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An Age Composition Similarity Calculation and Industrial Indices

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Abstract. To instantly find similar municipalities, some studies in Japan have examined a calculation method that employs only age-composition vector data. Although this method does not use other attributes, the calculation can also be related to certain other industrial indices. This study demonstrates that the average score of some industrial indices, such as the Financial Strength Index of municipalities that are output by the calculation, is strongly correlated with the score of the original municipality.

1. Introduction

In municipal policy making, referring to the governance of other similar municipalities is a practical way to improve the quality of decision-making. However, finding similar municipalities is a potentially complex problem as they can be grouped differently according to viewpoints and attributes, such as population, location, industrial structure, or development of public transportation. The single attribute of "population" can also be divided into various sub-attributes, such as the youth population or aging rate.

Recently, to instantly find similar municipalities, some studies in Japan have examined a calculation method that employs only age-composition vector data ([1], [3]). A government website provides an information service that exploits this type of calculation ([4]). There is also future population prognosis research related to this calculation ([5]). As it does not use other attributes, this calculation cannot deal with some municipal characteristics, such as climate or the possibility of natural disasters. However, it may be related to certain industrial indices.

This study presents a basic examination of the relationship between the quick calculations and industrial indices of local governments in Japan. Although this study is co-authored, Section 3 is mainly written by the first author.

2. Calculation of Age Composition Similarity

This section summarizes the instant calculation of age composition similarity (ACS calculation) described in the previous section. Although the details of the ACS calculation vary, we followed the early context in this study [3].

The basic similarity score between the two population vectors is obtained using the cosine formula:

$$\cos(\vec{x}, \vec{y}) = \frac{\vec{x}}{|\vec{x}|} \cdot \frac{\vec{y}}{|\vec{y}|} = \frac{\vec{x} \cdot \vec{y}}{|\vec{x}||\vec{y}|} = \frac{\sum_{i=1}^{17} x_i y_i}{\sqrt{\sum_{i=1}^{17} x_i^2}\sqrt{\sum_{i=1}^{17} y_i^2}}$$

Each vector has 17 dimensions and reflects a municipality's population structure by five-year age groups (the "17th dimension" refers to the population aged ≥80 years). If we focus on one municipality, other municipalities can be ordered according to the score of similarity to the municipality, which is the focus of this study. The top municipalities (40 in [3]) on the list are the outputs of the ACS calculation. In [3], population data were derived from the Residential Basic Book of Japan (Ministry of Internal Affairs and Communications).

The ACS calculation can be modeled as follows: $M = \{m_1, m_2, \dots, m_p\}$ denotes the set of all municipalities. For each $m_x \in M$, the output of the ACS calculation with threshold number n (such as 40 in the above section) is defined as follows:

$$ACS(m_x, n) = \{m_y \in M \mid Rank(m_y, List(m_x)) \leq n\}$$

Here, $List(m_x)$ denotes the list of all the members of $M - \{m_x\}$. The order in the list reflects the degree of similarity to m_x, which is obtained using the cosine calculation described above. $Rank(m_y, List(m_x))$ denotes the rank of m_y in $List(m_x)$ (we used 40 as n in this study).

This calculation does not involve a thorough examination of municipal data, but is very simple and quick. Although it uses only age composition, the output data show certain tendencies in terms of geography or administrative systems. For example, it was reported that the set of output municipalities tends to include municipalities that are geographically close to the municipality of focus ([1], [3]). It can also be expected that the output municipalities have similar economic conditions to the original municipality, which is the focus of the study, as tax income would be related to the share of the working-age population, although it has not yet been examined.

3. Calculation of ACS and Industrial Indices

This section examines the relationship between the municipality and the output municipalities of the ACS calculation from an industrial indices perspective. As typical industrial indices, we examined the Financial Strength Index (FSI) and Primary Industry Population Ratio (PIPR). Each data point was based on governmental surveys conducted in 2015.

The FSI is an index of local governments' financial strength. It is a simple arithmetic average of the scores calculated as [standard financial revenue] / [standard financial requirement] during three fiscal years. The higher the FSI, the greater is the total amount of financial resources reserved, meaning that the local government has more financial resources to spare.

The method of examination is as follows: 1) for each municipality, the FSI value is clear and listed (N=1,741); 2) for each municipality, we calculated the average FSI value of the output of the top 40 municipalities by the ACS calculation and listed them; 3) by using these two lists, we examined the correlation between the FSI score of the original municipality and the average FSI score of the municipalities that are output by the ACS calculation (for procedures 1 and 2, we used data from [2]).

The results were as follows. Fig. 1 shows a scatter plot between the FSI value of the original municipality and the average FSI value of the output municipalities. Pearson's correlation value was 0.819, and the P-value was 2.20E-16.

