論文の要旨(Abstract of Dissertation)

論 文 題 目 (Dissertation Title): Long Term Demographic Predictions Considering the Spatial Distribution of Population

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　　　　Japan is being into depopulation since 2009 by declining fertility rate with a super-aging society and massive urban agglomeration occurred due to the emigrations from rural areas, which results in rural–urban disparities. Population losses made reducing in the labor force which can directly impact on the economic and demographic sustainability. To solve the need of Japan's labor force and the social problems, in the recent years, depopulation has been mitigated by the acceptance of foreign migrants in Japan. The foreign migrants and its spatial distribution significantly change along with the acceptance of specialized and technical skills workforce. The presence of foreign workforce is a crucial stabilizing force in the fragile, rapidly aging society. However, the social and economic divisions between rural areas and urban areas increased by urban agglomeration as a result of internal and international migration, the government faces difficulty in maintaining infrastructure, social services, and the outbreak of emergencies such as the current Covid-19 pandemic. Therefore, in order to preserve the social sustainability for both the domestic and foreign residents, it is essential to understand the agglomeration and population distribution phenomena occurring in the Japanese regions in long term.

　　　　In regional planning, population prediction for observing the demographic transition is one of the attentive methods that gives fundamental information for decision-making about maintaining the infrastructures, subsidizing to planned public projects. Population predictions are mainly based on the (latest) past trends, and many socioeconomic factors influence on population dynamics. The relationships between the various socioeconomic factors are complex and its exact structure is not well-known so that most of the population prediction methods depend on the particular assumptions. The national population prediction method of Japan made by Cohort-Component Analysis (CCA) requires minimum demographic information assuming a simple dynamic for each cohort. However, in CCA, migration is a difficult component since the geographical heterogeneity behind them. While CCA has well defined structure, the population prediction in sub-regions such as prefectures and municipalities of a country still relies on a trend extrapolation due to the limited availability of data (e.g., demographic and migration data) and resources.

　　　　As population distribution at municipality scale shows the spatial dependency that is often referred as agglomeration phenomena, we should not neglect the spatial correlations among the contiguous regions since the daily activities are dependent. To clarify the significance of spatial dependencies in migration phenomena, this dissertation tribally applied the statistical model with spatial dependencies to predict the migration of Japan. The improved population prediction approach can clarify not only the future population distribution but also the workforce agglomeration in sub-regions. As the acceptance of the foreign migrants had a significantly contribution on the future demographic structure of Japan, this dissertation also focuses on the transition of foreign residents' characteristics with time series and observes the structural breaks in the migration trend. With better understanding of future population structure in local areas for both domestic and foreign residents, we can implement the progressive policy making for regional sustainable development. Also, the effects of incentives to attract the workforce from the industrial zones in urban areas to local communities with innovative technologies-based business entities can be demonstrated by the proposed approach. A brief description of each chapter in this dissertation is as follows.

Chapter 1 provides the background of the depopulation by declining fertility rate with a super-aging society and population studies focus on the migration phenomena. Based on the research background, research motivation and objectives of the study are discussed.

In Chapter 2, literature about the demographic studies, population predictions, spatial demography, demographic transition of both domestic and foreign residents, economic development, and urbanization are reviewed. Following part is about the current situation and issues of study area.

Chapter 3 focus on the explanation of the methodology of the study and data collection procedures. This study consists of four main methodologies. First is about the existing methodology: conventional Cohort Component Analysis (CCA) and the second part is about our proposed methodology: integration of CCA with spatial statistic model (spatial autoregressive SAR model) to analyze the distribution of the population, migration, and prediction of future demographic structure. Third part is about nonnegative matrix factorization model (NMF) which is going to imply to clarify the transition of foreign residents' cohorts' trends on time series with the different patterns and geographical potential of migrants. Final part is for the explanation of the multiple linear regression model setting to observe the transition of foreign residents' internal and international migration. The data collection and data setting for this dissertation are explained in the following part. According to the data availability for foreign residents for cohort structure and migration, this dissertation will only focus on the prefecture level estimation and discussion will be based on the 8 regions with 47 prefectures of Japan.

