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Impact of Population Ageing on Japan's Inter-Prefectural Migration: A Spatial Econometrics Analysis

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0. Abstract

This paper examines the impact that the decline in the Japanese population has had on its inter-prefectural migration flows over the last 15 years. The early 2000s saw the number of internal migrants consistently decrease, reaching all-time low records in both intra and inter-prefectural migration. Economic inequalities between cities and other regions began to shrink in the 1970s due to the indirect effects of the post Second World War's so-called "economic miracle". Also, after 2003, such disparities between metropolitan and rural areas further intensified due to an increase in the income gap, as Japan recorded the start of an aging society phenomenon. How the prefecture's socio-economical and healthcare characteristics are affecting the flow of migration will be examined through spatiotemporal autoregressive models.

I. Introduction

The beginning of the 1950's saw the Japanese economy remarkably rise after being depleted by the Second World War. Indeed, the real per capita GDP overtook its 1940's level thanks to an average annual rate of 7.1% during this recovery period. This rapid-growth era however ended in 1973 after its expansion first slowed down until 1991, marking the last year of the "bubble economy". This also marked the start of the simultaneous decrease in the number of inter-prefectural migrants as well as that of the overall population growth rate. The fall of the total factor of productivity's growth rate and of the rate of return in the 1990s in return increased the steady-state capital-output ratio during this period.

Any decline in population "has important indirect implications for migration, citizenship, health, and retirement policies" as well as "pensions, […] access to medical assistance, and health care provision in new destinations" [27]. Indeed, an ageing population generally results in a reduced working-age population. This will in turn, among other things, generate a deficit in global income to a point where it tries to cover for the cost of the health and pension systems. Because Japan's "pay-as-you-go" pension system is hyper-dependent on the working population' tax revenues and subsidies, the national social benefit system is set to rapidly deteriorate if no change is performed. The Japanese pension system is effectively an unfunded pension system which uses collected taxes and insurance premiums from the working generations in order to fund the currently retired generations. Potential impacts created by such a set-up were well identified by the National Institute of Population and Social Security Research Organization. As such, although it is robust against inflation and rises in wages, it is extremely vulnerable to any shift in demographics. This disadvantage is further worsened by recent contribution evasion among younger people [17]. In the private insurance sector, moral hazard, and especially adverse behaviour, seems to be enhanced by high opportunity costs. This prompted the Japanese government to intervene against such cases by providing long-term care as well as employment insurance. However, one of the downsides of the social insurance is that individual contribution is proportional to the person's ability to pay. This foundation makes the income redistribution scheme heavily based on the insured people's economic status.

Rather than economic consequences, the healthcare provision system is obviously the most heavily affected sector by the ageing population phenomenon. Indeed, direct challenges include a shift in the health profiles, an increased in the demand for health service (both short and long-term), as well as rising health costs (extra-costs of at-home long-term services, number of hospitalized patients…). Changes in health profiles leads to proportional variations in the nature of each age group' health issues, which could eventually also cause a possible overhaul in the medical specialization fields' usage. Such adjustments may also result in the improved mobility of longer-term healthcare service workers, as well as the creation of more on-site nursing care for the highly dependent population. This improvement in the health services necessitated a recalculation and an according adjustment of the health care workforce (in terms of numbers, distribution, and skill sets) towards wherever need occurs.

Since the beginning of the millennium, in search of solutions to address this newly ageing society issues, the Japanese government has been diligently implementing policies touching upon the pension system, its respective health-care benefits and institutional care. As a matter of fact, the disparities between regions, which were deepened by the economic growth spurt of the second half of the 1900s, also accentuated the variations in the growth rate of the elderly population in different prefectures. Hence, due to the fundamental changes in socio-economic conditions, Japan was required to implement cost-containing policies in the health sector. Thus, in order to efficiently distribute healthcare resources proportional to the region's needs, a "Regional Medical Care Vision" within the "Medica Care Plan" was put in place. This was an important part of the 2006 Healthcare Structural Reform Package Act which was passed with the aim of reforming both the service delivery system and the insurance system into one package [6]. Further down the line, the 2008 Long-Term Care Insurance Act, among other amendments, has established ways to reduce the cost of supplies (by restricting the coverage available and tariffs offered) while expanding financial resources by increasing taxation and co-payment of the 70-years-old and above bracket from 10% to 20% [14]. This was further emphasized by the 2013 "Proposal for Promotion of Social Security System Reform" which introduced a reduced burden of social insurance premiums paid by working people and corporations and enhanced communication networks through which people can obtain crucial information on the social security system reforms changes made in the past. Moreover, in response to regional discrepancies, the responsibilities of medical care and expenditure tracking for the elderly shifted from municipal to prefectural governments where they were asked to prepare a 5-year plan to create a system designed to control medical expenditure. Adjacently, this plan would be aimed at those suffering from lifestyle-related diseases as well as reduce the average length of hospital stays.

1.1. Aim and purposes of the thesis

As is further explained later in the paper, problems linked to Japan's ageing population has not only worsened but have also become critical between 2010 and 2012 where the overall population magnitude also started declining. Thus, in an attempt to examine the effects of such an issue on the inter-prefectural migration flows, spatiotemporal autoregressive models (Spatial Linear Regression Model (SLRM) and Spatial Autoregressive Model (SAR)) are used to find out which prefectural characteristics are the most important on the population's decision to migrate. In order to do so, the data will be separated into three different age groups to have a complete and detailed analysis of the situation.

> Research Objective: Inquire about the motivation behind the inter-prefectural migration of three different age groups following the recent decrease in the Japanese population as well as the response from the government concerning this issue.

1.2. Descriptive characteristics

While the second World War had disastrous effects on the Japanese population, the post war economic era brought about a baby boom (trend that is also present in other countries after both World Wars). Based on the data gathered from the (1940-2020) Population Censuses' Total Population Estimates, this period saw an increase in the population growth rate of 15.6% between 1945 and 1950; yearly rate that neared 2.5% at its peak and averaging 1.9% between 1945 to 1953 [19]. However, this baby boom quickly subsided, and the population growth rate started slowing down before once again increasing throughout the 1960's.

However, as described by David Frum in his 2000 book *How we got Here: The '70s,* Japan was among the countries that were the most severely hit by the 1973 worldwide oil crisis, as it imported 90% of its oil from the Middle East [4]. Coincidently, 1973 also saw the beginning of the decline in the population growth rate. From 1.45%, it then consistently shrank until it finally became negative around 2006-2010 (depending on the data sources) before hitting an all time low of -0.37% in 2021.

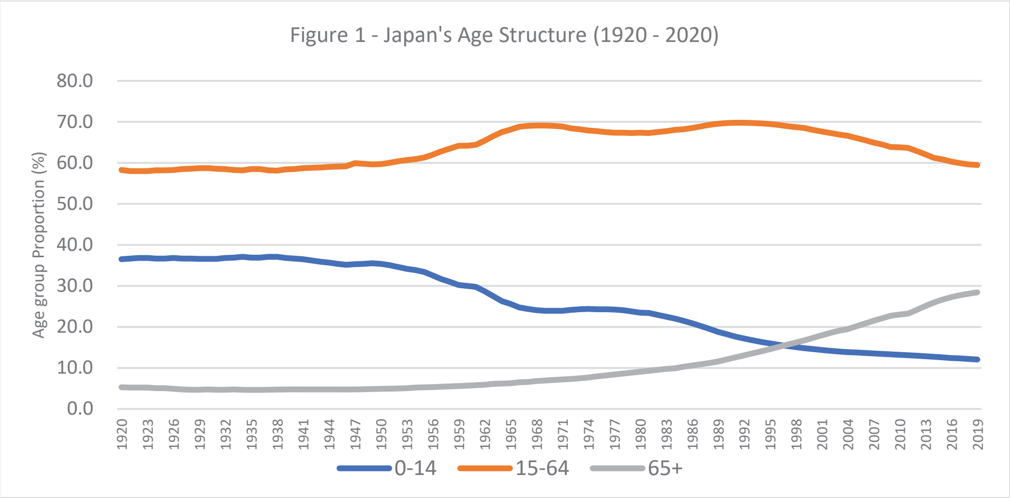
1.3. Historical Demographic Dynamics

Such changes in the overall population growth rate and magnitude are sure to also bring about changes in the demographics' dynamics. In a trend that is much more pronounced in Japan that in any other countries worldwide, generational shares have shifted over time in a way that now shows a predominantly ageing Japanese population. As a direct product of the improvement of the healthcare technology in Japan, this demographic shift was seen to be slowly emerging in the 1970s. However, this ageing curve worsened in the 1980s due to the slowing down of the thus far growing economy. Later on, with the bursting of the aforementioned "bubble economy" in the 1990s, this downward trend accelerated and is now at its worse.

As we can see on Figure 1 (built on the same data from the Population Census as previously), the upward trend exhibited by the share of the 65 years old and over individuals is clearly visible. In 1950, Japan's population share of people aged 65 years old and above was a meager 4.9% which was relatively low for that time. However, by 1980, this percentage had already almost doubled to reach 9.1%. Although this increase was also seen in other countries, it continued to rise until it reached 12.1% in 1990 and even 17.36% in 2000. However, health and economic variables led this trend to worsen even more, as it reached a staggering 22.5% when the population growth rate became negative in 2008-2010, before rising even higher to 28.44% in 2019. That is to say, the share of Japanese people aged above 65 years old has almost grown sixfold in the last 70 years.

A similar but opposite trend can also be discerned in the 0-14 year-old population share, as its decline started slightly earlier on (around 1950). The 0-14 year old population's share declined from 35.4% in 1950 to 23.51% in 1980 and then 14.58% in 2000 before ending up at 12.06% in 2019.

While these two generation shares demonstrated contradictory trends over the past 70 years, the working age generation’s share has not changed much, remaining between 60% and 70% but is now consistently decreasing as shown in Figure 1.



1.4. Main Reasons Behind the Population Decline

Although the issue is not unique to Japan, this country is home to the world’s oldest population as per their proportion of citizens above 65 years old. The reasons for the emergence of this so-called “super-ageing society” may therefore be most evident in Japan.

We can separate these contributing factors into the following three categories:

1. Increase of life expectancy. The Japanese health technology significantly improved over the past 50 years, leading to Japan’s life expectancy for both men and women becoming the highest in the world. Highlighted in the World Bank’s data and reports, although marginally decreasing over time, Japan’s life expectancy came from being the lowest of the G7 countries in 1960 (at 68 years-old) to becoming the highest in the world in 1981 (76 years-old). This can be attributed in part to low mortality from ischemic heart disease and cancer. It then reached an all-time high in 2022 (84.91 years-old) a 0.14% increase compared to 2021 [13].

