A Study of Fertility Decline in Japan and South Korea

Focusing on the Factors Behind the Rise in Female Unmarried Rates

Yutaka Taniguchi / Takuro Sorihashi / Toki Oyama

33rd International Congress of Actuaries (ICA2026)

© Yutaka Taniguchi; Takuro Sorihashi; Toki Oyama

Presentation outline

1. Motivation & Previous Studies
2. Assumption
   - Research question and analytical data
   - Hypotheses and proxy variables
3. Analysis
   - Fixed-effects model
   - Regional upper–lower analysis
4. Findings
   - Japan
   - South Korea
5. Conclusion & Future Research

Motivation: Fertility decline

Japan and South Korea are early cases of ultra-low fertility in East Asia.

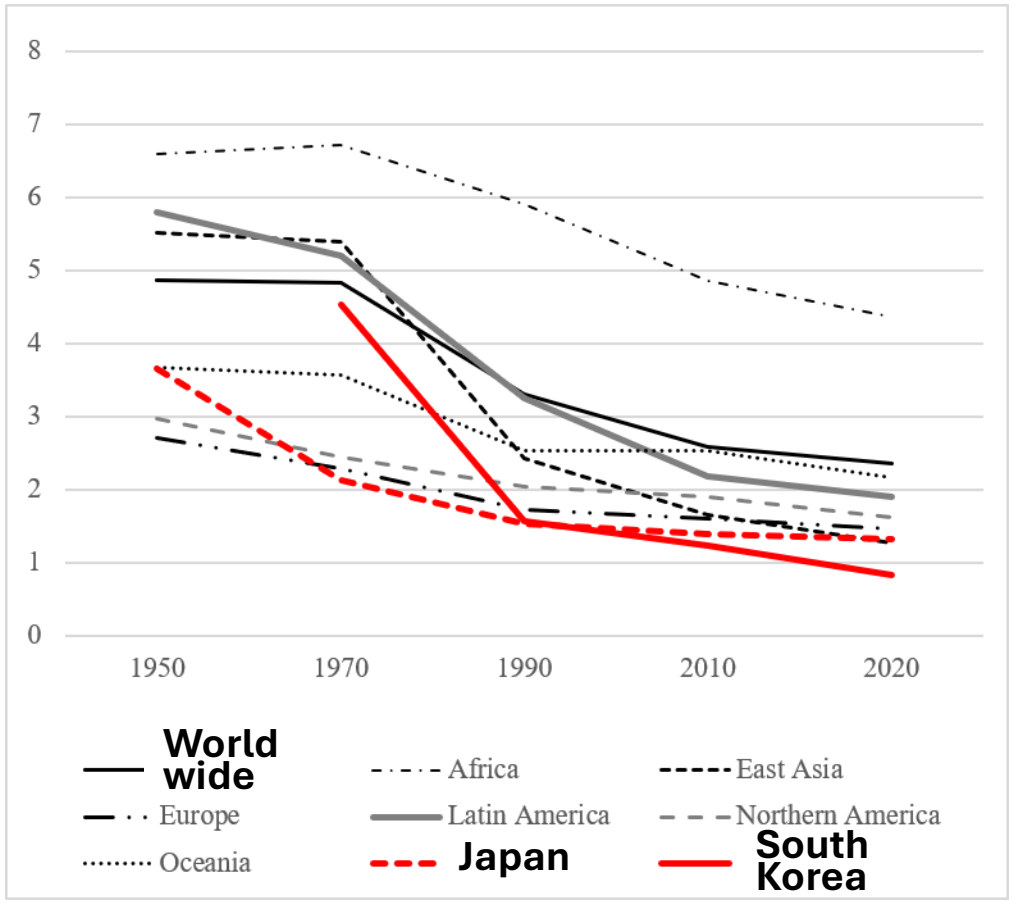


Figure 1. Trends in world fertility rates

World TFR	Japan 2023	South Korea 2023
4.84→2.23	1.20	0.72

Why Japan and South Korea?

Geographically and culturally similar countries where TFR decline is ahead of the global trend. Identifying core drivers in these two countries can inform other countries and support preventive measures before future TFR decline deepens.

