years and the latest available is for 2010. The 2020 Census data, which will be published in late 2021, will allow the investigation of more recent labor productivity changes, more recent contribution of generations and more recent contribution of immigrants. Second, since the data I use in this study are from the national, regional (prefectural) and sectoral levels, some aspects of the roles of human capital in the economy are not investigated. For example, if data were available at the levels of individuals or households for such variables as earnings, educational attainments, immigration status and work experience, I would have been able to conduct critical analyses such as to estimate the Mincer's earning function, returns to schooling models and models of the impact of immigrant status on key employment outcomes and structures (e.g., assimilation, integration, discrimination and privilege). The availability of annual micro- or household-level data is very critical in Japan. For example, it will allow more dynamic analysis that can better inform policy makers in anticipating the effects of public policies.

[28] According to the Population Projection for Japan by the National Institute of Population and Social Security Research (IPSS), total population in Japan continues to decrease from 127 million in 2015 to 88.0 million in 2065. The percentage of people aged more than 64 continues to increase from 26.6% in 2015 to 38.4% in 2065 (medium-fertility and medium-mortality projection) (IPSS 2017).

Deeper analysis is needed on immigration-related issues. For example, it would be useful to conduct deeper investigation into the issue of sector- and region-selection by immigrants and the impact on national output. One relevant question for Japan is whether or not the current low productivity of immigrants, vis-à-vis native-born Japanese, is due to the lack of immigrant access to highly-productive sectors, to discrimination, to low immigrant qualification for high paying technical jobs, or to low levels of education. More granular data would have helped in addressing this question. Another relevant question on immigration is whether the declining contributions of certain generations is due to the outsourcing by Japanese companies of the types of jobs that Japanese resident would have been able to fill. Sector- and prefecture-level data on international outsourcing of jobs would have been helpful. Yet another question is how the growing competition of Japanese automobile and electronic products have shaped production and employment opportunities at home.

Now, I offer a few suggestions for future studies on human capital and economic growth in Japan. For example, Japan's electronics and automobile sectors, which were viewed internationally competitive, outsourced critical components to low-cost producing countries such as China and South East Asian nations as the Japan's economy matured. This may have changed the required skills or backgrounds of domestic workers (e.g., educational attainment, understanding of foreign language and affairs, and connection to other countries). Future studies considering these changes would improve analyses of the sources of labor productivity differences and changes in each sector.

Furthermore, the domestic-oriented sectors, which include many of the agricultural and service sectors, and part of the manufacturing sector, face overall shrinking in domestic demand due to population aging. Since most of the workers in these sectors are currently native Japanese, the sectors also face shrinking domestic labor market. Therefore, to improve or maintain their productivity or profitability, some of these sectors have tried to introduce ICT, robotics and immigrant workers, to target specific people or regions, and to make the sector more export-oriented. Investigating the roles of these efforts will be of significant value.

In this dissertation, I briefly mentioned gender differences in Japan's labor market. Taking gender differences (e.g., sectors they are engaged in, educational attainment and type of occupation) into consideration in evaluating the role of human capital would reveal important policy-relevant information about gender aspects of Japanese economic development.

Finally, since most of the data I used in this dissertation is panel in nature, I tried to use dynamic panel estimation techniques. However, while the panel data has a large enough cross-sectional dimension (47 prefectures), it does not have a large enough time series dimension to allow effective use of the dynamic panel estimation techniques. I suggest that future studies which use a longer-time series panel database should try to apply dynamic panel estimation technique.

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