

What Population Leaves Unexplained Is Not Explained by Income or Land Prices — Prefecture Matters More

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Abstract

The number of industrial subcategories present in a municipality is almost fully determined by the common logarithm of population ($R^2 = 0.925$).

This paper asks whether the **residual** can be explained by income, land prices or population change.

None of them explains much. Correlations with the residual are $r = +0.106$ for taxable income per taxpayer (1,721 municipalities), $r = +0.064$ for commercial land price in logs (1,352), and $r = -0.082$ for the five-year rate of population change (1,889).

Among the 1,186 municipalities having both income and land price, adding all three to the population-only fit ($R^2 = 0.9101$) raises it only to $R^2 = 0.9236$.

By contrast, **the median residual by prefecture ranges from -23.4 to $+15.0$** — a spread of 38.4 subcategories, exceeding the residual standard deviation of 25.6.

Highest are Fukui ($+15.0$), Hiroshima ($+14.9$) and Yamanashi ($+13.5$); lowest are Okinawa (-23.4), Fukuoka (-20.7) and Kanagawa (-19.3). Hokkaido is $+1.0$, ranking 25th of 47 — exactly in the middle.

What population leaves unexplained is accounted for not by how wealthy a municipality is, but by where it is.

1. Introduction

R001 showed that the number of industrial subcategories in a municipality is almost fully determined by log population, and proposed the residual as a quantity specific to the place.

The natural next question follows.

What explains the residual?

The plausible candidates — residents' income, land prices, and population change — are all available per municipality as open data.

2. Data

Establishments	Statistics Bureau of Japan and METI, 2021 Economic Census for Business Activity (1 June 2021)
Population	MIC, Basic Resident Register population, 1 January 2026 (and 1 January 2021)
Income	MIC, Survey of Municipal Taxation, FY2025. Taxable income per taxpayer
Land price	Land Price Publication 2026 (National Land Numerical Information). Mean commercial land price, yen/m ²

Matched	Municipalities
Population and subcategories available	1,889
Income available	1,721
Land price available	1,352
Both income and land price	1,186

Municipalities without a commercial standard site have no land price. Those missing are concentrated among smaller municipalities; the missingness is not random.

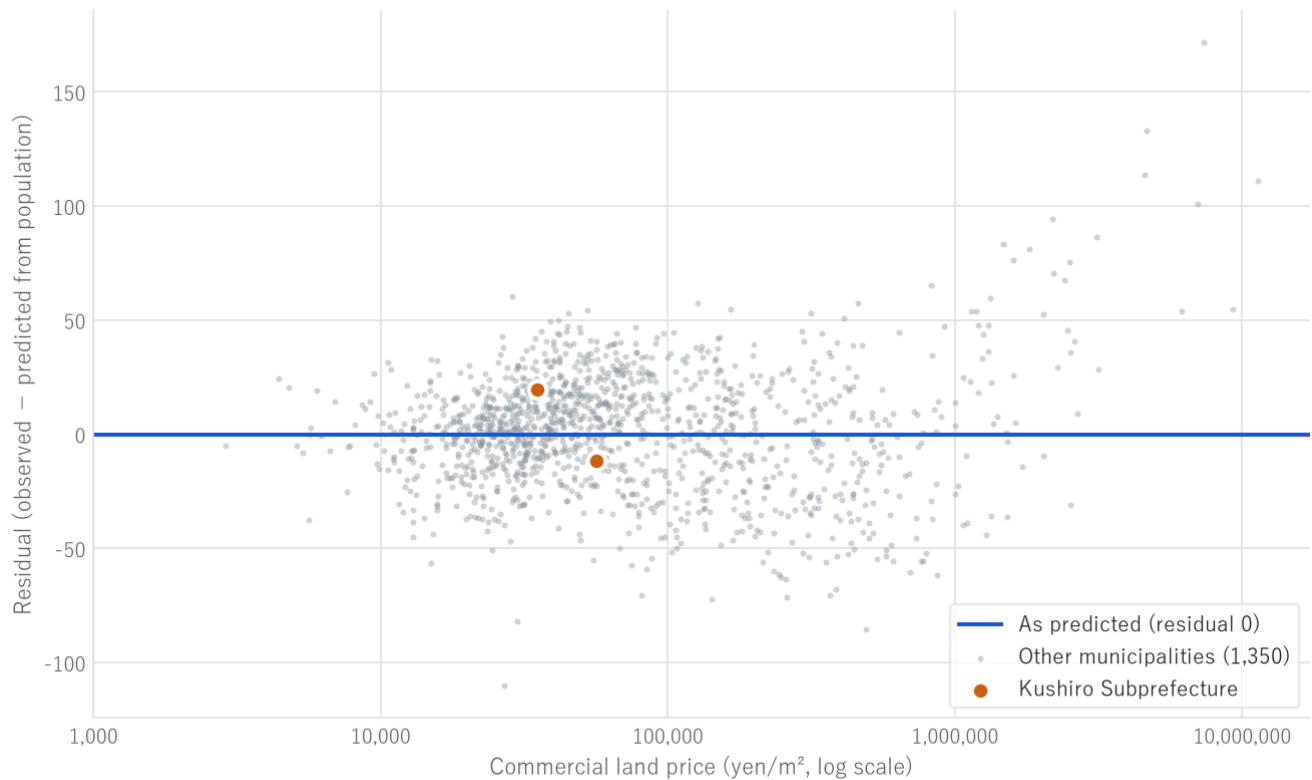
3. Results

3-1 None of them explains much

The population-only fit is **subcategories present** = $134.93 \times \log_{10}(\text{population}) - 378.69$ ($R^2 = 0.925$, $n = 1,889$). Correlations with its residual:

Variable	Correlation	Municipalities
Taxable income per taxpayer (thousand yen)	+0.106	1,721
Commercial land price (yen/m ² , log)	+0.064	1,352
Five-year rate of population change	− 0.082	1,889

Commercial land price and the residual are essentially unrelated ($r = +0.064$)



Sources: Economic Census 2021; Basic Resident Register 2026; Land Price Publication 2026. $n = 1,352$.