Previous studies (1/3)

Decomposition of TFR	Hypothesis		Prior evidence		Match with each other
	-	Additional underlying hypothesis	Japan	South Korea	
Decline in women's marriage rate	Decline in desire to marry	-	No	Yes	Difference
	Desire to marry exists but it is not a top priority	Desire to have the freedom to use one's time and money	No	No	Match
		Satisfied with one's current life	No	N/A	N/A
		Marriage doesn't have to be done right now	Yes	N/A	N/A
		Women's opportunity loss is significant	Yes	Yes	Match
		Inability to decide in the absence of a decisive reason	N/A	N/A	N/A

Previous studies (2/3)

Decomposition of TFR	Hypothesis		Prior evidence		Match with each other
	-	Additional underlying hypothesis	Japan	South Korea	
Decline in women's marriage rate	Desire to marry exists but marriage is not achieved	Too few opportunities to meet	Yes	No	Difference
		No time to meet potential partners	N/A	N/A	N/A
		Few opportunities to meet the opposite sex in one's place of residence	N/A	N/A	N/A
		Few opportunities to meet the opposite sex during school years	N/A	N/A	N/A
		Opportunities exist but preparing marriage funds is difficult	Yes	Yes	Match

Previous studies (3/3)

Decomposition of TFR	Hypothesis		Prior evidence		Match with each other
	-	Additional underlying hypothesis	Japan	South Korea	
Decline in women's marriage rate	Desire to marry exists but marriage is not achieved	Opportunities exist but they don't match desired criteria	Yes	Yes	Match
		Men earn less than women	N/A	N/A	N/A
		Men are less educated than women	N/A	N/A	N/A
		Too many opportunities to meet, making choice difficult	N/A	N/A	N/A

Novelty

This study formulates and tests additional hypotheses to identify the underlying causal mechanisms, using proxy variables constructed from regional data.

Research question and analytical data

Analysis Fertility Rate ⇔ **Analysis Female unmarried rate**

Because
- TFR ≒ Marital fertility x Female marriage rate
- Marital fertility is relatively stable in Japan and South Korea.

In this study

- As shown in the left figures, this study **focuses on the female unmarried rate.**
- This study constructs proxy variables from regional data to test the hypotheses.
- Using the followings:
  - ➢Fixed-effects models
  - ➢Regional comparisons

About Data:

Japan data

Public statistics based on the Population Census. About 1,700 municipalities are used, covering 2015 and 2020.

South Korea data

Public statistics based on the Population Census. About 250 si/gun/gu areas are used, covering 2015 and 2020.

Hypotheses and proxy variables (1/2)

Decomposition of TFR	Hypothesis			Proxy variables
	-	Additional underlying hypothesis		
Decline in women's marriage rate	Decline in desire to marry	-		Share of three-generation households; divorce rate
	Desire to marry exists but it is not a top priority	Inability to decide in the absence of a decisive reason		Share of three-generation households; divorce rate
	Desire to marry exists but marriage is not achieved	Too few opportunities to meet	No time to meet potential partners	Commuting time
			Few opportunities to meet the opposite sex in one's place of residence	Population density; sex ratio; female in-migration rate; female out-migration rate; share of primary industry (South Korea: share of agriculture)
			Few opportunities to meet the opposite sex during school years	Number of junior high school students; number of high school students (South Korea: No data)

Hypotheses and proxy variables (2/2)

Decomposition of TFR	Hypothesis			Proxy variables
	-	Additional underlying hypothesis		
Decline in women's marriage rate	Desire to marry exists but marriage is not achieved	Opportunities exist but desired partner conditions are not met	Men earn less than women	Share of non-regular male employees; share of non-regular female employees (no South Korean data)
			Men are less educated than women	Male education; female education
		Opportunities exist but preparing marriage funds is difficult		Land price growth; per-capita tax burden (Japan: income)
		Too many opportunities to meet, making choice difficult		Population density; sex ratio; share of primary industry (South Korea: share of agriculture)

Fixed-effects model: what it controls for

What are fixed effects?

- Removes region-specific bias.
- Associations between changes in regional factors and changes in female unmarried rates within the same local area.

One-way fixed-effects

- γ is not included.
- Includes regional fixed effects only.

Two-way fixed-effects

- γ is included.
- Adds year effects, so common shocks are absorbed while regional differences in change remain identified.