2. Continuous worsening of the private economic status of the Japanese population. Industry-based partitioning along with deteriorating work-life balance are largely responsible for the quick decrease in the fertility rate. Long working hours, although proven to be minimally efficient, being culturally recognized as the pinnacle of professional success and devotion, has put a dent in the ability of (mainly urban-based) working population to create a family. The slow improvement towards a more gender-equal society means that more young women now shy away from starting a family early on as it would severely lessen their professional market values in the future. Even more so than in other countries, the Japanese social norm dictating that wives should take time off work to focus on childcare decreases the chances of coming back to work following pregnancies. "Does a Mother's Early Return to Work after Childbirth Improve Her Future Employment Status? Evidence Using the Birth Month of Japanese Babies" is an interesting paper exploring this issue in detail [9]. This factor leads to lower marriage rates, and to an increase in the average age for a first marriage (now nearing 31 years old). In addition, those who do end up marrying face low wages, deteriorating labor market segmentation among industries and medical insurance not covering many of the costs of childbirth and childcare in large cities, leaving close to no room for family creation [9].
3. Opposition of the Japan's public to international immigration. This is the last and perhaps one of the less widely studied reason. Whereas it is vastly sympathetic to influences from the West (baseball becoming the national sport and the increasing number of fast food joints), the Japanese population, perhaps influenced by a willingness to preserve cultural purity stemmed from past traumatic historical events, now imposes gentle but extremely restrictive constraints on immigrating people.

1.5. Past Inter-prefectural Migration

The following is in part a summary of multiple studies, which have analysed the historical trends of the Japanese population's inter-prefectural migration. These include Takashi Yamaguchi's "Population Redistribution of Japan – within the context of the national settlement system" and Masatoshi Yorimitsu's "A review of recent population changes in Japan" [24, 25].

One of the most significant examples of changes in Japan's demographics is related to the population concentration in metropolitan areas (MAs) compared to rural areas (non-MAs) since the end of the 1960s. A steady rise of population inflow into metropolitan prefectures was clearly shown accompanying the Post World War 2 economic growth. This economic growth shifted priorities, which in turn greatly influenced residential selection, in a move resembling *Metropolization* [24].

However, once the growth rate of productivity started to slowly decrease at the beginning of the 1970s, mainly due to the first oil shock in 1973, a clear positive correlation between the growth rate of real GNP and the rate of internal migration can be observed. This relationship is even more prominent when comparing rural and urban prefectures' economic status. The national decline in the natural birth rate, as well as a reduction in deviation between rural and urban rates, meant that internal migration became the major determinant of population growth in each region. As a matter of fact, although the natural population growth rate of rural prefectures used to be higher than that of urban prefectures before the 1970s, this relationship was later reversed. The number of prefectures where net-migration was negative decreased from 25/47 in 1960-1965 to only 1/47 in 1980-1985 [25]. The inter-prefectural migration rate began to decrease in 1973. Whereas excess in-migration made up more than half of Tokyo-MA and Osaka-MA population growth rate during the 1960s, it decreased all the way to 3% in Osaka and 30% in Tokyo in the first half of the 1970s, such exodus mainly consisted of 20-24 years-old men.

Ultimately, any positive changes in population change between 1975 and 1980 can exclusively be attributed to natural means.

Ever since the beginning of the 1970s, economic inequalities between cities and rural regions have been shrinking. However, the emergence of the ageing-society phenomenon sparked a shift in each prefectures' share of responsibilities concerning healthcare activities. This, although meant to decrease the burden of the ageing society put on the national healthcare system, is another way prefectural differences are increased. As is generally true in most countries, wages are disproportionally higher for full-time employees of major Japanese firms compared to other types of sectors. Therefore, most job-seekers head to densely inhabited urban areas where major companies are located, far from rural prefectures. This is particularly true for the 25-29 years old demographics who represents the vast majority of the job seeking population, also making up almost 50% of the total inter-prefectural migrants between 1991 and 1996.

However, the main contributing factors of metropolitan out-migration after the rapid economic expansion include the ensuing deterioration of living conditions in under-prepared over-populated metropolitan areas, an astonishing rise in land and housing costs, as well as undesirable commuting distances [24].

While Koji Murayama and Jun Nagayasu affirm that "the inter-prefectural differential factor of per capita income is less valid for explaining any type of migration", they also notice that the increase in employment opportunities still plays an important role in out-migration [8]. Result highlighted in "Key factors in determining internal migration to rural areas and its promoting measures - A case study of Hirosaki City, Aomori Prefecture", relocation to rural areas simply came from the desire of people (mostly unmarried or self-employed) to return to their hometown due to the presence of their parents' homes [10]. Due to the strong correlation between job-to-applicant ratio and population migration, it is natural to also notice a lack of educational institutes and of opportunity costs in job hunting activities for those who migrate to more rural prefectures. The relationship between distance and age with the inter-prefectural migration flow is also observed to be negative.

II. Model Description

2.1. Model Choice

Originally derived from Newton's theory of gravitation, the standard gravity model put forth first by Jan Tinbergen in 1969 was one of the first utilizing spatial dependence to explore international trade movements [22]. This gravity model also recently helped provide or theoretical framework to forecast the effects of Brexit onto international trade flows. However, my work's interest lies in population migration flow, rather than trade flows. Thus, to transform this model into one that can take into account spatial dependence in relation to internal migration flows rather than trade flows between regions, we consider the unique characteristics of both regions, parameters introduced into the X variables below. Equation (1) represents the transition from the international trade gravity model to one that considers migration, while equation (2) is its extension into a spatial linear regression model.

$$Y_{od} = G\frac{X_0 X_d}{dist_{ij}} \quad (1)$$

[1]

$$Y_{od} = \alpha + \beta_o X_o + \beta_d X_d + \gamma dist_{od} + \epsilon \quad (2)$$

[For reference, please let n be the number of regions studied in each section, i and j two arbitrary regions/prefectures where $i, j \in [1, n]$, α a constant intercept term and ∈ the error term] .

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[1] $F_{ij} = G\frac{M_i M_j}{D_{ij}}$ where G is a spatial constant, F_{ij} represent the trade flow from region i to region j, M_i and M_j stand for economic dimensions of regions i and j respectively and finally D_{ij} represents the distance between the two regions

The above Y_{od} is a n^2 x 1 matrix representing the migration flow from the prefecture of origin o to the destination d prefecture. Its elements equal 0 when the origin prefecture is the same as the destination prefecture. While K is a spatial constant, $dist_{ij}$ denotes the n^2 x 1 vectorized origin-destination log geographical distances, which acts as a proxy for the transaction costs of migration. Similar to the inter-prefectural migration flow, the distance variable's elements equal to 0 if i = j. Finally, X_o and X_d characterize the k prefectural characteristics we have chosen to interpret the effects in sectors that were deemed the most significant in the migration decisions based on past studies. The nature of these variables will be explained later on in the "Data" section of the paper.

Next, spatial autocorrelation between migration flows can be added to the standard spatial model. Such spatial interaction models have been applied, notably by E. Marrocu and R. Paci, to examine the destination and routes tourists choose depending on variables such as their income, received amenities and the destination region's accessibility, distance and population [15]. Moreover, James J. Lepage and R. Kelly Pace have, in their paper "Spatial Econometric Modeling of Origin-Destination Flows", furthered this model by introducing origin and destination-based spatial weight matrices to turn it into a Spatial Autoregressive Model resulting in the following equation (3) [12]:

$$Y_{od} = \rho_o W_o Y_{od} + \rho_d W_d Y_{od} + \alpha\iota + \beta_o X_o + \beta_d X_d + \gamma dist_{od} + \epsilon \quad (3)$$

The two spatial weight matrices W_o and W_d are respectively the origin and destination-based matrices. Firstly, the spatial lag interaction term $W_o Y_{od}$ represents the average flow from the neighbors of the origin prefectures to the destination prefectures. Similarly, the second type of spatial dependence arises from the destination-based dependence and takes the form of the spatial lag interaction term $W_d Y_{od}$, which captures the spatial dependence of the migration flows from origin prefectures to the neighbors of the destination prefectures.

One of the most important parts of the equation is the multiplication of each weight matrix by the response variable Y_{od} to get rid of the potential collinearity present in the previous gravity model. This method allows the model to remove endogeneity caused by the migration flow on the variables of the two prefectures involved in the inhabitant exchange.

The two aforementioned spatial weight matrices are however first and foremost based on a typical row-standardized inverse distance squared weighted interpolation. This spatial matrix indicates the spatial relationships between regions, where the distance between each prefecture's capital is calculated. Each element w_{ij} of this n x n matrix are spatial weights whose value take the form of:

$$w_{ij} = \begin{cases} \frac{dist_{ij}^{-2}}{\sum_{j=1}^{47} dist_{ij}^{-2}}, & if\ i \neq j \\ 0, & otherwise \end{cases} \tag{4}$$

As shown in equation (4), the choice of power used is arbitrary, here p = 2 being the default value. An increase in p would imply the rapid decrease in the importance of distant points in the regression, and only the immediate neighbors would end up influencing the analysis. Moreover, because distances between prefecture's capitals are not always representative of the distance of moves performed, proportional weights are created by row standardization. Row standardization is a technique in which we divide each element of a row by the sum of all elements in the same row, making the sum of each row equal to 1.

The distances the W matrix is based on were calculated using each prefectural capitals longitudinal (*long*) and latitudinal (*lat*) data found in the Final Report of the 2015 Population Census of the Population and Households of Japan section [19]. Considering all 47 Japanese prefectures in this analysis means that the W matrix's dimensions are 47x47.