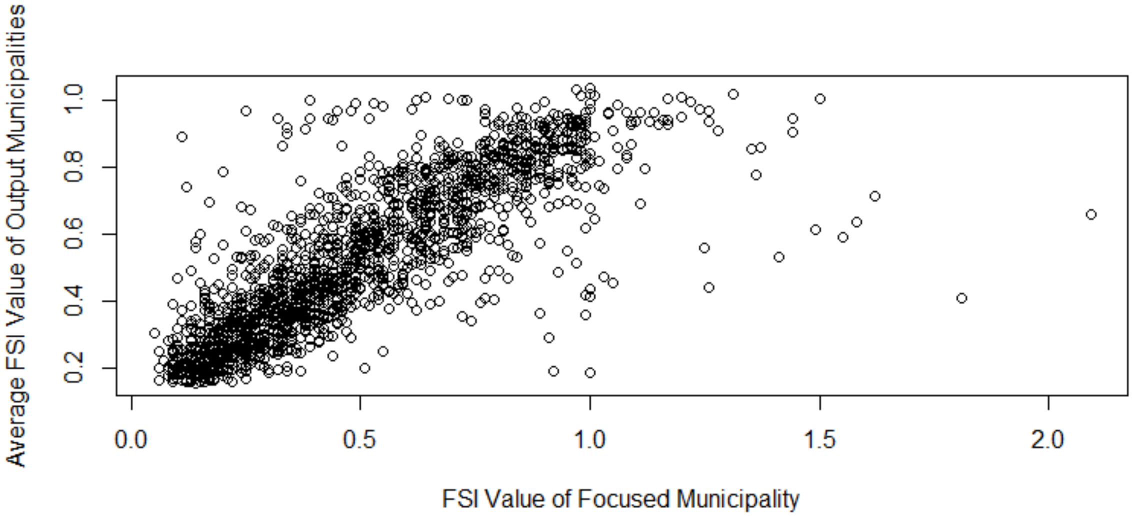

Fig. 1. Similarity of FSI Values of Output Municipalities

PIPR reflects the ratio of the primary industry population to the total working population. The examination method followed the same procedure as described above. Fig. 2 shows the results. Pearson's correlation value was 0.687, and the P-value was 2.20E-16.

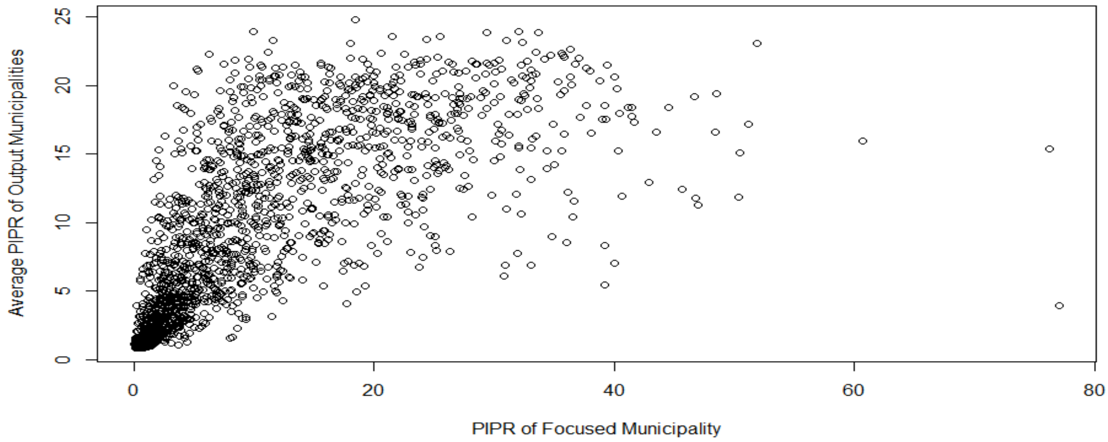

Fig. 2. Similarity of PIPR Values of Output Municipalities

As expected, the average FSI score of the output municipalities in the ACS calculation was correlated with the FSI score of the original municipality. The correlation was strong and reasonable, as the tax income of the municipality is related to the share of the working-age population. A similar tendency was also observed for the PIPR score.

4. Concluding Remarks

This study presented a basic examination of the relationship between the original municipality and the output municipalities of the ACS calculation from the viewpoint of FSI and PIPR as typical industrial indices. We demonstrated that the average FSI score of the municipalities that are output by the ACS calculation was strongly correlated with the FSI score of the original municipality. We also demonstrated a similar tendency with PIPR scores.

However, FSI and PIPR are only a few examples of industrial indices of municipalities, and other indices exist, such as the Ordinary Balance Ratio or Real Debt Service Ratio. Examining these indices is a task for the next stage of this study.

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