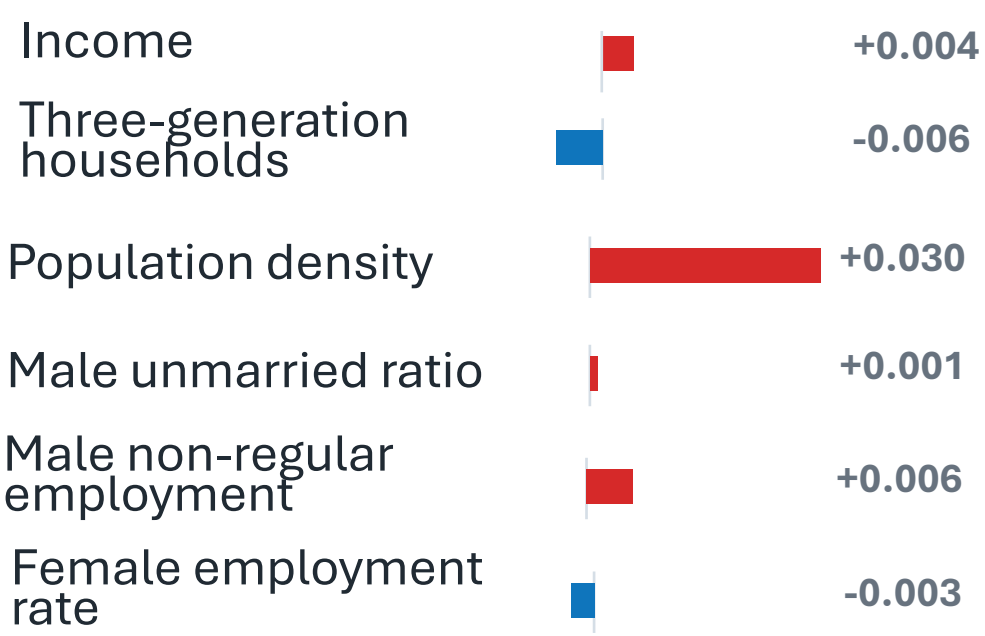
Model notation

$$Y_{it} = \alpha_i + \beta X_{it} + \gamma_t + \varepsilon_{it}$$

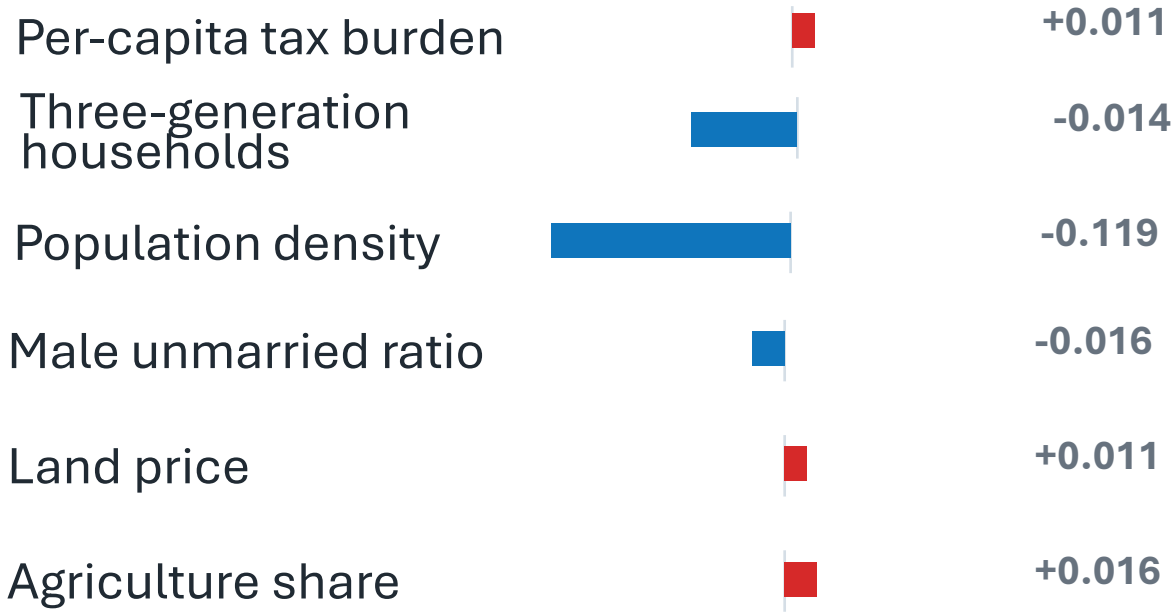
Y_{it}: unmarried rate in region (i) at time (t)
α_i: region-specific fixed effect
X_{it}: explanatory variables
γ_t: year effect (not included in the one-way model)
ε_{it}: error term

Fixed-effects model results

Japan



South Korea



Common factor

Economic conditions affect marriage behavior.
Family structure and support may matter.