While the intra-prefectural distance is set to 0, equation (4)'s *dist* variable is computed the following way for any two prefectures i and j (such that $i, j \epsilon [1{,}47]$):

$$dist_{ij} = arcos(\cos(90 - lat_i)) * \cos(90 - lat_j))$$

$$+ \sin(90 - lat_i)) * \sin(90 - lat_j)) * \cos((long_i - long_j))) * 6371$$

Thereafter, we can build the two spatial weight matrices by multiplying the W matrix described above from both sides by the identity matrix I_n (where n = 47 in our case) using an outer product such as to get:

a. $W_o = I_n \otimes W$

$$W_o = \begin{pmatrix} W & \underline{0} & \cdots & \underline{0} \\ \underline{0} & W & \underline{0} & \vdots \\ \vdots & \underline{0} & \ddots & \underline{0} \\ \underline{0} & \cdots & \underline{0} & W \end{pmatrix}$$

Because the same W matrix was transcribed 47 times onto the diagonal once for each prefecture as pictured above, a 2209 x 2209 W_o matrix was formed.

b. $W_d = W \otimes I_n$ (In the case of n = 3, the W_d matrix would look such as below)

$$W_d = \begin{pmatrix} \underline{0} & w_{21} * I_3 & w_{31} * I_3 \\ w_{12} * I_3 & \underline{0} & w_{32} * I_3 \\ w_{13} * I_3 & w_{23} * I_3 & \underline{0} \end{pmatrix}$$

The diagonal elements of W_d are n x n matrices with elements 0, and the non-diagonal elements (where $i \neq j$) are equal to $w_{ij} * I_n$. Hence, for this paper, a 47 x 47 identity matrix was thus subsequently multiplied by each element of the W matrix.

2.2. Estimation Methods

Although very computational heavy, standard Maximum Likelihood Estimation (MLE) can be efficiently applied to origin-destination flow-based modeling estimations. Thoroughly investigated by K. Ord in his 1975 paper entitled "Estimation Methods for Models of Spatial Interaction", evaluating a Spatial Autoregressive Model involving two spatial weight matrices provides greater efficiency and stability by offering flexibility when it comes to evaluating a wide variety of functions [18]. Moreover, more so than any other methods, unbiased estimations for larger samples can be obtained. Methods such as the Bayesian Markov Chain Monte Carlo procedure put forward by LeSage (1997) as well as the Marginal Maximum Likelihood (MML) approach proposed by Thomas Suesse (2017) in the case of missing data can also be employed to evaluate such spatial interaction models [11, 21].

Calculating the log-determinant values for cases where *n* is large may be quite difficult. As is examined by LeSage, the "log-determinant ensures that the transformed continuous random variable has a proper density" [12]. Neglecting this calculation in any way would "reduce the magnitude of the estimation residuals to a negligible level" [12]. This log-determinant can be measured by the trace of the matrix logarithm of the transformation: $tr(\ln(I_{n^2} - \rho_o W_o - \rho_d W_d))$.

The analyses methods discussed above were all performed in R Studio.

III. Data Description

3.1. Years of interest

As past papers (such as "International and Interprefectural migration in Japan: Implications for the Spatial Assimilation Theory") have principally featured the period between 2005 and 2010, this study emphases the results for the subsequent period (2010-2015) [8]. There are two main reasons for it. The first is that the last available set of prefectural variables (X_o and X_d) data is that of 2015. Although the

2015-2020 period is officially over, some time is always required to provide such detailed information and disclose it to the public, and the data is still not fully available. The COVID-19 pandemic has also had a detrimental effect on data release times. The second reason is that this period is the first full 5-year period following the start of the population decline, which started at the end of the 2000s.

3.2. Type of Data

Among all prefectural characteristics on hand, the following independent variables are chosen in order to fully capture the prefectures' socio-economic conditions as well as the main healthcare aspects. They were chosen as a result of gathering the most crucial results which have been deemed to be of importance in past papers.

First of all, the variable of interest, migration flow data (variable Y_{od}) is directly obtained from the database of the Statistics Bureau of Japan, under the charge of the Ministry of Internal Affairs and Communications. 5-year periods are analysed because the Population Census database (especially the section "Tabulation on Internal Migration for Population") captures the current location of each prefecture's resident and compares it to their respective "place of usual residence five years ago" [19]. Later graphs found in Section 4 are based on data found in the 2005, 2010, 2015 and 2020 Censuses. There, the 2005 and 2020 data, out of the official of the study, are given for information purposes only in order for the reader to get a feeling of the trends.

Data related to prefectural characteristics (X_o and X_d) was taken from the Japanese Governmental Statistics' website, under the System of Social and Demographic Statistics (SSDS) section. For the most part, yearly data for each variable is available (unemployment rate being the main exception). However, because the migration flow data is only available every 5 years, prefectural characteristics' data is chosen according to the same 5-year span. Hence, the origin characteristics X_o correspond to the 2010 data, the parameters of the "place of residence five years ago" [20]. Likewise, the destination characteristics X_d

represent the 2015 data of the "current" location. As we consider the 7 variables described thereafter in Table 1, the X_o and X_d are both 47 x 7 dimensional matrices.

Gravity characteristics: The prefectures' "**total population"** is introduced due to its role as a proxy to the size of the labor market, as it was found that larger population usually tends to encourage in-migration (see 1.3 Historical Demographic Dynamics for more details). Geomorphologically, due to massive differences in prefectural size, the variable "**area**" is also added in order to regulate the effects of such disparities in the migration flows.

Economic variables: Generally speaking, "**Per capita Gross Prefectural Product"** is always being considered as an important determinant in the migration process. As in past literature, real per capita GPP is also used here as a proxy for income, in an attempt to reflect each prefecture's basic-yet-fluctuating economic characteristics. While GPP somewhat displays the prefectures' labor markets impact on migration, the addition of "**unemployment rates"** would however help assess the importance of job opportunities in migration flows as well.

Healthcare: As is commonly the case, the impact of ageing can generally be seen through shifts in the healthcare system structure. Because prefectures have gradually been given more responsibilities related to medical care and expenditure tracking over the years, healthcare variables such as "**prefectural medical care expenditure for the elderly**", "**the average length of stay in hospital**" and the "**percentage of death attributed to lifestyle diseases**" (malignant neoplasm, diabetes, hypertension indued diseases, cardiac diseases, and Cerebrovascular diseases) are used in order to examine the effects of fluctuations in the healthcare system onto the migration flow.

The effects of the variables "unemployment rate" and "medical expenditure" are especially vital as "good infrastructure, environmental amenities, and lower costs of living and housing income become important in older age and acts as a pull-factor for migration of the elderly and retirement migration, including return migration" [27].

Table 1: Variables' Units

Variable	Units
Migration Flow	Person (1,000 / 10,000 people depending on model)
Population	Number of people (natural log)
Area	Hectares (natural log)
Real per capita Gross Prefectural Product	2011 Base Million yen (natural log)
Unemployment rate	Percentage of total working age population
Medical care expenditure for elderly per insured person	Yen (natural log)
Average length of stay in hospital	Days (natural log)
Death per lifestyle disease	Percentage of total number of deaths

IV. Population Migration Flow Dynamics

As presented in section 3.1, due to the unavailability of some necessary data for the 2015-2020 period, the period of interest of the paper's regression analysis is the 2010-2015 period. However, the migration flow data of the 2015-2020 period having been made accessible on the Japanese government official website in February 2022, it is included in as to give an idea of the comparison of the migratio flows. Thus, examining the evolutionary net-migration trends exhibited in this section's graphs give a complete overview of national trends surrounding the period of interest.

4.1. General Migration Flows

4.1.1. Magnitudinal Net-migration

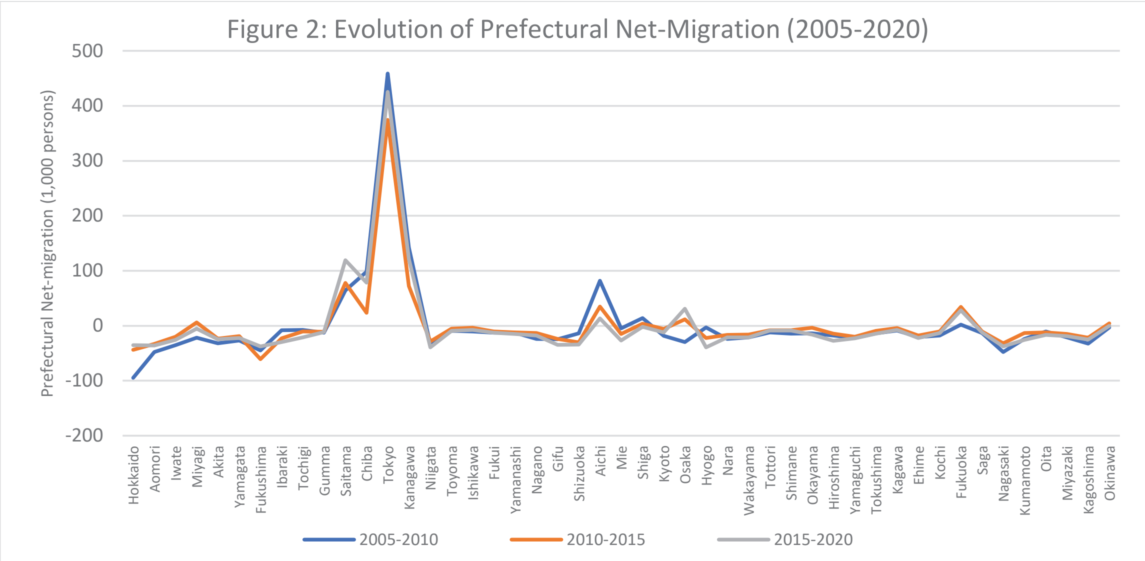


Figure 2 above uses the "Japanese Government Statistics' Report" on Internal Migration in Japan, which features yearly prefectural net-migration. For each prefecture, data was then grouped into 5 year long periods, including in addition to the 2010-2015 period of interest, earlier 2005-2010 and later 2010-

2015 (i.e. 2005, 2006, 2007, 2008, 2009 and 2010 formed the 2005-2010 group), producing the above three curves in Figure 2 [19].

Although remaining negative, the net-migration of three of the prefectures containing some of the most populated cities in Japan (namely Hokkaido (Sapporo), Miyagi (Sendai) and Hiroshima) have gradually been rising. Similar tendencies can also be observed in Fukuoka, Kyoto and Osaka, whose original net-migration was negative during the 2005-2010 period and then became positive later on. Conversely, among the last three other large cities, Shizuoka is seeing its population decrease at an even greater rate as the years pass. Displaying a comparable trend as Shizuoka, Aichi's (Nagoya) inorganic population growth rate (yet still positive today) has been decreasing rapidly and is recently even nearing 0, threshold surpassed by its neighboring prefecture Mie (Tsu).

Tokyo has, however, always been somewhat of exception as it is both the economic and political capital. Indeed, even though both Japan's and Tokyo's populations have steadily been decreasing for the past 12 years, Tokyo prefectural net-migration on the other hand continues to be positive. Still, it had first decreased between 2010 and 2015 compared to the five previous years, before increasing again between 2015 and 2020 without nonetheless returning to the 2005 rate.

