Aging and Real Estate Prices:
Evidence from Japanese and US Regional Data

15th Macro Conference at University of Tokyo

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1. Motivation

- Aging is expected to have substantial effects on the country's economic systems, including its social security system.
- However, the impact of demographic changes on real estate prices has been controversial.
  - Mankiw and Weil (1989)
  - Otake and Shintani (1996)
- Questions
  - How much demographic factors affected real estate prices in Japan?
  - How about in the U.S.?
  - Will demographic factors lead to a real estate price asset meltdown?
2. Empirical Method and Data

Empirical method

- Model estimated by Takáts (2012)

\[ \Delta \ln P_{it} = \alpha + \beta \Delta \ln GDPPC_{it} + \gamma \Delta \ln OLDDEP_{it} + \delta \Delta \ln TPOP_{it} + \varepsilon_{it} \]

GDPPC<sub>it</sub>: per capita GDP for region i year t

OLDDEP<sub>it</sub>: old age dependency ratio for region i year t

= ratio of population aged 65+ to population aged 20-64 (the working-age population)

TPOP<sub>it</sub>: total population for region i year t

: disturbance term

\[ \varepsilon_{it} \]
2. Empirical Method and Data

Real Land Prices

- Regional real estate price data (nominal)
  - Japan: Hedonic prices (our estimates)

For each prefecture, we estimate the model below

\[ \ln p_{jt} = \sum_{k=0}^{K} \beta_k X_{jkt} + \sum_{s=0}^\tau \delta_s D_s + \nu_{jt}, \]

- \( p_{jt} \): nominal land prices for a property \( j \) in year \( t \)
- \( X_{jkt} \): attributes associated with property \( j \)
- \( D_s \): time dummy
- \( \nu_{jt} \): disturbance term

- Deflator
  - US: Bureau of Labor Statistics “CPI for all items” by state
  - Japan: Statistics Bureau of Japan, “Consumer price index” by prefecture

Attributes: Acreage, Building to land ratio, Floor area ratio, Distance to nearest station, Distance to urban center
2. Empirical Method and Data

Demographic measure

- Takáts (2012) and our model

  Old age dependency Ratio = \frac{\text{aged 65+}}{\text{population aged 20–64}}

- Similar measure used by Nishimura (2011)

  Dependency Ratio = \frac{\text{aged 0–19 and 65+}}{\text{population aged 20–64}}
2. Empirical Method and Data
Relationship between Real Estate Prices and demographic factors
2. Empirical Method and Data

Relationship between Real Estate Prices and demographic factors

U.S.
3. Empirical Results

Unit Root Test

- Test Equation

\[ y_{it} = \rho_i y_{it-1} + \theta_{mi} d_{mt} + \varepsilon_{it} \]
\[ \Delta y_{it} = \delta_i y_{it-1} + \sum_{k=1}^{L_i} \gamma_{ik} \Delta y_{it-k} + \theta_{mi} d_{mt} + \varepsilon_{it} \]

  - Assumes common unit root process
  \[ H_0 : \delta_i = \delta = 0 \]
  \[ H_1 : \delta_i = \delta < 0 \]

- The individual unit root test: Maddala and Wu (1999)
  - Assumes individual unit root process
  \[ H_0 : \delta_i = 0 \text{ for all } i \]
  \[ H_1 : \delta_i < 0 \text{ for at least one } i \]
3. Empirical Results

Unit Root Test Results

<table>
<thead>
<tr>
<th></th>
<th>Level</th>
<th>First difference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Common unit root</td>
<td>Individual unit root</td>
</tr>
<tr>
<td></td>
<td>Levin-Lin-Chu</td>
<td>ADF-Fisher</td>
</tr>
<tr>
<td>Real land price</td>
<td>-5.7 (0.00) ***</td>
<td>123 (0.03) **</td>
</tr>
<tr>
<td>Per capita GDP</td>
<td>-10.5 (0.00) ***</td>
<td>144 (0.00) ***</td>
</tr>
<tr>
<td>Dependency ratio</td>
<td>0.6 (0.72)</td>
<td>24 (1.00)</td>
</tr>
<tr>
<td>Population</td>
<td>0.1 (0.53)</td>
<td>99 (0.34)</td>
</tr>
<tr>
<td>Real interest rate</td>
<td>-12.2 (0.00) ***</td>
<td>285 (0.00) ***</td>
</tr>
<tr>
<td>New housing starts</td>
<td>5.3 (1.00)</td>
<td>50 (1.00)</td>
</tr>
</tbody>
</table>