Difference from Japan / South Korea

Population density:
Positive / Negative (respectively)
Male unmarried ratio:
Positive / Negative (respectively)

Regional upper–lower analysis (1/3)

The analysis complements fixed effects by focusing on the regional categories.
At first, we divide the regions into the followings:

		Metropolitan area			Non-metropolitan area	
		Cat.1	Cat. 2	Cat. 3	Cat. 4	Cat. 5
Name and Explanation		Capital	Government-Designated/ Metropolitan	Population density comparable to Cat. 2	Cities	Towns and villages / Counties
Japan	Num.	23	20	81	691	920
	Exa.	Tokyo	Sapporo, Nagoya, Osaka, etc.	Kawaguchi, Higashiosaka, Naha, etc.	Asahikawa, Kanazawa, Kagoshima, etc.	Niseko, Karuizawa, Yakushima, etc.
South Korea	Num.	25	49	13	86	77
	Exa.	Seoul	Busan, Daegu, Incheon, etc.	Some districts in Gyeonggi Province	Hwaseong, Jeonju, Changwon, etc.	Yangpyeong, Pyeongchang, Wando, etc.

Regional upper–lower analysis (2/3)

Second, identify the top and bottom quartiles of the change in the female unmarried rate.
Therefore, the relationship of the top/bottom quartiles and the categories is as follows:

		Top					Bottom				
		Metro. area			Non-metro. area		Metro. area			Non-metro. area	
		Cat.1	Cat.2	Cat.3	Cat.4	Cat.5	Cat.1	Cat.2	Cat.3	Cat.4	Cat.5
Japan	Count	21	5	33	110	265	1	3	8	126	294
	Ratio	91%	25%	41%	16%	29%	4%	15%	10%	18%	32%
South Korea	Count	18	16	6	5	18	0	8	0	37	18
	Ratio	72%	33%	46%	6%	23%	0%	16%	0%	43%	23%

See Top/Bottom quartile

Top/Bottom-quartile shares are, respectively, higher in metro./non-metro areas in both Japan and South Korea.
⇒This is consistent with the results of the fixed-effects model.

By the way, see Non-metro. area in Japan

The share of non-metro. area in Japan is similar in top and bottom quartiles.
⇒ **Japan's non-metro. areas may be further disaggregated by regional characteristics.**

Regional upper–lower analysis (3/3)

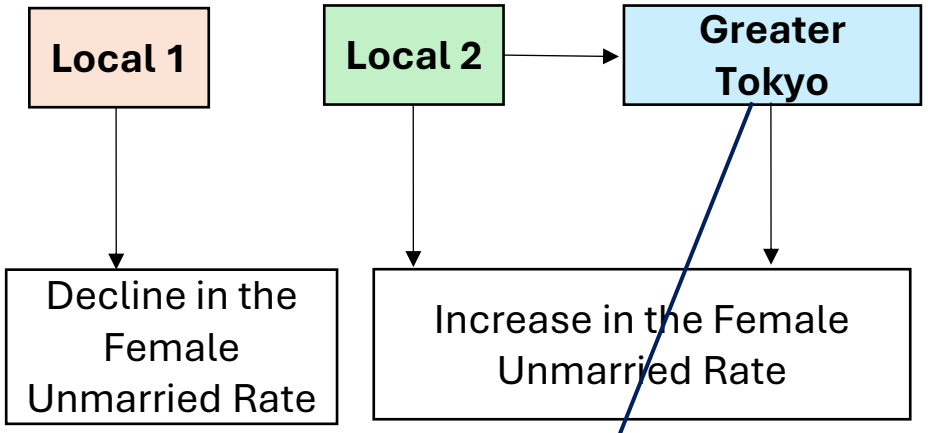
We focus on Japan's non-metro. areas. From the table on the right, we observe notable differences in trends across many variables in non-metro. areas.