All the same, (with the exception of Okinawa's which became positive between 2015 and 2020), net-migrations of non-metropolitean prefectures are mainly negative while no clear unified uplifiting trends is yet to be observed.

As we compare the difference in trends between 2010-2015 and 2015-2020 time periods, we should be aware of the fact that the impact of the COVID-19 pandemic is likely to account for a somewhat big part of the overall trend exhibited by some prefectures in the 2015-2020 period's data. This is highly probable due to the fact that the 2020 Popualtion Census' survey date is October 2020 rather than

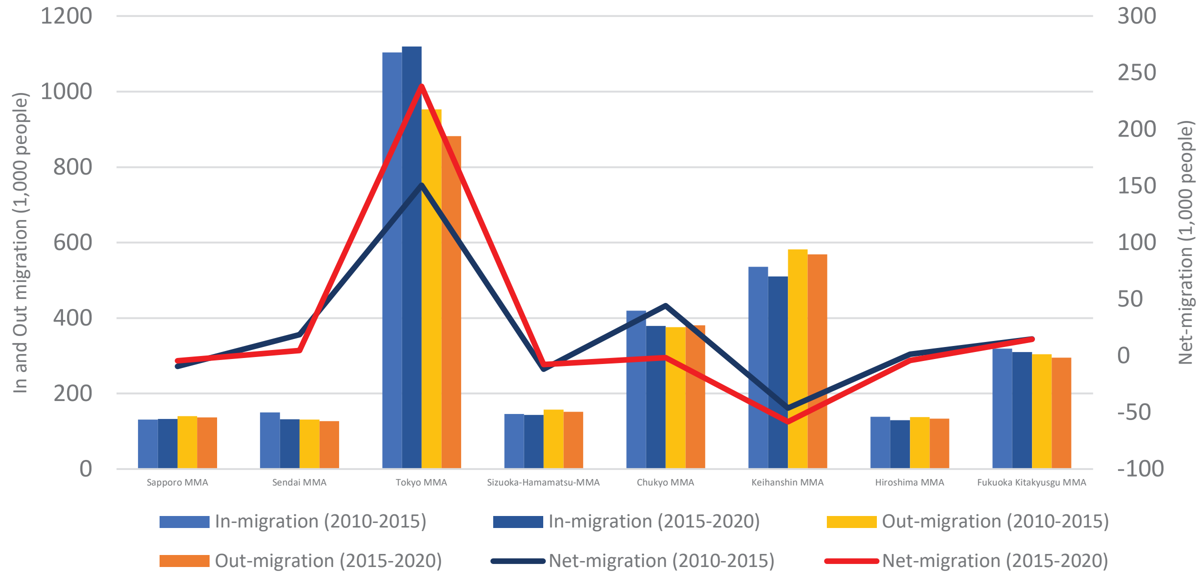
December 2019 (as is often the case globally). The gap between the beginning of the COVID-19 pandemic (in March 2020) and October 2020 leaves room for fluctuations in popualtion movement.

4.1.2. Metropolitan Areas' Net-migration

First and foremost, to form the 8 metropolitan areas, 22 of the 47 prefectures were divided into the following groups:

1. Sapporo MA: Hokkaido
2. Sendai MA: Miyagi
3. Tokyo MA: Ibaraki, Tochigi, Gumma, Saitama, Chiba, Tokyo, Kanagawa and Yamanashi
4. Shizuoka-Hamamatsu MA: Shizuoka
5. Chukyo MA: Aichi, Mie and Shiga
6. Keihanshin MA: Kyoto, Osaka and Hyogo
7. Hiroshima MA : Hiroshima
8. Fukuoka-Kitakyushu MA: Yamaguchi, Fukuoka and Saga

Figure 3 - Metropolitan Areas' Net-Migration (2010-2020)



While still acknowledging the prefectural capitals' significant influence on their own prefectural net-migration flow, it cannot systematically account for that of the multi-prefectural metroplitean areas they belong to. As they represent the majority of Japan's total population (73-74%), understanding the traffic flow both from and to Metropolitan Areas (MA) and non-Metropolitan Areas (non-MAs) before performing a model analysis enlightens us on the veractiy fo our hypothetical statement.

In-migration data introduced in Figure 3 below was obtained by adding the migration in the direction of each individual metropolitan area from all other prefectures that are not part of it. Correspondingly, the out-migration corresponds to the migration out of the prefecture(s) within the metropolitan area to all other prefectures combined. Mathematically speaking, the sample size for both in-migration and out-migration is: $47 - n_{MApref\_i}$ (where n_{MApref_i} is the number of prefecture within each metropolitan area *i*). The difference in magntidude between the two (net-migration) is then calculated during two consecutive 5-year time periods: 2010-2015 and 2015-2020.

While Sapporo-MA, Sendai-MA, Shizuoka-Hamamatsu-MA and Hiroshima-MA are mono-prefectural metropolitean areas, different migration flow are exhibited by the remaining 4 metropolitean areas. Unsurprisingly, Tokyo-MA's overall net migration is the largest by far. Tokyo's continuous supply of job opportunities and somewhat constant economic prosperity over the years have also influenced its neighboring prefectures' net migration flows as well. As it is, with the exception of Ibaraki, all prefectures in the Tokyo-MA show positive net-migration. In addition, Tokyo-MA's net-migration has risen significantly between the two periods (2010-2015 and 2015-2020) mainly due to the decrease in the metropolitan area's out-migration (from 952,953 people in 2010-2015 to 881,832 in 2015-2020).

Although on another magnitude, Sendai-MA and Keihanshin-MA also both saw their respective net-migration decrease compared to the earlier time period. Indeed, while the fault in Sendai-MMA falls onto the greater decrease in in-migration, the opposite is true in Keihanshin-MMA and its net-migration continues to fall much further than below 0.

On the contrary, the stagnation of out-migration combined with a decrease in in-migration resulted in a net decline in Chukyo-MA's net migration, going as far as becoming negative between 2015 and 2020 (from 44,195 people to -1,573 people).

While biding farewell to more people than it welcomed between 2010 and 2015 (-3,979 people), Hiroshima-MA's net-migration has only become slightly positive (1,514 people) in the following period althought its overall levels of migration stayed quite similar.

In total, the non-metropolitan areas documented an overall net-migration loss of 253,851 persons between 2010 and 2015 (most of them moving to Tokyo (14.4%), Fukuoka (11%) and Aichi (9.3%) prefectures). On the opposite, all metropolitan areas welcomed a net-migration increase of 181,568 persons in the second time period (the majority due to Tokyo's massive increase from 150,568 persons to 237,944 persons).

4.2. Age-Group Specific Migration Flows

As they continue to make up an increasing percentage of the Japanese population, the likelihood of the elderly population migrating is generally thought to be heavily reduced due to the general "intensification of globalization process, development of technologies, and telecommunications" [7]. However, only few papers investigate the connection between the population ageing phenomenon and the factors affecting the older population's migration decisions in particular. Although reasons for migration differ per age groups, such motivations most likely always stem from a desire to improve their way of live one way or another. As people get older, their center of attention is thought to shift towards factors which may influence their health conditions as well as their ability to live out the rest of their lives with relative ease.

In addition to total migration information, tables accessed from the “Tabulation on Internal Migration for Population” report displays separate data for all ages (from 1 year old babies to 87+ elderly individuals) [19]. Hence, in order to form age groups which would represent each a specific social and economic situation in one’s life, yearly data is then rearranged manually in the following three groups:

1. 18-25 years old (refered to as “youngest generation” or “y”)
2. 26-64 years old (representing the “working individuals” or “w”)
3. 65+ (symbolizing the “retired population” or “r”)

Because each age group has a distinct set of inherent characteristics, section 5.1 will later discuss the difference in the regression analysis’ expected results from each age group’s perspective.

4.2.1. Japan-wide Inter-Prefectural Migration Flows

New moves are generally performed by people between 18 years old and their late 30s, with the concentration of people in their 20s being the largest because it is the first time they get the opportunity to do so on their own. Most of younger adults’ first move occurs upon entering university, getting their first job or even when moving in their first house after deciding on where they settle down. On the contrary, even if they still consist of the majority of the migrating population, the people between 26 and 64 years old usually are largely motivated by changes in their professional or familial statuses. Further down the line, the migration rate of people having reached their late 50s drops considerably, far lower than that of 18-25 year olds despite their population being much greater.

For the two most recent consecutive periods (2020-2015 and 2015-2020), Figure 4's age-specific proportions are calculated by taking the percentage taken up by each age group out of the total out-migrating population's magnitude, i.e.:

$$age\_perc_i = \frac{age\_magn_i * 100}{total\_magn}, \qquad where\ i\ \epsilon\ [y, w, r]$$

(Note: Of course, because we do not take into account the 0-17 years-old share, the total percentage does not sum up to 100%)

The difference in the the aforementioned percentages of each age group's inter-prefectural out-migration in the two consecutive periods 2010-2015 and 2015-2020 can be seen in Table 2. The corresponding actual percentages are visually represented in Figure 4. Prefectures whose names are written in red are prefectures located in high density metropolitan areas. Moreover, the magnitude of each difference is displayed as a coloured gradient (from green being highly positive to red representing highly negative).