Figure 1. Commercial land price and the residual (1,352 municipalities).

Grey points are the other municipalities, the blue line marks a residual of zero (as predicted from population), and the orange points are the Kushiro Subprefecture. The horizontal axis is on a common-logarithmic scale.

3-2 Adding variables barely raises R^2

Compared on the same 1,186 municipalities having both income and land price.

Explanatory variables	R ²
Population only	0.9101
Population + income	0.9104
Population + land price	0.9132
Population + income + land price	0.9171
Population + income + land price + population change	0.9236

Adding all three raises R² by **0.0135**.

3-3 Prefecture matters more

Median residual by prefecture, for prefectures with at least 10 municipalities.

Highest	Median	Municipalities
Fukui	+15.0	17
Hiroshima	+14.9	30
Yamanashi	+13.5	27
Ishikawa	+12.4	19
Shimane	+12.0	19

Lowest	Median	Municipalities
Aomori	− 13.3	40
Kanagawa	− 19.3	58
Fukuoka	− 20.7	72
Okinawa	− 23.4	41

The spread of 38.4 subcategories exceeds the residual standard deviation of 25.6.

Prefecture differences are larger than income, land price or population change.

Hokkaido is **+1.0**, ranking 25th of 47 — exactly in the middle.

3-4 The Kushiro Subprefecture

Municipality	Population	Residual	Income (thousand yen)	Land price (yen/m ²)	5-yea
Kushiro City	151,566	+19.7	3,121.2	35,140	− 8.5
Kushiro Town	18,021	− 11.5	2,971.0	56,500	− 7.0
Akkeshi	7,976	+13.2	3,310.8	—	− 12.
Hamanaka	5,172	− 16.4	3,460.0	—	− 8.6
Shibecha	6,698	− 5.6	3,364.9	—	− 9.7
Teshikaga	6,327	+7.8	3,415.9	—	− 8.7
Tsurui	2,368	− 4.6	3,357.2	—	− 6.0
Shiranuka	6,840	− 6.8	2,665.6	—	− 9.2

Six of the eight have no commercial land price, no standard site being located there.

The highest income is in Hamanaka (3,460.0), which also has the lowest residual (−16.4): higher income is not accompanied by more subcategories.

Kushiro Town's land price (56,500) exceeds Kushiro City's (35,140). This presumably reflects where standard sites happen to be placed in a city centre versus an adjacent town, but that has not been verified.

4. Discussion

4-1 A negative result

The finding of this paper is that the residual was **not** explained. Income, land price and population change all fail.

This does not narrow the usefulness of the residual; it **clarifies** it. The residual is not a restatement of residents' wealth.

What population leaves unexplained is something else.

4-2 "Where" matters more

The prefecture spread (38.4 subcategories) exceeds any of the three variables.

The residual therefore contains a component arising from **regional grouping**.

That Kanagawa (−19.3) and Fukuoka (−20.7) sit near the bottom may relate to **unit A splitting designated cities into wards**.

A ward is part of a city, and if functions are divided across wards, each ward shows fewer subcategories than the city as a whole. **This hypothesis can be tested with unit B (designated cities counted as one); it is not tested here.**

For Okinawa (−23.4) no explanation is offered.

4-3 What to look at next

Candidates not tried here include the ratio of daytime to nighttime population, the size of neighbouring municipalities, road and rail connections, and industrial history.

All concern **how a municipality is connected to what surrounds it**. The result in 3-3 points that way.

5. Limitations

- Establishments are from 2021, population from 2026, income from FY2025 and land prices from 2026: **the reference dates do not align**
 - **Municipalities without a commercial standard site drop out of the land-price analysis**, and the missingness is concentrated among small municipalities
 - Prefecture medians depend on the composition of municipalities within each prefecture, including whether wards of designated cities are counted
 - Correlation and regression describe association, **not the direction of causation**
 - A positive residual does **not** mean prosperity, nor a negative one opportunity
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6. Reproduction

1. Compute the residual of the population-only fit as in R001
2. Take taxable income per taxpayer from the Survey of Municipal Taxation
3. Build municipal mean commercial land prices from the Land Price Publication (National Land Numerical Information)
4. Join on the municipality code; compute correlations and the R^2 of successive specifications
5. Take the median residual by prefecture

All values are the output of a single script (`kensan_187`). No intermediate value was transcribed by hand.

References and data sources

1. Statistics Bureau of Japan and METI, 2021 Economic Census for Business Activity.
2. MIC, Population Based on the Basic Resident Register, 1 January 2026.
3. MIC, Survey of Municipal Taxation, FY2025.
4. MLIT, Land Price Publication 2026 (National Land Numerical Information).
5. Y. Yamagishi, "Population and the Number of Industrial Subcategories Present in Japanese Municipalities" (R001). Zenodo. <https://doi.org/10.5281/zenodo.22872218>

Items 1–4 are published on e-Stat and on the ministries' websites.

Version history

Version	Date	Change
1	2026-09-21	First release