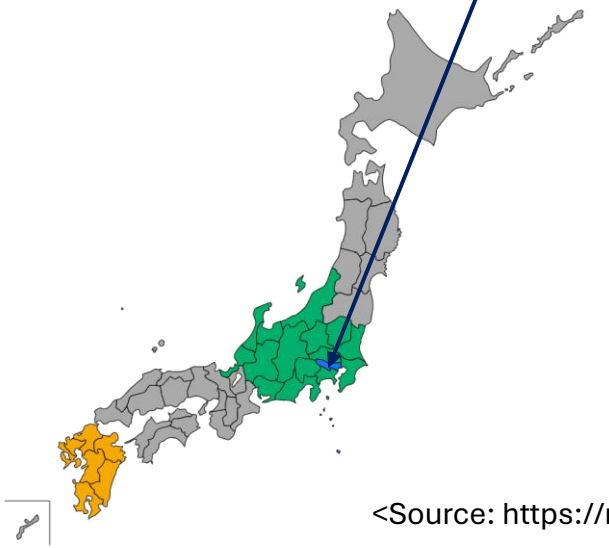
Looking at the regional distribution

Areas with increasing unmarried rates are concentrated in Eastern Japan (particularly in the Kanto and Chubu regions).
In contrast, areas with decreasing unmarried rates are more prevalent in the Kyushu region.

	Top		Bottom		FE Results (One-Way)
	Metro.	Non-Metro.	Metro.	Non-Metro.	
Share (%)	47%	**23%**	10%	**26%**	
Female Unmarried Rate	1.131	**1.166**	-1.051	**-1.114**	
Density	2.746	**-0.186**	2.252	**-0.08**	+
Female Employment Rate	-0.258	**-0.045**	-0.981	**0.221**	−
Male Non-Regular Employment Rate	-0.402	**0.06**	-0.362	**-0.109**	+
Income	0.611	**-0.049**	0.433	**0.058**	+
Male Unmarried Rate	-0.34	**-0.497**	-0.282	**0.472**	+
Number of Three-Generation Households	1.228	**-0.025**	0.956	**-0.087**	−
Female Educational Attainment	-0.696	**0.186**	-0.536	**0.19**	+

Findings: Japan





<Source: https://n.freemap.jp>

Local 1 (Kyushu): Increase in the Male Unmarried Rate

- Many women remain in their local areas for employment.
- Community-based social networks and traditional matchmaking practices remain prevalent.

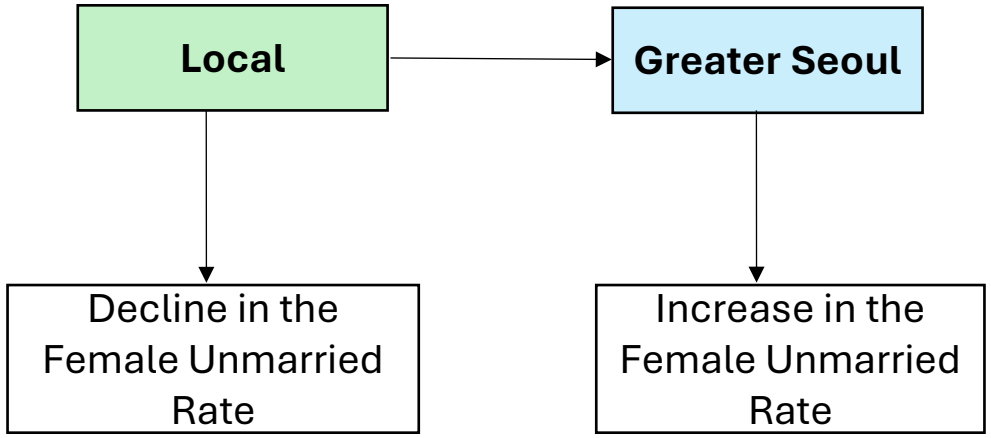
Local 2 (Kanto and Chubu): Decline in the Male Unmarried Rate

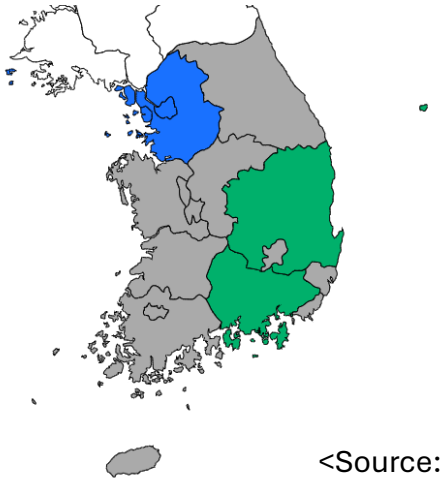
- An increase in male non-regular employment may reduce their attractiveness as potential marriage partners.
- Areas lacking shared school-based social experiences tend to exhibit higher unmarried rates.