Figure 4 - Proportion of the Three Age Groups in Japan-wide Inter-Prefectural Out-Migration (2010-2020)

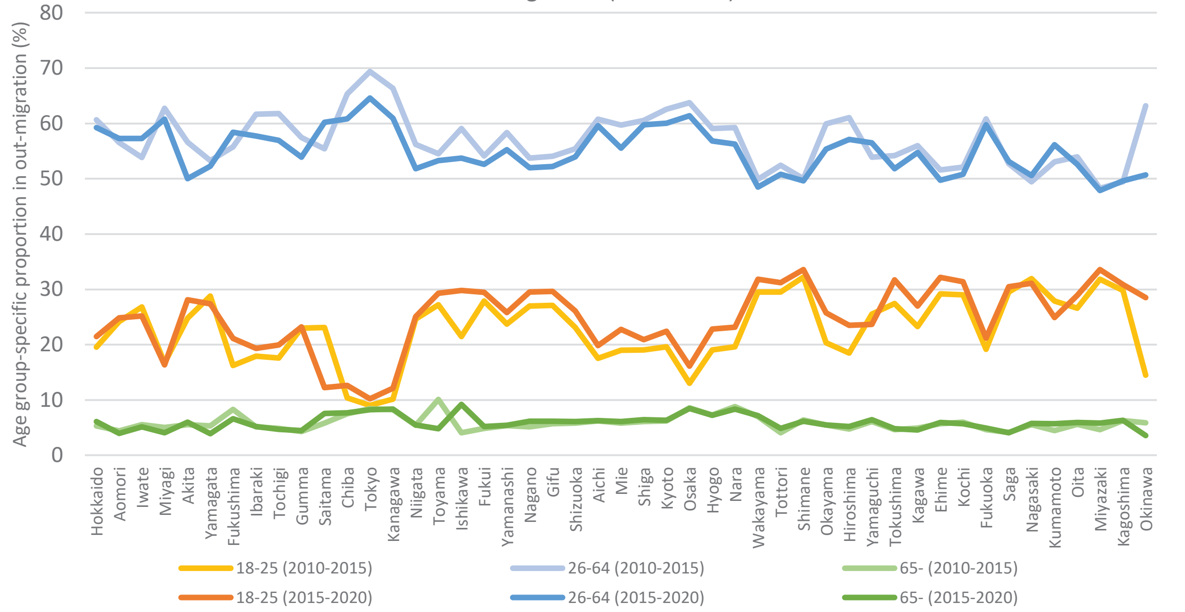


Table 2 - Difference in the Age Structure's Proportions (2010-2015 / 2015-2020)

	18-25	26-64	65-		18-25	26-64	65-
Hokkaido	1.932	-1.419	0.746	Shiga	1.827	-0.807	0.307
Aomori	0.675	0.715	-0.460	Kyoto	2.798	-2.501	0.136
Iwate	-1.658	3.483	-0.411	Osaka	3.098	-2.348	-0.084
Miyagi	-0.301	-1.977	-0.912	Hyogo	3.801	-2.259	-0.066
Akita	3.310	-6.638	0.451	Nara	3.514	-3.000	-0.468
Yamagata	-1.407	-1.007	-1.395	Wakayama	2.266	-1.425	0.152
Fukushima	4.895	2.685	-1.662	Tottori	1.702	-1.612	0.760
Ibaraki	1.421	-3.961	0.040	Shimane	1.306	-0.386	-0.198
Tochigi	2.353	-4.831	-0.214	Okayama	5.417	-4.583	-0.015
Gumma	0.216	-3.584	0.158	Hiroshima	5.027	-3.953	0.445
Saitama	-10.825	4.783	1.748	Yamaguchi	-1.870	2.623	0.335
Chiba	2.242	-4.501	0.173	Tokushima	4.246	-2.352	0.152
Tokyo	1.207	-4.828	-0.167	Kagawa	3.708	-1.240	-0.295
Kanagawa	1.979	-5.363	0.085	Ehime	2.983	-1.809	0.246
Niigata	0.424	-4.416	0.030	Kochi	2.356	-1.300	-0.304
Toyama	2.046	-1.246	-5.278	Fukuoka	2.073	-1.031	0.250
Ishikawa	8.309	-5.363	5.087	Saga	0.933	0.390	-0.059
Fukui	1.600	-1.547	0.324	Nagasaki	-0.824	1.125	0.267
Yamanashi	2.074	-3.103	0.066	Kumamoto	-2.978	3.119	1.263
Nagano	2.492	-1.772	1.017	Oita	2.315	-1.337	0.354
Gifu	2.545	-1.861	0.452	Miyazaki	1.764	-0.345	1.163
Shizuoka	3.012	-1.474	0.261	Kagoshima	1.055	0.193	0.056
Aichi	2.358	-1.184	0.098	Okinawa	13.999	-12.508	-2.327
Mie	3.815	-4.174	0.255		2.0262	-1.913	0.0545

What we first notice is that the percentage of 26-64 year-olds' out-migrants in Figure 4 obviously twarts those of the other two. Although the proportion taken by the older generation has not changed at all between the two time periods, a decrease of 2.0262% in the percentage of the working population can be matched by a proportional increase in the relative fraction taken up by the younger generation (-1.913%).

Unsurprisingly, this ratio of working population out-migrating from Tokyo-MA's prefectures is the highest (64-70%), while it is at the lowest in Wakayama (47-50%), Shimane (50-51%), Nagasaki (49-51%), Miyazaki (47-48%) and Kagoshima (48-49%). Naturally, these fluctuations are almost systematically combined with an opposite trend among the youngest generation in the same prefecture (8-10% in Tokyo compared to 29-31% in Wakayama, 32-34% in Shimane, 31-32% in Nagasaki, 31-34% in Miyasaki, and 29-31% in Kagoshima).

Interestingly enough, while the percentage of elderly people does not vary excessively between prefectures, it is around 8-10% in Tokyo (which is the only prefecture with almost the same amount of 18-25 years old moving out as 65+ years-olds) and Toyama, 9% in Ishikawa as well as 8.5% in Osaka and 8.4%

in Nara. Moreover, such trend has not changed between the two time periods, and has remained low, only exhibiting an overall average difference of 0.0545%.

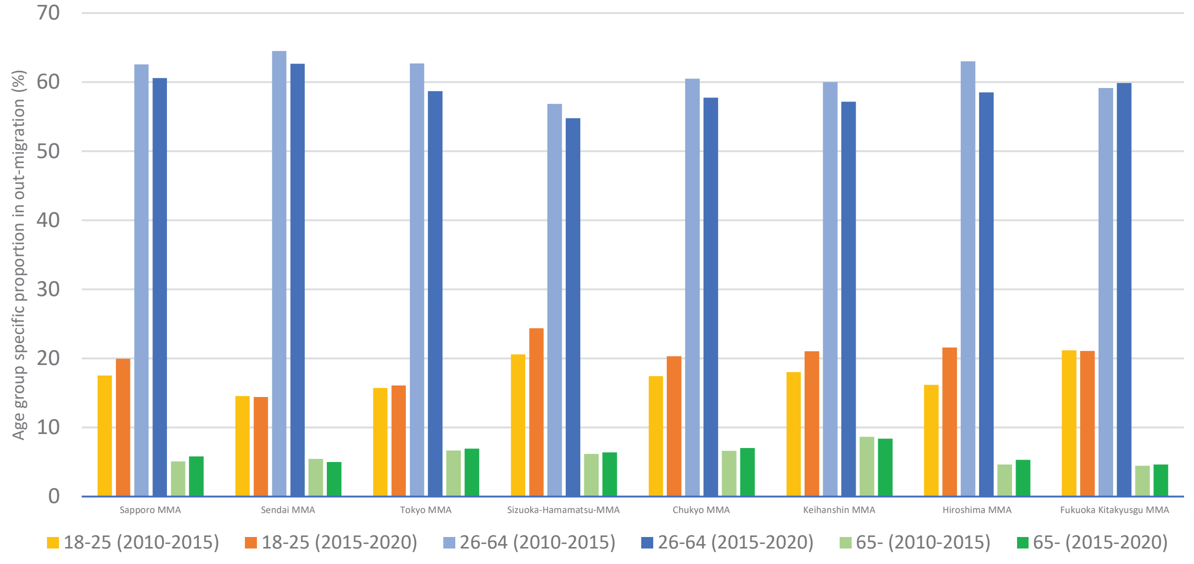
Three prefectures' trends however stand out among them.

1. Obviously, Okinawa's age group evolutionary gaps are by far the largest. As a matter of fact, the proportion taken up by the working population drastically decreased from being the second largest (at 63.2%) all the way down to 50.7% and becoming one of the lowest, dropping by 12.508%. Because the elderly population's percentage only decreased by 2.327%, the younger population moved a lot more in comparison to the previous five years (from 14.5% in 2010-2015 to 28.5% between 2015 and 2020). As a matter of fact, Okinawa's effort in twarting the coronavirus' infection in the prefecture was compromised by the regrettably low standard of infection protection enforced by the US military. Potential indirect exposition to the military personel (both Japanese and American) has induced the government to impose a stricter lockdown on Okinawa where vacation-related trips account for most of the migration.

   Although much more weakly, the other prefecture which followed a similar trend was Ishikawa. In fact, 8.3% more people aged 18-25 y.o moved out of Ishiawa while the retired population exhibited a 5.087% increase. In the countrary, 5.363% less working age persons moved out compared to 2010-2015.
2. Saitama, on the other hand, displayed the opposite tendency, losing 10.825% more young people than in the last time period, while gaining 4.783% more work capable people.

4.2.2. Age-Group Specific Metropolitan Areas' Net-migration

Figure 5 - Proportion by Age group of migration from Metropolitan Areas to non-Metropolitan Areas (2010-2015 / 2015-2020)



Whereas previous graphs focused on Japan-wide out-migration (i.e. out-migration to all other prefectures other than itself), Figure 5 shows the results of out-migration from each metropolitan areas to all Non-Metropolitan areas' prefectures only. Population Census' migration flow data during the same two time periods (2010-2015 and 2015-2020) were divided in two simultaneous ways [19]:

1. Division between Metropolitan Areas' and Non-Metropolitan Areas' prefectures
2. Segmentation into three age groups (18-25, 26-64 and 65+)

Similarly to before, the proportion of younger individual moving out of almost all prefectures (and hence whole metropolitan areas too) rose while the working popualtion's share decreased by an approximately similar amount.

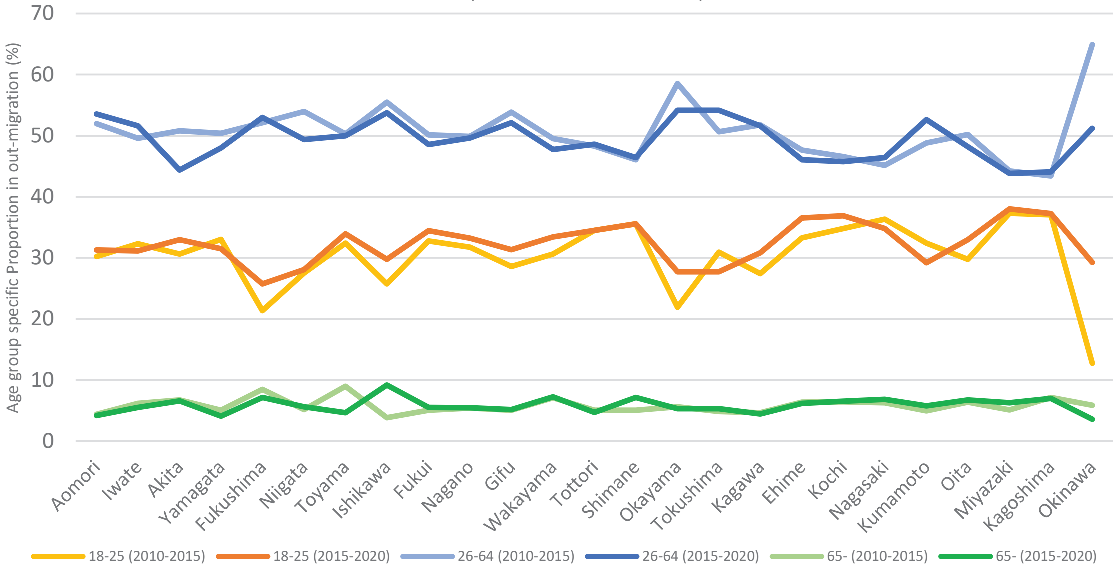
With the rise of Tohoku Unviersity as one of the leading universities in the country, it is not surprising to see than Miyagi-MA has the lowest ratio of 18-25 years olds moving out (14%), coupled with the highest ratio of 26-64 year olds (64%). A similar thinking could be applied to Tokyo-MA, which has always been the most important hub for education, economic and entertainment purposes.