|                         | U.S.                       |                             |                             |
| Real housing price      | -6.9 (0.00) ***            | 209 (0.00) ***              | -9.1 (0.00) ***             | 379 (0.00) ***              |
| Per capita GDP          | -3.4 (0.00) ***            | 50 (1.00)                   | -19.5 (0.00) ***            | 701 (0.00) ***              |
| Dependency ratio        | -4.3 (0.00) ***            | -6.3 (0.02) **              | -4.2 (0.00) ***            | -7 (0.00)                   |
| Population              | -2.7 (0.00) ***            | 84 (0.89)                   | -18.6 (0.00) ***            | 547 (0.00) ***              |
| Real interest rate      | -2.8 (0.00) ***            | 230 (0.00) ***              | 0 (0.00) ***               | 786 (0.00) ***              |
| New housing starts      | -3.6 (0.00) ***            | 225 (0.00) ***              | -18.2 (0.00) ***           | 536 (0.00) ***              |

Note: Figures in the table represent test statistics with the associated p-values in parentheses. ***, **, and * indicate that the null hypothesis is rejected at the 1 percent, 5 percent, and 10 percent significance level. The lag of each ADF test is chosen based on the SIC criterion.

Note2: If the absence of cross-sectional correlation among disturbance is suspicious, the use of critical values calculated by bootstrap method is recommended by Maddala and Wu (1999). This methodology is planned to be applied in the future work.
3. Empirical Results
Cointegration Test

Test Equation
\[ \Delta \hat{e}_{it} = \mu_i \hat{e}_{it-1} + \sum_{k=1}^{L_i} \phi_{ik} \Delta \hat{e}_{it-k} + e_{it} \quad e_{it}: \text{estimated error} \]

- **Kao test**: Kao (1999)
  - Cointegration relationship in each region is *identical*.
    \[ H_0 : \mu_i = \mu = 0 \quad H_1 : \mu_i = \mu < 0 \]

- **Pedroni Panel test**: Pedroni (1999)
  - Cointegration relationship in each region is *identical*
    \[ H_0 : \mu_i = \mu = 0 \quad H_1 : \mu_i = \mu < 0 \]

- **Pedroni Group test**: Pedroni (1999)
  - Cointegration relationship is *heterogeneous* across regions
    \[ H_0 : \mu_i = \mu = 0 \quad H_1 : \mu_i < 0 \quad \text{for all } i \]
3. Empirical Results

Cointegration Test Results

<table>
<thead>
<tr>
<th>Region</th>
<th>Kao test ADF</th>
<th>Panel rho</th>
<th>Pedroni test Panel ADF</th>
<th>Group rho</th>
<th>Group ADF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Japan</td>
<td>-5.8 (0.00) ***</td>
<td>0.3 (0.63)</td>
<td>-4.1 (0.00) ***</td>
<td>2.7 (1.00)</td>
<td>-7.2 (0.00) ***</td>
</tr>
<tr>
<td>U.S.</td>
<td>0.0 (0.00) ***</td>
<td>-0.8 (0.22)</td>
<td>-4.2 (0.00) ***</td>
<td>1.8 (0.97)</td>
<td>-4.3 (0.00) ***</td>
</tr>
</tbody>
</table>

Note: The figure in each field represents the test statistic (P value). "***" indicates that the null hypothesis is dismissed at a 1% level of significance, "**" at a 5% level of significance, and "*" at a 10% level of significance. The ADF test lag order was selected based on the SIC criterion.

- The presence of cointegration relationship among the four variables.
- the use of Error Correction Model
$\Delta \ln P_{it} = a_{mi} + b_{1m} \Delta \ln GDPPC_{it} + b_{2m} \Delta \ln OLDDEP_{it} + b_{3m} \Delta \ln TPOP_{it} + b_{4m} ECT_{it-1} + v_{it}$

$ECT_{it} \equiv \ln P_{it} - \left( \alpha_{mi} + \beta_{1m} \ln GDPPC_{it} + \beta_{2m} \ln OLDDEP_{it} + \beta_{3m} \ln TPOP_{it} \right)$
## 3 Empirical Results