Greater Tokyo

- Longer commuting times for women may reduce opportunities to meet potential partners.
- Further increases in population density may make it more difficult to find a suitable partner.

Findings: South Korea





<Source: https://n.freemap.jp>

Local (Gyeongsangnam-do and Gyeongsangbuk-do): Increase in the Male Unmarried Rate

- A higher proportion of unmarried men may make it easier for women to find potential partners.
- Lower living costs contribute to a more favorable living environment.
- Population decentralization policies implemented by the South Korean government to alleviate overconcentration in Seoul have contributed to rising population density in non-capital regions.

Greater Seoul: Decline in the Male Unmarried Rate

- Rising per capita tax burdens and land prices increase the cost of living.
- Women may place greater emphasis on men's economic stability and earning capacity when selecting marriage partners.

Conclusion

Decomposition of TFR	Hypothesis		Result		Proxy variables
	-	Additional underlying hypothesis	Japan	South Korea	
Decline in women's marriage rate	Decline in desire to marry	-	No	Yes	
	Desire to marry exists but it is not a top priority	Desire to have the freedom to use one's time and money	No	No	
		Satisfied with one's current life	No	N/A	
		Marriage doesn't have to be done right now	Yes	N/A	
		Women's opportunity loss is significant	Yes	Yes	
		Inability to decide in the absence of a decisive reason	**Yes**	**Yes**	Share of three-generation households; divorce rate

Conclusion

Decomposition of TFR	Hypothesis		Result		Proxy variables
	-	Additional underlying hypothesis	Japan	South Korea	
Decline in women's marriage rate	Desire to marry exists but marriage is not achieved	Too few opportunities to meet	Yes	No	
		No time to meet potential partners	**No**	**No**	Commuting time
		Few opportunities to meet the opposite sex in one's place of residence	**No**	**No**	Population density; sex ratio
		Few opportunities to meet the opposite sex during school years	**No**	**N/A**	Number of junior high school students; number of high school students (South Korean: No data)
		Opportunities exist but preparing marriage funds is difficult	Yes	Yes	

Conclusion

Decomposition of TFR	Hypothesis		Result		Proxy variables
	-	Additional underlying hypothesis	Japan	South Korea	
Decline in women's marriage rate	Desire to marry exists but marriage is not achieved	Opportunities exist but they don't match desired criteria	Yes	Yes	
		Men earn less than women	**Yes**	**N/A**	Share of non-regular male employees; share of non-regular female employees (South Korean: No data)
		Men are less educated than women	**Yes**	**No**	Male education; female education
		Too many opportunities to meet, making choice difficult	**No**	**No**	Population density; sex ratio; share of primary industry (South Korea: share of agriculture)

The table above includes the prior studies, which are grayed out.

Future research

- **Limitations**

The analysis relies on aggregate public data, and proxy variables do not perfectly capture preferences, norms, partner search, or household-level decision-making.

- **Future research**

Direct survey data, richer microdata, and newer South Korean local data can test whether the proposed mechanisms operate through preferences, constraints, or matching.

Thank you for your attention

Appendix

Appendix. Decomposition of TFR

$$TFR = \frac{\text{Births to married women}}{\text{Married women + Unmarried women}} + \frac{\text{Births to unmarried women}}{\text{Married women + Unmarried women}}$$

$$= \frac{\text{Births to married women}}{\text{Married women}} \times \frac{\text{Married women}}{\text{Married women + Unmarried women}} + \varepsilon$$

$$= \text{Marital fertility} \times \text{Marriage rate} + \varepsilon$$

ε is defined by this.

In East Asian cultures, the number of births to unmarried women is very small.
i.e. the above ε is also small.
Therefore this study ignores the ε.