On the contrary, Shizuoka-MA and Fukuoka-Kitakyushuu-MA exhibit opposing tendencies, with a lot of younger individuals moving out of the prefectures (21%), coupled with low working population out-migration (57% and 59% respectively). Among all metropolitan areas, Shizuoka-MA and Hiroshima-MA demonstrated the biggest change in the proportion of young individual moving out (3.8% in Shizuoka and 3.5% in Hiroshima compared to 2% on average).

On a similar note, while metropolitan areas with some of the lowest population (Sendai-MA, Hiroshima-MA and Fukuoka-MA) had the lowest percentage of retired people moving to other prefectures, Keihanshin-MA's elderly population seems to be the least willing to move out. Its 8.5% proportion overshadows the other metropolitan areas by an average of 3%.

4.2.3. Age-Group Specific Non-Metropolitan Areas' Net-migration

Figure 6 - Proportion by Age group of migration from Non-Metropolitan Areas to Metropolitan Areas (2010-2015 / 2015-2020)



Similar to Figure 5, the above Figure 6 considers the migration from non-metropolitan prefectures in direction of all prefectures constituing metropolitan areas only. Just like previous assessements, the proportion of elderly retired people does not vary much while the the yougest generation also increased their out-migration to metropolitan areas at the expense of the working population. While the difference between time period is mostly minimal, some rurual prefectures showcased some more drastic changes. Indeed, the proportion of younger individuals migrating from Fukushima, Ishikawa, Okayama and especially Okinawa (for similar reasons as previously discussed) had greatly decreased. Comparably, Yamagata, Okayama and Okinawa saw their working population decrease more than the average.

V. Regression Analysis Results

5.1. Expected Results

The main focus of this thesis concerns the population migration flow's relationship to changes in spatial characteristics, with an emphasis on the connection between population movement and the now not-so-recent ageing population.

1. Based on previous papers reviewing past trends of similar variables, there are reasons to believe that the most significant factors impacting spatial migration flows for the years of interest are linked to the location's population and the economic factors: prefectural GPP and unemployment rates (proxies for potential future remunerations and job opportunities respectively). This trend, I believe, will be more impactful among the younger generation (18-25 years-old) who are in search of their first professional experience. This chief motivation will most likely lead them to move in the direction of metropolitan areas, which will have an ambiguous impact on the distance covered during a move.
2. The majority of migration performed by 25-64 year-olds are hypothetically motivated primarily by either professional intent or family related business. Such moves (albeit intra-prefectural

moves) are thought to rather be long-distance travels. Whereas couples with kids might also attach greater importance to the health care offers (especially pediatric specializations), childless couples and single people's interests are instead focused on career-affecting variables. Therefore, which coefficients end up the most significant is left to be determined.

3. Furthermore, it is hypothesized that indirect changes in variables in the medical field precedented by the healthcare system's revamp of the late 2000s may have a greater impact on the 65+ migration flow. Additionally, instead of presenting a desire to move to prefectures with high population density, it is more likely plausible that the older population would instead seek quieter and less densely inhabited areas. While it is expected that a ruralisation-led exodus on the part of the elder population is likely to take place, they would instead predominantly perform short-distance moves.
4. Finally, upon analysing the results of the spatial autoregressive model, the weight matrices' coefficients are expected to be statistically significant and positive for all following trends observed previously.

5.2. Regression Analysis Results

Two different analyses are performed below using data gathered from all 47 prefectures.

1. By applying Spatial Gravity Linear Regression and the Spatial Autoregressive Models (SAR), inter-prefectural migration flows are evaluated using data from all 47 prefectures at once, regardless of age.
2. After manually segmenting the data into the three different age classes (namely 18-25y.o., 26-64y.o. and 65+y.o.), the significance of each age group's motivating factors is compared in more details. When comparing the results for all 3 separate age groups, the coefficients (as well as their standard errors and significance levels) are all entered in Table 5

5.2.1. Spatial Linear Regression Model Results

In order to examine the influence that the spatial weight matrices have within migration econometrics, we first observe the results of the spatial weight-less spatial (gravity) linear regression model which uses equation: $Y_{od} = \alpha + \beta_o X_o + \beta_d X_d + \gamma dist_{ij} + \epsilon$.

Table 3 below shows a summary of the results obtained by applying the aforementioned gravity model onto the data from all 47 prefectures. It includes analysis by Ordinary Least Squares robust standard errors) as well as Maximum Likelihood Estimation.

According to Table 3 results, there seems to be a strong tendency for people to move to prefectures with a large population (0.82 (0.074) ***). Such inclination is highly statistically significant even to the 1% significance level in both robust OLS and when MLE (0.82 (0.074) ***). If we couple this result with the fact that people also seem to want to migrate to smaller prefectures (- 0.34 (0.066) ***), then prefectures' population density seems to have a predominant positive effect.

Among included economic variables, per capita Gross Prefectural Product (GPP) at both the origin and destination prefectures are found to be positive. However, the surprising result that only the origin coefficient (0.89 (0.30) **) is statistically significant at the 5% level means that the population tends to leave prefectures with higher per capita GPP more substantially rather than moving towards those with high pcGPP (0.50 (0.29)). However, we may think of this occurrence as a reason as to why, although immigration tends to increase the average income of workers, it may also lead to a decrease in the wages of low-paid workers, especially in richer high-density populated areas.

Although neither is significant, it is important to notice the signs of the coefficients attributed to the respective unemployment rates' coefficients. Indeed, while the origin's positive coefficient (0.034 (0.018)) reflects a greater emigration out of prefectures with lower unemployment rates, the negative coefficient at the destination (0.0070 (0.031)) means that people are more inclined to move to prefectures with higher unemployment rates.

Remarkably, none of the healthcare variables are significant neither under the robust standard errors nor MLE. Only the destination's medical expenses' coefficient (- 0.20 (0.52)) tends to decrease the coming of new population. This is rather counter-intuitive as we may think that people, especially the older generation, may be more tempted to move to prefectures whose more budget is attributed to medical expenses.

Finally, the negative and highly statistically significant coefficient of the distance variable (- 0.31 (0.035) ***) concords with what is expected from general understanding of migration principles, stating that the further away the destination, the less likely you are to perform the relocation.

Table 3 – Spatial Linear (Gravity) Model Results

	Robust Standard errors	**MLE**
Intercept	-16.17 (3.83) ***	- 16.17 (5.11) **
Pop_o	0.73 (0.12) ***	0.73 (0.075) ***
Area_o	-0.29 (0.086) ***	- 0.29 (0.066) ***
pcGPP_o	0.89 (0.97)	0.89 (0.30) **
Unemployment rate_o	0.034 (0.026)	0.034 (0.018)
Medical expenses_o	0.027 (0.47)	0.027 (0.53)
Lifestyle disease deaths_o	0.027 (0.014) .	0.027 (0.012) .
Length of hospital stays_o	0.13 (0.29)	0.13 (0.37)
Pop_d	0.82 (0.16) ***	0.82 (0.074) ***
Area_d	-0.34 (0.094) ***	- 0.34 (0.066) ***
pcGPP_d	0.50 (0.80)	0.50 (0.29)
Unemployment rate_d	0.0070 (0.031)	0.0070 (0.032)
Medical expenses_d	-0.20 (0.53)	- 0.20 (0.52)
Lifestyle disease deaths_d	0.013 (0.0081)	0.013 (0.011)
Length of hospital stays_d	0.29 (0.29)	0.29 (0.39)
Distance_od	-0.31 (0.056) ***	- 0.31 (0.035) ***

5.2.2. Spatial Autoregressive Model

$$Y_{od} = \rho_o W_o Y_{od} + \rho_d W_d Y_{od} + \alpha\iota + \beta_o X_o + \beta_d X_d + \gamma dist_{od} + \epsilon$$

Studying the effects of spatial inference and spatial autocorrelation necessarily involves the introduction of interaction terms in the form of weight matrices, which will provide support in analysing the impact of local flows from nearby prefectures. Indeed, an OLS analysis assumes that the explanatory variables' coefficients are constant across any and all spatial dimensions. Hence, inevitably, if any spatial variations exist, it would be introduced in the error term ϵ.

A regression that is similar in all aspect to the one described above was first performed using a contiguity matrix instead of the aforementioned usual inverse distance matrix as base for the weight matrices. This spatial "nearest neighbors" weight matrix indicates the spatial relationships between regions, where the regions are considered "contiguous" if they share a common frontier. Each element w_{ij} of this n x n matrix are spatial weights taking on non-zero values when regions i and j are contiguous neighbors, and zero otherwise. Although the issue only rarely occurred, it was decided that the "queen contiguity" method should be used (method where neighbors are defined as two regions share any type of frontier, no matter how small). The results to this regression are shown in Table Ap. 2, while its respective Moran's I statistics are present in Table Ap. 1.

Before going forward with the Spatial Autoregressive Model, the presence of implied spatial autocorrelation must first be tested through a Moran's I test. The p-values (all smaller than 0.0001) in Table 4 below confirm that, in all cases, the common assumption arguing against spatial correlation can be rejected. Looking in more details, the Moran I statistic for W_d is greater than that of W_o overall as well as for the youngest generation. However, the opposite is found when it comes to analysing the whole population at once. This means that there is convincing spatial autocorrelation based on destination among each age group's individual migration flow, which is not found for Japan as a whole.