Following Chapter 4 to Chapter 7 are about the discussions of research contributions and findings. Chapter 4 examines the inter-regional migration prediction for economic development by considering the spatial dependencies based on spatial statistic model (SAR). This chapter clarified the significance of spatial dependencies in migration phenomena with industrial indices for Japanese municipalities. The results give strong evidence to consider the spatial dependencies that should be considered in population prediction, which is possible to be integrated by adopting the model frame. According to the findings, the simulation analysis of the population following to proposed approach should be tried. Since the spatial distribution of industries is spatially agglomerated, population prediction with the statistical analysis would result in more severe demographic disparities in Japan, comparing with the conventional CCA.

To confirm the conclusion remark of Chapter 4, Chapter 5 observes the long-term impact of inter-regional migrants on population prediction by considering the spatial distribution of urbanization indices. In this chapter, the estimation of natural increase and decrease are calculated with CCA, and the migration phenomena is applied by using SAR model approach from previous chapter. By the recursive estimation, the prediction of the population distribution and migration with cohorts' structure are carried out. The proposed approach predicts the higher populations among the middle-aged cohorts than those population by the conventional CCA in 2040 supposes that this is a contribution of foreign migrants from oversea. The results show that the future Japanese populations will become more concentrated in urban areas, with a lower fertility rate, and migration from overseas which also tend to concentrate in urban area. Furthermore, the manufacturing employees will be attracted to metropolitan areas or to regions with industrial zones, and that the number of retailers will undergo changes over time, even in urbanized areas.

According to the findings of Chapter 5, foreign resident's migration has the positive contribution on the future demographic structures of Japan. Therefore, following Chapter 6 aims to analyze the transition of foreign residents' characteristics with time series, in order to clarify the policy building for foreign migrants by local government. Nonnegative matrix factorization model (NMF) is applied to the cohort data of foreign residents in 47 Japanese prefectures in 2010, 2015 and 2020. This chapter proves that due to the policy change about the foreign labor force acceptance to Japan, the trend of foreign migration from 2010 to 2020 was structurally changed. The results show the cohort transition for foreign migrants with infants or child were significantly different especially between Tohoku and Kyusyu regions from 2010 to 2020. Elderly cohort also had a significant change in Tohoku region from 2015 to 2020. Since the regions highlighted in this analysis includes many depopulated areas and the capacity of those local government for the policy building would not be enough, they should be supported well by the national government.

Chapter 7 focus to clarify the structural break of foreign residents' domestic and international migration in Japan. Constrained multiple linear regression models which designed for OD matrix structure are estimated to find the structural break in foreign residents' migrations by using migration data in Japan with 47 prefectures and an oversea category between 2010 to 2020. The proposed models fit well for all the predicted periods, so, then the residual test about spatial dependency can be used to find the structural breaks. The findings show that the foreign resident's domestic migration is significantly changed among all the Japanese prefectures in observed period. The structural break of foreign residents' migration had changed four times between 2010 and 2020. These breaks were observed for immigration but only a break was observed for emigration in 2020. This finding suggests that the immigration is unstable, while the emigration is stable except in 2020.

Chapter 8 is about the conclusion remarks of this dissertation. In this chapter, overall summary is described with various policy recommendations based on the outcomes from the dissertation. At the end of this chapter, contributions, limitations, and some suggestions for future studies are brought out.

As a student of Taoyaka program, I got a chance to participate in the Taoyaka team project which consisting of two team members from different backgrounds. The team project was fully supported by Taoyaka program and guided by a mentor, Associate Professor Ayami NAKAYA from the Graduate School of International Cooperation and Development. The team report was presented in Taoyaka Onsite Team Project Workshop, and I here proudly added individual report of the team project as an appendix of the dissertation.