Appendix. Regression Results - Japan

Summary statistics

	2015				2020		
Variable	**Ave.**	**SD**	**Min**	**Max**	**Ave.**	**SD**	**Min**
Female Unmarried Rate (15–49) (%)	41.82	4.45	21.11	66.00	43.30	4.58	21.95
Population Density (persons/km^2)	1,390	2,563	11	22,380	1,388	2,658	10
Female Employment Rate (15–49) (%)	66.05	6.19	39.33	88.78	67.72	6.81	38.97
Male Non-Regular Employment Rate (%)	18.82	4.09	6.96	75.22	19.11	4.04	5.63
Female Non-Regular Employment Rate (%)	53.78	6.12	15.01	70.73	52.06	5.97	26.37
Average Number of Junior High School Students per School	264	172	0	983	246	167	0
Average Number of High School Students per School	393	333	0	1,433	359	320	0
Employment Share in the Primary Sector (%)	11.12	10.33	0.04	77.06	10.45	9.98	0.02
Average Female Commuting Time (minutes)	19.71	6.08	7.80	51.80	19.95	6.11	8.70
Income (thousand JPY)	2,746	471	1,958	8,720	2,928	475	2,200
Male Unmarried Rate (15–49) (%)	1.3972	0.9075	0.8810	37.400	1.3779	0.2668	0.8333
Share of Three-Generation Households (%)	9.68	6.27	0.00	36.30	7.31	4.93	0.00
Divorce Rate (%)	41.31	17.70	0.00	250.00	47.71	31.97	0.00
Share of Single-Mother Households (%)	7.80	1.38	1.03	14.95	8.01	1.42	1.07
Female Educational Attainment (15–49, Years of Schooling)	19.31	0.43	18.32	21.40	19.50	0.42	18.46

Note: The same municipalities were observed in both 2015 and 2020. The number of observations (N) in each year is 1,734.

(1) one-way fixed effects model, (2) two-way fixed effects model

Variable	(1) Coefficient	(1) Standard Error	(2) Coefficient	(2) Standard Error
Population Density	0.0302***	0.0105	0.0331***	0.0102
Female Employment Rate (Ages 15–49)	-0.0033***	0.0012	-0.0049***	0.0012
Male Non-Regular Employment Rate	0.0055***	0.0012	0.0036***	0.0012
Female Non-Regular Employment Rate	-0.0085***	0.0013	-0.0044***	0.0014
Average Number of Junior High School Students per School	-0.0088***	0.0022	-0.0068***	0.0021
Average Number of High School Students per School	-0.0065**	0.0027	-0.0013	0.0028
Employment Share in the Primary Sector	0.0026	0.0044	0.0064	0.0043
Average Female Commuting Time	0.0008	0.0013	0.0004	0.0013
Income	0.0044**	0.0017	-0.0029	0.0019
Male Unmarried Rate (Ages 15–49)	0.0013***	0.0005	0.0016***	0.0004
Number of Three-Generation Households	-0.0063***	0.0020	0.0024	0.0022
Divorce Rate	-0.0002	0.0004	-0.0003	0.0004
Share of Single-Mother Households	-0.0026*	0.0014	-0.0035***	0.0014
Female Educational Attainment (Ages 15–49)	0.0142***	0.0019	0.0053**	0.0021
Observations	3474		3474	
Within R^2	0.309		0.055	
Municipality Fixed Effects	YES		YES	
Year Fixed Effects			YES	

Note: All explanatory variables were standardized to have a mean of 0 and a standard deviation of 1. *** p < 0.01, ** p < 0.05, * p < 0.10.

Appendix. Regression Results – South Korea

Summary statistics

	2015				2020		
Variable	**Ave.**	**SD**	**Min**	**Max**	**Ave.**	**SD**	**Min**
Female Unmarried Rate (15–49) (%)	43.39	5.82	30.19	60.56	46.74	6.80	29.19
Population Density (persons/km^2)	4,000	6,082	19	26,748	3,888	5,858	18
Per Capita Tax Burden (KRW)	1,146	925	434	9,809	1,516	1,077	516
Male Unmarried Rate (20–39) (%)	1.58	0.39	0.95	3.97	1.54	0.34	0.89
Female Educational Attainment (20–39, Years of Schooling)	20.58	0.41	19.79	21.94	20.79	0.34	20.12
Female In-Migration Rate (20–24) (%)	16.45	7.82	0.00	38.40	19.31	9.82	0.00
Share of Three-Generation Households (%)	5.57	0.71	3.63	7.82	3.73	0.59	2.46
Land Price (Million KRW)	233	171	63	1,522	273	221	70
Divorce Rate (per 1,000 Population)	1.807	0.806	0.000	3.500	2.096	0.396	0.000
Employment Share in Agriculture (%)	11.97	12.65	0.12	46.52	10.59	11.10	0.23
Average Commuting Time (minutes)	29.1	11.2	13.2	54.8	28.6	10.9	0.0

Note: The same municipalities were observed in both 2015 and 2020. The number of observations (N) in each year is 500.