Table 4 – Moran's I Test

Spatial Weight Matrix	Moran's I statistics	Expectation	SD	p-value
W_o	0.338	-0.000453	0.0111	0.000
W_d	0.337	-0.000453	0.0111	0.000
W_o (18-25)	0.327	-0.000452	0.0115	0.000
W_d (18-25)	0.486	-0.000453	0.0115	0.000
W_o (26-64)	0.323	-0.000452	0.0115	0.000
W_d (26-64)	0.483	-0.000452	0.0115	0.000
W_o (65+)	0.312	-0.000453	0.0115	0.000
W_d (65+)	0.489	-0.000452	0.0115	0.000

Results summarized in Table 5 below show the results of analysing inter-prefectural migration flow by Maximum Likelihood Estimation. The first column displays the results for all migrants, irrespective of age, while the next three column summarize those of the three aforementioned age groups.

Table 5 – Spatial Autoregressive Model Results

	All Age Groups	18-25	26-64	65+
Intercept	-20.67 (5.36) ***	-34.78 (8.36) ***	-12.64 (3.54) ***	-5.79(4.71)
Pop_o	0.50 (0.077) ***	0.54 (0.12) ***	0.26 (0.051) ***	0.25 (0.068) ***
Area_o	-0.19 (0.68) **	0.11 (0.11)	- 0.12 (0.045) **	-0.14 (0.060) *
pcGPP_o	0.97 (0.31) **	0.66 (0.48)	0.78 (0.20) ***	1.038 (0.27) ***
Unemployment rate_o	0.031 (0.018) *	0.016 (0.028)	0.023 (0.012) *	0.032 (0.016) .
Medical expenses_o	0.39 (0.54)	0.60 (0.85)	0.27 (0.36)	0.20 (0.48)
Lifestyle disease deaths_o	0.03 (0.013) .	0.0023 (0.020)	0.014 (0.0083) .	0.019 (0.011) .
Length of hospital stays_o	-0.00052 (0.38)	0.10 (0.59)	-0.091 (0.25)	-0.039 (0.33)
Pop_d	0.29 (0.076) ***	0.63 (0.12) ***	0.39 (0.050) ***	0.55 (0.067) ***
Area_d	-0.23 (0.067) ***	-0.28 (0.11) **	-0.14 (0.045) **	-0.19 (0.059) **
pcGPP_d	0.68 (0.29) *	1.93 (0.46) ***	0.27 (0.20)	-0.69 (0.26) **
Unemployment rate_d	0.11 (0.032) .	0.030 (0.050)	0.000030 (0.021)	-0.023 (0.028)
Medical expenses_d	0.25 (0.53)	1.14 (0.83)	0.15 (0.35)	-0.34 (0.47)
Lifestyle disease deaths_d	0.011 (0.011)	0.019 (0.018)	0.0041 (0.0077)	0.0026 (0.010)
Length of hospital stays_d	0.11 (0.40)	-0.022 (0.62)	0.054 (0.26)	0.31 (0.51)
WoYod	0.15 (0.31) ***	0.14 (0.026) ***	0.24 (0.027) ***	0.35 (0.026) *
WdYod	0.13 (0.031) **	0.44 (0.028) ***	0.028 (0.029)	-0.069 (0.026) **
Distance_od	-0.18 (0.036) ***	-0.12 (0.056) *	-0.10 (0.024) ***	-0.15 (0.032) ***

Gravity characteristics:

Even though the origin prefectures' population matters significantly to the youngest generation (0.54 (0.12) ***) as much as it does to the others, the area (0.11 (0.11)) doesn't seem to be of importance, which makes the origin prefecture's population density inconsequential in their decision. However, the same observation cannot be made when it comes to the destination's population density. Indeed, as it is the case for all age groups, the higher the destination's population density (pop_d = 0.63 (0.12) *** and area_d = -0.28 (0.11) ***), the more likely people are to take residence there. With regard to the retired generation, we however fail to establish the expected negative link between their migration flow and the destination's population density. Indeed, it seems that, like other age groups, retired people also tend to hold population density as significant in their migration decision.

Economic variables:

When contemplating all age groups indiscriminately, we find out that the origin per capita GPP has a positive and significant coefficient (0.97 (0.31) **), which is also somewhat the case for the destination's coefficient (0.68 (0.29) *). Moreover, our initial hypothesis saying that job opportunities are a relevant (yet only slightly significant) factor in determining migration decisions is somewhat verified. As a matter of fact, the origin's unemployment rate coefficients are all positive, while its destination's counterparts are on the contrary only significant at the 10% level for the population in general and even negative in the case of the elderly population. One of the most substantial differences between the regression using the contiguity matrix as a base rather than the inverse distance matrix concerns the sign of the destination's unemployment rate's coefficient. Indeed, in the alternative case, the sign for all is negative and non-significant, which indicates that the unemployment rates of the origin prefecture (0.031 (0.018) *) increases the benefits the workers experience through out-migration, making them move to prefectures with more opportunities. Adding this to the fact that a rise in the destination prefectures' wages (0.11 (0.032) .) improve in-migrants' chances at receiving more, it is implied that job opportunities instead of the prospect of earning more seems to be the main motivation for an eventual relocation.

Although the unemployment rate's coefficients are as described above for the population in general, the evaluation of these results may be different for each age group. Firstly, as expected, the youngest generation attaches high significance to the destination's per capita GPP (1.93 (0.46) ***), which acts as a proxy for prefectural economic stability and their potential future private income.

Furthermore, the finding that the origin's per capita GPP is highly significant and positive (0.78 (0.20) ***), while the destination's corresponding coefficient is also positive yet unsignificant (0.27 (0.20)) is intriguing. In fact, it would indicate that the working generation may be more heavily influenced by the prospect of job openings (0.000030 (0.021)) than greater salaries. It may explain the fact that lower employment rates can be found in high density areas, alongside lower salaries for employees doing manual labor.

Finally, as we had commonly hypothesized, there exists a strong relationship between per capita GPP and the retired population's migration. In truth, the origin's highly significant and positive coefficient (1.038 (0.27 ***) signifies that elderly people tend to move out of strongly productive areas to move to much less productive prefectures after retirement, as proven by the statistically negative coefficient of the destination (-0.69 (0.26) *).

Healthcare:

In all cases, none of the destination's healthcare variables chosen in this regression were neither high in magnitude nor statistically significant. However, we may notice that while the length of hospital stay is negative at the origin (-0.00052 (0.38)), it is positive at the destination (0.11 (0.40)), meaning that the population seems to move from prefectures where they are projected to stay longer in the hospital in the direction of prefectures where they may spend less time there.

Moreover, lifestyle diseases induced deaths' coefficient at the origin is positive and slightly significant for the two older generations but small and non-significant at the destination. This fits in the sense that the higher the percentage of deaths attributed to lifestyle diseases, the more people may decide to move to prefectures with lower rate of deaths due to diseases which could be prevented depending on the prefectural healthcare system. However, whether this variable is easily observable on the resident side is debatable as these are most likely only results which they could see or read in specific media medium.

Taking all into account, none of the healthcare variables are vital when it comes to migrating among the oldest population either. This is a relationship that goes against our hypothesis as well. Surprisingly, economic variables as well as distance were among the variables which retired people hold as most significant in their migration decision, even more so than heath related services.

Weight matrices:

As hypothesized, introducing the spatial weight matrices results in positive and highly significant correlations. It is to say that both migration from the origin prefecture to the destination's neighboring prefectures and migration from the origin's neighboring prefectures to the destination both show significant spatial dependence, except in the case of the working population's surprising destination-based spatial dependence (0.028 (0.029)). While the aforementioned is the case for the overall population and youngest generation, a substantially negative coefficient can also be observed on the destination weight matrix of the retired generation (-0.069 (0.026) **) while its respective origin-based weight matrix is only significant at the 10% level (0.35 (0.26) *). This dictates a negative spatial dependence between the origin and the destination's neighbors as most retired people tend to either come back to their native prefecture or stay in the prefecture in which they had been working prior to retiring.

Distance:

Like it is often the case, people tend to decide to move to prefectures that are closer to their starting point, which makes the distance matrix coefficient negative and more or less statistically significant, depending on the age group. As it can be seen in Table 5, this is especially true for people over 25 years of age. Indeed, common sense would generally dictate that as people grow older, having to travel longer distances may negatively impact their decisions. Keeping this in mind, the youngest generation's distance's coefficient being negative and only slightly significant (-0.12 (0.056)*) may however only mean that they can be willing to move farther way from their origin prefecture in order to get higher salaries and better job opportunities.

VI. Conclusion

Although the post Second World War era brought economic rejuvenation thanks to high growth rate of total factor of productivity, Japan experienced a short but inevitable "baby boom". Later on, because of the serious impact of the 1973 oil crisis on the "bubble economy", the start of economic uncertainty resulted in the decrease in the frequency of inter-prefectural migration rates. Coincidentally, the simultaneous decline in the overall Japanese population also reaped changes in the demographics' dynamics. As is now a well-know fact, Japan is home to the oldest population in the world with the current 65+ year-old individuals taking up 29% of the total population (by more than tripling in the last 40 years).

The early 1950's *metropolization* slowly faded out two decades later and economic inequalities between rural and urban areas began shrinking. On the other hand, as a result of the ageing-society phenomenon impact on the population movements, prefectural governments' responsibilities regarding healthcare and financial situations also increased. In the late 2000s - early 2010s, the population growth rate officially becoming negative meant that the weight internal migration bears on prefectural growth rates increased.

The use of a Spatial Autoregressive Model with weight matrices allows for an efficient study of spatial dependence and spatial correlation. The regression performed on four different demographics' data revealed some interesting results. As expected, the two socio-geographical variables are highly significant, except in the case of the younger generation which only considers the destination prefecture's area to be significant. Moreover, the 18-25 year-olds regard only the destination's per capita GPP as relevant, trend that is reversed for the other generations. It is to say that without previous work experience, the young new workers would only consider the location of their first work to be the most pertinent in their decision to relocate. Similarly, we could attribute the fact that only the working population is significantly influenced by the unemployment rates of the origin prefecture to their willingness to relocate in order to get better job opportunities. However, the older retired generation exhibited other curious results. While the economic variables remain comparably vital in their decision, none of the health care variables never had any real significant impact. Distance, however, is always significantly negative, because performing long distance moves is even more so a detrimental obstacle to all and especially to the elderly.