### ECM Estimation Results

<table>
<thead>
<tr>
<th></th>
<th>GDP per capita</th>
<th>Old age dependency ratio</th>
<th>Total population</th>
<th>EC term</th>
<th>Obs.</th>
<th>Adj. R2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Japan Coefficient</td>
<td>0.2188</td>
<td>-1.3167</td>
<td>0.9177</td>
<td>-0.1033</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S.E.</td>
<td>0.067</td>
<td>0.202</td>
<td>0.341</td>
<td>0.011</td>
<td>1645</td>
<td>0.629</td>
</tr>
<tr>
<td>t-stat</td>
<td>3.25</td>
<td>-6.5</td>
<td>2.69</td>
<td>-9.66</td>
<td></td>
<td></td>
</tr>
<tr>
<td>U.S. Coefficient</td>
<td>0.4515</td>
<td>-0.9067</td>
<td>0.7514</td>
<td>-0.1272</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S.E.</td>
<td>0.0111</td>
<td>0.142</td>
<td>0.141</td>
<td>0.013</td>
<td>1836</td>
<td>0.439</td>
</tr>
<tr>
<td>t-stat</td>
<td>4.06</td>
<td>-6.4</td>
<td>5.32</td>
<td>-9.54</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Takáts (2012) Coefficient</td>
<td>0.8842</td>
<td>-0.6818</td>
<td>1.0547</td>
<td></td>
<td>855</td>
<td>0.31</td>
</tr>
<tr>
<td>22 advanced economies S.E.</td>
<td>0.439</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>t-stat</td>
<td>1.83</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Comparing with Takáts (2012),

- The coefficient on the per capita GDP is much smaller
- The coefficient on the old age dependency ratio is larger
- The coefficient on total population is almost identical
Average impacts

- Real land price growth: +7.3 percent
- Economic growth: +0.6 percent
- Demographic changes: -2.9 percent
3. Empirical Results

Demographic and economic impact 1991-2010

Average impacts
- Real land price growth: -3.4 percent
- Economic growth: -0.1 percent
- Demographic changes: -4.2 percent
4. Demographic Impact over the Next 30 Years

Assumption on future population

- The medium variant projection on demographic changes calculated by IPSS (National Institute of Population and Social Security Research)

Note: IPSS projection is based on natural increases/decreases calculated from the survival probability and the number of births by cohort and social increases/decreases due to movement between regions.
4. Demographic Impact over the Next 30 Years

Historic and Forecasted Demographic Impacts on Land Prices

The average contribution of demographic changes:

1976-2010 : -3.8 percent per year
2010-2040 : -2.4 percent per year
4. Demographic Impact over the Next 30 Years: Contribution of Demographic Changes Estimated Based on IPSS and UN Population Projections

**IPSS**

<table>
<thead>
<tr>
<th></th>
<th>Low variant</th>
<th>Medium variant</th>
<th>High variant</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>TPOP</td>
<td>OLDDEP</td>
<td>Impact</td>
</tr>
<tr>
<td>2020</td>
<td>122,384,895</td>
<td>50.205%</td>
<td>-0.934%</td>
</tr>
<tr>
<td>2030</td>
<td>113,182,509</td>
<td>57.337%</td>
<td>-1.551%</td>
</tr>
<tr>
<td>2040</td>
<td>102,350,474</td>
<td>71.223%</td>
<td>-2.496%</td>
</tr>
</tbody>
</table>

**United nations**

<table>
<thead>
<tr>
<th></th>
<th>Low variant</th>
<th>Medium variant</th>
<th>High variant</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>TPOP</td>
<td>OLDDEP</td>
<td>Impact</td>
</tr>
<tr>
<td>2020</td>
<td>123,068,714</td>
<td>52.728%</td>
<td>-1.083%</td>
</tr>
<tr>
<td>2030</td>
<td>115,234,250</td>
<td>58.217%</td>
<td>-1.560%</td>
</tr>
<tr>
<td>2040</td>
<td>106,182,068</td>
<td>73.393%</td>
<td>-2.510%</td>
</tr>
</tbody>
</table>
Effects of Inter-Prefectural Migration on Demographic Impacts in 2011-2040

The diagram shows the demographic impacts of inter-prefectural migration in different years (2020, 2030, 2040) for various prefectures in Japan. The x-axis represents the prefectures, and the y-axis shows the impact value. The bars indicate the change in population due to migration, with positive values indicating an increase and negative values indicating a decrease.
5. Conclusion

- The demographic factor had a greater impact on real estate prices in Japan than in the U.S.

- In Japan, our model forecasts that the demographic factor will be -2.4 percent per year in 2010-2040 while it was -3.8 percent per year in 1975-2010.

- Suggesting that aging will continue to have downward pressure on land prices over the next 30 years, although the demographic impact will be slightly smaller than it was in 1975-2010 as the old age dependency ratio will not increase as much as it did before.