(1) one-way fixed effects model, (2) two-way fixed effects model

Variable	(1) Coefficient	(1) Standard Error	(2) Coefficient	(2) Standard Error
Population Density	-0.1191***	0.0209	-0.0896***	0.0203
Per Capita Tax Burden	0.0114***	0.0035	0.0100***	0.0033
Male Unmarried Rate (Ages 20–39)	-0.0162***	0.0033	-0.0088***	0.0034
Female Educational Attainment (Ages 20–39)	0.0006	0.0017	-0.0010	0.0016
Female In-Migration Rate (Ages 20–24)	0.0007	0.0029	-0.0016	0.0027
Share of Three-Generation Households	-0.0139***	0.0015	0.0141***	0.0051
Land Price	0.0108*	0.0061	-0.0032	0.0062
Divorce Rate	0.0020	0.0012	0.0002	0.0012
Employment Share in Agriculture	0.0162**	0.0082	0.0110	0.0077
Average Commuting Time	-0.0053	0.0042	-0.0051	0.0040
Observations	500		500	
Within R^2	0.725		0.270	
Municipality Fixed Effects	YES		YES	
Year Fixed Effects			YES	

Note: All explanatory variables were standardized to have a mean of 0 and a standard deviation of 1. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

Appendix. Regional upper–lower analysis - Japan

	Top		Bottom		FE results (One-way)
	Metro.	Non-Metro.	Metro.	Non-Metro.	
N	58	375	12	421	
Share (%)	47%	23%	10%	26%	
Female Unmarried Rate	1.131	1.166	-1.051	-1.114	
Density	2.746	-0.186	2.252	-0.08	+
Female Employment Rate	-0.258	-0.045	-0.981	0.221	-
Male Non-Regular Employment Rate	-0.402	0.06	-0.362	-0.109	+
Female Non-Regular Employment Rate	-0.84	-0.085	-0.619	0.093	-
Average of Junior High School Students per School	0.234	-0.073	0.292	0.158	-
Average of High School Students per School	0.095	0.082	-0.038	0.114	-

	Top		Bottom		FE results (One-way)
	Metro.	Non-Metro.	Metro.	Non-Metro.	
Employment Share in the Primary Sector	0.481	-0.067	0.405	-0.138	+
Average Female Commuting Time	0.107	0.018	-0.206	-0.006	+
Income	0.611	-0.049	0.433	0.058	+
Male Unmarried Rate	-0.34	-0.497	-0.282	0.472	+
Number of Three-Generation Households	1.228	-0.025	0.956	-0.087	-
Divorce Rate	-0.155	-0.005	-0.173	0.032	-
Share of Single-Mother Households	-0.371	-0.018	-0.256	0.011	-
Female Educational Attainment	-0.696	0.186	-0.536	0.19	+

Appendix. Regional upper–lower analysis – South Korea

	Top		Bottom		FE results (One-way)
	Metro.	Non-Metro.	Metro.	Non-Metro.	
N	40	23	8	55	
Occupy	46%	14%	9%	34%	
Female Unmarried Rate	1.217	1.202	-1.616	-1.145	
Density	-1.079	0.187	0.535	0.426	-
Per Capita Tax Burden	0.346	0.101	-0.692	-0.185	+
Male Unmarried Rate	-0.572	-0.433	-0.1	0.364	-
Female Educational Attainment	-0.222	0.295	-0.317	0.188	+
Female In-Migration Rate	0.476	-0.453	0.153	-0.118	+
Share of Three-Generation Households	0.788	-0.123	-0.685	-0.504	-
Land Price	0.513	-0.41	-0.082	-0.286	+

	Top		Bottom		FE results (One-way)
	Metro.	Non-Metro.	Metro.	Non-Metro.	
Divorce Rate	-0.115	0.306	-0.662	0.203	+
Employment Share in Agriculture	0.692	-0.628	0.635	-0.385	+
Average Commuting Time	-0.416	0.131	-0.02	0.252	-