In an attempt to curb the declining population growth rate crisis' impact on the economy, the Japanese government has already attempted to implement a series of policies in the 2000s, as well as some more in the 2010s. While the last couple of years' focus was centered on reacting to the COVID-19 pandemic, which also directly impacted the population's death toll, the government is expected to direct its attention once again to the issue. As one of the countries with higher-than-average proportion of 65+ individuals, Japan should rather stray away from implementing financial policies or unpopular political reforms. As it is, economic theory states that the impact of excessive financial policies may be damped by the discrepancies between different demographics' activity levels which would both diminish the role of monetary policies in response to shocks.

One of the reforms the government had in mind involved, among other things, raising the ages for retirement and pension eligibility. As of now, elderly citizens can receive the Employee's Pension Insurance payments from age 60 and the National Pension Program any time between age 60 and 70. However, in 2018, Prime Minister Abe's government envisioned a scheme which would "increase the age of eligibility for the earnings-related pension to 65 years for both men (by 2025) and women (by 2030)" as well as strictly 70 years old for the National Pension Program [2].

Rather than considering the ageing of the population as an issue and systematically trying to remove the elderly population's negative impact on the population, exploring the presence of elderly individuals and their respective inter-prefectural migration may help advance the economy in a new direction.

Just like environmental preservation is mainly considered as a financial constraint by some, sagacious entrepreneurs take it as a leading opportunity to pursue innovation and create whole new sectors in the economy. Ignoring the potential benefits of elderly population's contribution may mean missing on improvements in, among others, personalized medicine (deemed "comfort" medicine) as well as the development of specific home appliances, some requiring the use of automatization and robotics. More importantly, sectors which had recently been close to abandoned by fear of unprofitability could benefit from the recording and transmission of knowledge and skills harbored by the more experienced individuals in sectors. Also, the right policies eventually permitting to combine retirement benefits and income in a proportion to be determined could revive lower return sectors that are less attractive to the working age population (25-64). These would benefit the whole economy in further diversifying it as elderly people would now profit from a (reduced) part-time salary without impacting the company which decided on it based on their productivity goals and nature of the work. The fields more advantaged are those from the artisanal and artistic sectors as well as the education field and eventually urban agriculture. In a country that is known for its craftmanship, it is imperative to find new approaches to tutor and mentor new generations through a modern type of schools and teaching methods.

Moving on from the paradigm of the "Slow Industry", responding to the needs and demand from a population that is progressively seeking goods with more meaning, niche fields could beneficiate from harvesting the rare and important skills of the elderly. Requiring less immediate productivity, some niche sectors are thus more suitable for those who choose to voluntary keep working longer. As recently reported by the Japanese Cabinet Office, around 70% of people aged 60 to 64 were still working in 2020 [1]. Moreover, an online survey conducted in 2020 by Nippon life Insurance Co. stated that 64% of its 7,543 surveyed policyholders desired to keep working beyond the retirement age (38.7% want to keep their current jobs while the other 25.3% would like to try something different). Despite the beforementioned governmental plans to raise the minimum age of those who can receive Employee Insurance benefits (page 39), the recently retired individuals may still have fewer financial constraints and could most likely be more willing to revitalize, or even create new sectors which may not provide the immediate financial rentability larger companies or younger workers are looking for. The same goes for entire prefectures where the cost of living is lower and possesses a certain environment more profitable to the development of all age groups, not only that of retired individuals. As found as part of the regression results, the elderly population's desire to reside in prefectures with somewhat high population density but low productivity (relationship difficult to achieve due to the natural, and almost inevitable, development of job opportunities in high density areas) may birth the perfect environment for the development of such methods (page 34).

That said, although taking advantage of the "Silver Economy" as a whole is an important step, it can become detrimental if not first implemented carefully. Multiple measures should first be put forward before exploiting such an opportunity. Indeed, the same set of criteria cannot be applied to the elderly the same way as it is to the young or working population. Criteria directed to the older generation should reflect each age group's values conditional on the current trends and cultural globalization. Working hours as well as working environment should be adapted to facilitate their integration in a new field or their continuation at the same company. The same way we would analyse a first-hand situation with the latest data, new specifications should be created in order to optimize the current circumstances rather than doing "more of the same". Because retaining intergenerational equity will, without doubt, be challenging if a "business-as-usual" mentality is continued, understanding what the elderly population really needs and aspires to, rather than force-feeding them the same system which has been part of the problem in the past is key. The government's decision to transmit more responsibility to the prefectures may be beneficial as each region has its own characteristics, needs and unique sets of opportunities. What other regions of the world may consider a hindrance to this type of development strategy may create "compensating" rather than "complimentary" action plans which would not be relevant to Japan's current and future situation. In addition to the prospect of strong positive fiscal impact on both the government and companies, this evolutionary system will allow the elderly population to enjoy short term benefit that satisfy their needs as well as long-term advantages for their future final retirement.

Yet, the hereby recommended course of action regarding the ageing population is heavily based on three assumptions that are particular to Japan:

1. More than in any other countries, Japanese elderly individuals have the motivation to keep working even after the pre-set "retirement age" of 60 or 65.
2. The unemployment rate among the younger generation is low enough so that the "retired" population does not get fully crowded out by the new workers entering the market upon graduation. This assumption is strongly backed up by the World Bank Database information which

places Japan's youth (15-24 y.o) unemployment rate at 4.9% while, in comparison, the United States is up to 14.9% and France points all the way to 20.2% [26].

3. The belief that individuals above 60 (or even 65) years old still remain somewhat productive in the field they plan on working in

Ensuring labor market flexibility towards a continuous high productivity growth throughout is thus essential. It is imperative that Japan creates a setting in which working older people can still prove themselves and their skills for a longer period of time. One of the policies which so far have come the closest to presenting the most adequate first set of goals is the 2018 "Guidelines of Measures for Ageing Society", its mission put forward in the subsequent Annual Reports on the Ageing Society (2019, 2020 and 2021) [1]. According to the Cabinet Office website, these Guidelines aim to implement status of measures in six fields, each with more-or-less detailed medium-term goals. Among those are: stably operating a public pension system as well as sustainably managing long-term medical care system for elderly people. One of the more well-accepted programs involves increasing the mandatory retirement age for civil servants from 60 to 65 in addition to helping companies keep elderly workers in order to somewhat lessen the burden that the dependence ratio imposes on the working generation. Aiming to do so by 2025, the ratio of working individuals to the total population would allegedly be restored to its 2008 level, which coincides with the beginning of the population decline. The government, in addition to providing full pension benefits to only those over 65 or 70 (premium now increasing to 20% rather than 10% as per past decree), it would also distribute reduced pension benefits to those still working over 65 years of age. Other areas of focus of these Guidelines include promoting the elderly's learning activities in social environments, comprehensively stimulate small town development which were affected by consecutive urbanization waves, encourage R&D initiatives which would potentially attract knowledge and challenges from/to foreign countries as well as widen the use of adult guardianship.

In conclusion, although most of the results obtained from the regression models were as expected, the non-dependency of the Japanese population on the chosen health-care variables indicates that a Japanese elderly may have the same intensions as a healthy, working person. Hence, in addition to progressive fiscal policies, combining diminished governmental pensions (distributed to 65+ only individuals) and appropriate income/pension to motivated elderly people, the awareness of both the rest of the population and companies concerning the promotion of elderly individuals' social integration activities should be optimized. This is why establishing an Age-Free society where creating mutual support where "people of all ages can make use of their motivation and abilities depending on their hope" is encouraged [1].

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VIII. Appendix

Table Ap. 1 – Moran's I Test (Contiguity Matrix)

Spatial Weight Matrix	Moran's I statistics	Expectation	SD	p-value
W_o	0.297	-0.000453	0.0153	0.000
W_d	0.303	-0.000453	0.0153	0.000
W_o (18-25)	0.271	-0.000453	0.0159	0.000
W_d (18-25)	0.533	-0.000453	0.0159	0.000
W_o (26-64)	0.286	-0.000453	0.0150	0.000
W_d(26-64)	0.229	-0.000453	0.0150	0.000
W_o(65+)	0.367	-0.000453	0.0146	0.000

Table Ap. 2 – Spatial Autoregressive Model Results (Contiguity Matrix)

	All years	18-25 y.o.	26-64 y.o.	65+ y.o.
Intercept	-18.031 (5.37) ***	-29.18 (8.19) ***	-12.53 (3.54) ***	-8.37 (4.71) .
Pop_o	0.54 (0.077) ***	0.65 (0.12) ***	0.29 (0.051) ***	0.24 (0.068) ***
Area_o	-0.21 (0.068) **	0.038 (0.10)	-0.13 (0.045) **	-0.14 (0.060) **
pcGPP_o	0.76 (0.31) *	0.29 (0.47)	0.81 (0.20) ***	1.17 (0.016) ***
Unemployment rate_o	0.025 (0.018)	0.015 (0.028)	0.024 (0.012) .	0.034 (0.016) *
Medical expenses_o	0.42 (0.55)	0.58 (0.83)	0.42 (0.36)	0.36 (0.48)
Lifestyle disease deaths_o	0.024 (0.013) .	0.0026 (0.020)	0.015 (0.0083) .	0.020 (0.011) .
Length of hospital stays_o	-0.045 (0.38)	-0.086 (0.58)	-0.17 (0.25)	-0.13 (0.33)
Pop_d	0.61(0.076) ***	0.816 (0.12) ***	0.38 (0.050) ***	0.52 (0.067) ***
Area_d	-0.25 (0.068) ***	-0.38 (0.10) ***	-0.15 (0.045) **	-0.18 (0.059) **
pcGPP_d	0.44 (0.30)	1.49 (0.45) **	0.12 (0.20)	-0.69 (0.26) *
Unemployment rate_d	-0.0019 (0.032)	-0.0060 (0.049)	-0.0069 (0.021)	-0.027 (0.028)
Medical expenses_d	0.20 (0.53)	0.94 (0.81)	0.072 (0.35)	-0.20 (0.47)
Lifestyle disease deaths_d	0.013 (0.012)	0.027 (0.018)	0.0055 (0.0077)	0.0058 (0.010)
Length of hospital stays_d	0.11 (0.40)	0.037 (0.61)	0.064 (0.26)	0.24 (0.35)
WoYod	0.17 (0.036) ***	0.14 (0.025) **	0.19 (0.026) ***	0.33 (0.023) ***
WdYod	0.19 (0.027) **	0.42 (0.022) ***	0.16 (0.029) ***	-0.0023 (0.030) **
Distance_od	-0.14 (0.036) ***	-0.064 (0.055)	-0.082 (0.024) ***	-0.12 (0.032) ***